Technology and Industrial Arts

Construction Technology

Senior High

Grade 12

Teacher Guide

Standards-Based

Department of Education

'FREE ISSUE
NOT FOR SALE'

Technology and Industrial Arts

Construction Technology

Teacher Guide

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Standards-Based

Papua New Guinea
Department of Education

Issued free to schools by the Department of Education

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Acronyms

AAL	Assessment as Learning
ARS	Audience Response System.
AFL	Assessment for Learning
AOL	Assessment of Learning
BoS	Board of Studies
CDD	Curriculum Development Division
CP	Curriculum Panel
DA	Diagnostic Assessment
IHD	Integral Human Development
GoPNG	Government of Papua New Guinea
KSVA	Knowledge Skills Values and Attitudes
MTDG	Medium Term Development Goals
NDoE	National Department of Education
OBC	Outcomes-Based Curriculum
OBE	Outcomes-Based Education
PNG	Papua New Guinea
SAC	Subject Advisory Committee
SBA	Standards-Based Assessment
SBC	Standards-Based Curriculum
SBE	Standards-Based Education
SCG	Subject Curriculum Group
STEAM	Science, Technology, Engineering, Arts and Mathematics
SRS	Student Response System
TIA	Technology and Industrial Arts
UoW	Unit of Work

Secretary's Message

The ultimate aim of Standards-Based Education in Papua New Guinea (PNG) is to prepare students for careers, higher education, and citizenship. This means that education should focus on developing and equipping students with essential knowledge, skills, values, and attitudes that they can use in all aspects of their lives. Education must also aim to motivate and prepare students to pursue Science, Technology, Engineering, Arts, and Mathematics (STEAM) courses in higher education institutions and pursue careers in STEAM related fields.

The Technology and Industrial Arts subject has 5 strands with their own teacher guides developed and this Construction Technology teacher guide is one of them. Construction Technology is a significant curriculum to develop in students proficiency and competency in the engineering applications, methodology and processes of structures that encompass building, electrical, plumbing and welding. Thus enabling students' knowledge and skills in building through opportunities to design and build various construction projects. However, it is equally important for students to understand technology, its impacts and implications and make decisive and collaborative decisions that will enable themselves to utilise technology more to their advantage.

Technology and Industrial Arts as a subject of which Construction Technology is a strand, is envisioned to benefit students in enabling them to utilise technology knowledge, skills, values and attitudes, and systems and processes to solve problems using the design process in a methodical and precise manner to innovate and invent design solutions. The integration of STEAM in the teaching and learning of Construction Technology will instill in students the abilities and capabilities to be highly proficient and competent end users and possibly creators of technology as STEAM is an integral component of the core curriculum.

Teachers are encouraged to read this teacher guide carefully to become familiar with the content so that they can be confident to use the new concepts and strategies as well as teach the content well. They can also adjust to suit the needs of the students.

I commend and approve this Grade 12 Technology and Industrial Arts: Construction Technology Teacher Guide to be used in all senior high schools throughout Papua New Guinea.

.....

UKE W KOMBRA, PhD, OBE
Secretary for Education

Introduction

The strand Construction Technology in the Technology and Industrial Arts (TIA) subject aims to help students become competent and confident in construction technology, who can make efficient, effective and creative use of building, electrical, plumbing, welding skills in their everyday activities. It further encourages them to individually and collaboratively apply processes, systems, techniques and materials to create, monitor, analyse, predict and shape the interactions within and between construction structures and the impact of on individuals, societies, economies and environments. It embraces the development in technology and emerging technologies using software and applications, safely, ethically and with greater responsibility.

The study of Construction Technology will enhance the students' knowledge to create and read technical drawings; become familiar with construction materials, components, processes and perform a variety of building operations using engineering skills and procedures of design. Thus understanding the importance of occupational health and safety, building codes and standards and regulations and further identify the impacts of construction technology in society. It also aims to provide lifelong skills and opportunities for students to live a productive life as well as a career or pursuing further learning. In the 21st Century, it is important to recognise that technology has become part of the educational process for all age levels and should be viewed and taught as a tool for problem solving and decision- making. Students should be encouraged to analyse, synthesise and evaluate situations at home, and school, thereby, apply technology to complete tasks efficiently and effectively and be prepared for the future in the face of a changing construction landscape.

Students' employability will be enhanced through the study and application of STEAM principles. STEAM is an integral component of the core curriculum. It is envisioned that the study of STEAM will motivate students to take up academic programs and careers in STEAM related fields. STEAM has been embedded in the Technology and Industrial Arts: Construction Technology curriculum.

Teachers of Construction Technology strand will plan and program the strand as it has own time allocation. The learning integration is more relevant including the STEAM approach to teach the essential knowledge, skills, values and attitudes, and processes.

Technology and Industrial Arts: Construction Technology is to be timetabled for 200 minutes (5 periods) per week in senior high school.

Structure of the Teacher Guide

The Construction Technology Strand Teacher Guide comprises four main sections that provide essential information that all teachers should know and do to effectively implement the Construction Technology curriculum.

1. General Information of the Subject/Strand

The general information section of the Teacher Guide informs teachers on the Construction Technology Strand under the following headings below;

- Introduction of the Strand Teacher Guide
- Structure of the Strand Teacher Guide
- Purpose of the Strand Teacher Guide
- How to use the Strand Teacher Guide

2. Teaching and Learning Section

The teaching and learning section of the Teacher Guide informs and guides teachers to apply the teaching and learning theories, principles, pedagogies and practices in planning, programing, teaching and assessing students. They are outlined in the headings bulleted below;

- Syllabus and Teacher Guide Alignment
- Learning and Performance Standards
- Core Curriculum
- Science Technology Engineering Arts Mathematics (STEAM)
- Curriculum Integration
- Essential Knowledge, Skills, Values and Attitudes
- Teaching and Learning Strategies
- Strands, Units and Topics
- Sample SBC Lesson Plans

3. Assessment Section

The assessment section of the Teacher Guide informs and guides teachers to plan and program assessment activities, formulate assessment rubrics and apply assessment strategies to assess studies. This section also guides teachers to monitor and report students' progress of learning and performances of the attainment of standards.

4. Glossary, References and Appendices Sections

These sections guide teachers to refer to terms and definitions of the strand/subject content, references outlined to guide the development of this teacher guide and essential and supplementary information provided to guide teachers on the content and the delivery of this strand/subject.

Purpose of the Teacher Guide

This teacher guide describes what teachers should know and do to effectively plan, program, teach and assess Grade 12 Construction Technology content to enable all students to attain the required learning and proficiency standards.

Ample information with thorough guidelines is provided for the teacher to use to achieve the essential Knowledge, Skills, Attitudes and Values (KSAV) embedded in the set national content standards and grade level benchmarks.

The overarching purpose of this teacher guide is to assist teachers to;

- understand the significance of aligning all the elements of standards-based curriculum (SBC) as the basis of achieving the expected level of education quality,

- effectively align all the components of SBC when planning, programming, teaching, and assessing students learning and levels of proficiency,

- effectively translate and align the Technology and Industrial Arts Syllabi and Construction Technology Strand teacher guides to plan, program, teach and assess different Construction Technology Strand Teacher Guide units and topics, and the essential knowledge, skills, attitudes and values (KSAVs) described in the grade – level benchmarks,

- understand the Construction Technology Strand national content standards, grade-level benchmarks, and evidence outcomes,

- effectively make sense of the content (KSAVs) described in the Communication Technology Strand national content standards and the essential components of the content described in the grade – level benchmarks,

- effectively guide students to progressively learn and demonstrate proficiency on a range of Construction Technology Strand skills, processes, concepts, ideas, principles, practices, values and attitudes,

- confidently interpret, translate and use Construction Technology Strand content standards and benchmarks to determine the learning objectives and performance standards, plan and program appropriately to enable all students to achieve these standards,

- embed the core curriculum in the Construction Technology Strand lesson planning, programming, instruction, and assessment to permit all students to learn and master the core knowledge, skills, values and attitudes required of all students,

- provide opportunities for all students understand how STEAM has and continues to shape the social, political, economic, cultural, and environment contexts and the consequences, and use STEAM principles, skills, processes, ideas and concepts to inquire into and solve problems relating to both the natural and physical worlds (human –made) as well as problems created by STEAM,

- integrate cognitive skills (critical, creative, reasoning, decision-making, and problem solving skills), high level thinking skills (analysis, synthesis and evaluation skills), values (personal, social, work, health, peace, relationship, sustain values), and attitudes in lesson planning, programming, instruction and assessment,

- meaningfully connect what students learn in Construction Technology Strand with what is learnt in other subjects to add values and enhance students learning so they can integrate what they learn and develop in-depth vertical and horizontal understanding of subject content,

- formulate effective SBC lesson plans using learning objectives identified for each of the topics,

- employ SBC assessment approaches to develop performance assessments to assess students' proficiency on a content standard or a component of the content standard described in the grade –level benchmark,

- effectively score and evaluate students' performance in relation to a core set of learning standards or criteria, and make sense of the data to ascertain status of progress towards meeting grade-level and nationally expected proficiency standards,

- use evidence from the assessment of students' performance to develop effective evidence – based intervention strategies to help students making inadequate or slow progress towards meeting the grade-level and national expectations to improve their learning performances.

How to use the Teacher Guide

The Grade 12 Construction Technology Strand Teacher Guide is an expansion of the content in the Technology and Industrial Art Syllabus. The Syllabus contains the content standards, benchmarks and evidence outcomes which are expanded into teaching and learning activities in the teacher guide. The Teacher Guide provides essential information about what the teacher needs to know and do to effectively plan, teach and assess students' learning and proficiency on learning and performance standards. It should be read in conjunction with the syllabus in order to understand what is expected of teachers and students to achieve the envisaged quality of education outcomes.

The first thing teachers should do is to read and understand each of the sections of the Teacher Guide to help them understand the key SBC concepts and ideas. A thorough understanding of these components will help teachers meet the teacher expectations for implementing SBC and therefore the effective implementation of Grade 12 Construction Technology Strand in Technology and Industrial Arts Curriculum. Based on this understanding, teachers should be able to effectively use the teacher guide to do the following:

The scope of learning is translated and programmed according to the four terms. The suggested teaching and learning strategies and the key important instructions provided for teachers can be used to design and manage teaching and learning activities for the students in the classroom.

The assessment methods, assessment samples, reporting and recording strategies contained in this guide will assist teachers to plan assessment in Strands for the school year.

The strand teacher guide can be used for developing both classroom learning and professional development activities. The document is a useful resource for developing school and community based in-service programs.

Teachers must thoroughly read the contents of the documents in order to develop an understanding and do the following;

Determine Learning Objectives and Lesson Topics

- The teaching and learning Standards are derived from the Content Standards and Benchmarks in the Syllabus. The Learning Objectives are extracted from the grade-level benchmarks and are used for teaching topics. And lesson objectives are derived from learning objectives and are used for teaching Lessons.

Identify and Teach Grade Appropriate Content

- Grade appropriate content has been identified and scoped and sequenced using appropriate content organisation principles. The content is sequenced using the spiralling sequence principles. The strand, topics and lesson concepts in the Teacher Guide can be spiralled and taught by Strand, by Topics or by lessons using the Benchmarks. Using the Benchmarks, Content Mapping in Programing will enable teacher to see the content from what the students have already learned in line with current to be taught and link to the next learning content.

Integrate the Core Curriculum in Lesson Planning, Instruction and Assessment

- This sequencing of content will enable students to progressively learn the essential knowledge, skills, values and attitudes as they progress further into their schooling.

Integrate Science, Technology, Engineering, Arts and Mathematics (STEAM) principles and skills in lesson planning, instruction and assessment

- STEAM principles and skills must be effectively taught and learned by students. Teachers should use the teacher guide to help them make informed decisions when selecting the types of teaching and learning methodologies to use in their teaching of the subject content, including STEAM principles and skills.

Plan and address the principles of Inclusive Teaching and Learning'

Teachers are obliged to create an inclusive learning environment to include students with special needs to promote learning for all. These special needs may include students who are gifted or disadvantaged physically, socially, emotionally and intellectually. Students may display combinations of any of these needs and therefore, the teaching and learning activities must have students with special needs in to participate to their fullest abilities. The different types of needs in students include;

- Physical disabilities
- Intellectual disabilities
- Hearing impairment
- Sight-vision impairment
- Speech impairment
- Behavioural and emotional disorders

It is important that the learning activities for TIA: Construction Technology are inclusive and foster the learning needs of all students.

Syllabus and Teacher Guide Alignment

The Grade 12 Construction Technology Strand Teacher Guide is closely aligned and complementary to the Technology and Industrial Art Syllabus.

They are the essential focus points for teaching and learning the essential knowledge, skills, values and attitudes.

Syllabus and Teacher Guide Alignment	
Syllabus Outlines the ultimate aim and goals, and what to teach and why teach it	**Teacher Guide** Describes how to plan, teach, and assess students' performance
• Overarching and SBC principles • Content overview • Core curriculum • Essential knowledge, skills, values and attitudes • Strands and units • Evidence outcomes • Content standards and grade-level benchmarks • Overview of assessment, evaluation, and reporting	• Determine topics for lesson planning, instruction and assessment • Formulate learning objectives • Plan SBC lesson plans • Select teaching and learning strategies • Implement SBC assessment and evaluation • Implement SBC reporting and monitoring

The syllabus outlines the ultimate aim and goals of SBE and SBC, what is to be taught and why it should be learned by students, the underlying principles and the articulation of the learning and proficiency standards that all students are expected to attain. On the other hand, the teacher guide expands on what is outlined in the syllabus by describing the approaches or the how of planning, teaching, learning, and assessing the content so that the intended learning outcomes are achieved.

This teacher guide should be used in conjunction with the syllabus. Teachers should use these documents when planning, teaching and assessing Grade 12 Construction Technology Strand content.

Teachers will extract information from the syllabus (e.g., content standards and grade-level benchmarks) for lesson planning, instruction and is for measuring students' attainment of a content standard as well as progress to the next grade of schooling.

Learning and Performance Standards Alignment

Content Standards, Benchmarks and Evidence Outcomes are linked to Learning Objectives, Lesson Objectives and Performance Standards in the Teacher Guide. (see table). There is a close linear relationship between these standards. Students' performance on a significant aspect of a benchmark (KSVA) is measured against a set of performance standards or criteria to determine their level of proficiency using performance assessment. Using the evidence from the performance assessment, individual student's proficiency

on the aspect of the benchmark assessed and progression towards meeting the benchmark and hence the content standard are then determined.

Standards Alignment	
Standards in Syllabus	**Standards in Teacher Guide**
• SBC Aims and Goals • Content Standard • Benchmarks • Evidence Outcomes	• Learning Objectives • Lesson Objectives • Essential Knowledge, Skills, Values and Attitude • Performance Standard

Standard Alignment

Standard Alignment shows the link between different standards in the Syllabus and Teacher Guide. It begins with SBC Aims and Goals which are National Standards in which the Syllabus Standard is derived from. The Content Standards or Subject Standard are expanded into Benchmarks which are Achievable Benchmarks for particular Grade Levels and are translated into the Teacher Guide as Teaching and Learning Standards and Assessment Standards. they become the components of Unit of Work (UOW).

The UOW consist of Achievable Standard for a particular Grade Level and is translated into Teaching and Learning Activities and Assessment Tasks.

It is essential that teachers know and can do standards alignment when planning, teaching, and assessing students' performance so that they can effectively guide their students towards meeting the grade-level benchmarks (grade expectations) and subsequently the content standards (national expectations).

Below is a diagram to show the relationship between Standards in the Syllabus and the Teacher Guide.

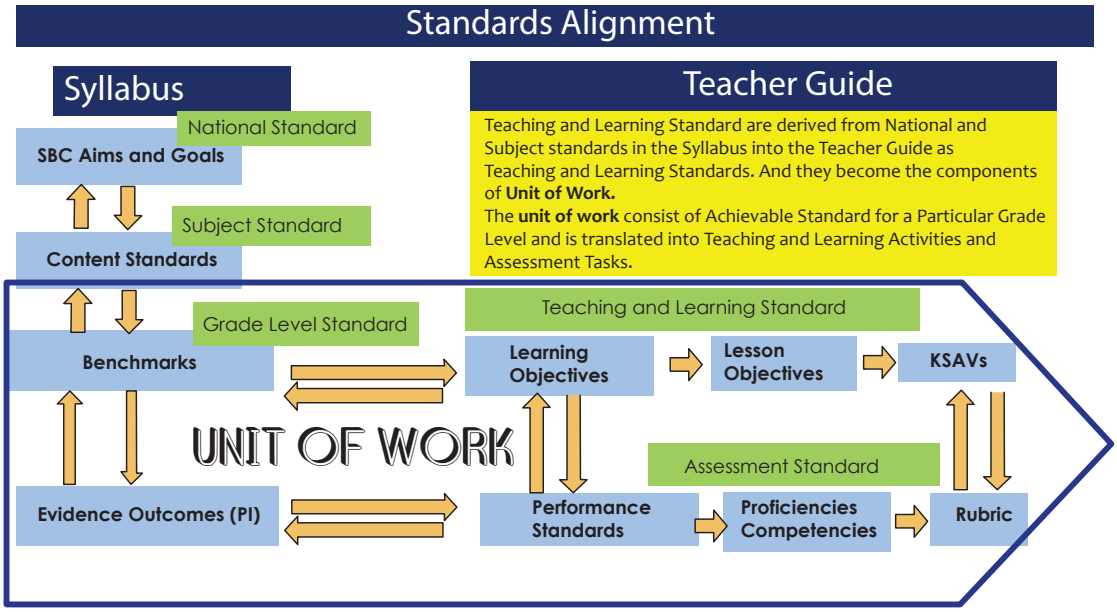


Figure 1: Standards Alignment that shows the alignment of standards in the syllabus and teacher guide

Learning and Performance Standards

Standards define the expected level of education quality that all students should achieve at a particular point in their schooling.

Content standards, benchmarks, and learning objectives are called learning standards while performance and proficiency standards (evidence outcomes) can be categorised as performance standards. These standards are used to measure students' performance, proficiency, progression and achievement of the desired level of education quality. Teachers are expected to understand and use these standards for programming, lesson planning, instruction and assessment.

Student's progression and achievement of education standard(s) are measured using performance standards or criteria to determine their demonstration or performance on significant aspects of the standards and therefore their levels of proficiency and competency. When they are judged to have attained a proficiency on a content standard or benchmark or components of these standards, they are then deemed to have met the standard(s) that is, achieve the intended level of education quality.

Content Standards

Content standards are evidence-based, rigorous and comparable regionally and globally. They have been formulated to target critical social, economic, political, cultural, environment, and employable skills gaps identified from a situational analysis. They were developed using examples and experiences from other countries and best practice, and contextualised to PNG contexts.

Content standards describe what **(content - knowledge, skills, values, and attitudes)** all students are expected to know and do **(how well students must learn and apply what is set out in the content standards)** at each grade-level before proceeding to the next grade. These standards are set at the national level and thus cannot be edited or changed.

Content Standards:

- are evidenced-based;
- are rigorous and comparable to regional and global standards;
- are set at the national level;
- state or describe the expected levels of quality or achievement;
- are clear, measurable and attainable;
- are linked to and aligned with the ultimate aim and goals of SBE and SBC and overarching and SBC principles;
- delineate what matters, provide clear expectations of what students should progressively learn and achieve in school, and guide lesson planning, instruction, assessment;
- comprise knowledge, skills, values, and attitudes that are the basis for quality education;
- provide teachers a clear basis for planning, teaching, and assessing lessons;

- provide provinces, districts, and schools with a clear focus on how to develop and organise their instruction and assessment programs as well as the content that they will include in their curriculum.

Benchmarks

Benchmarks are derived from the content standards and benchmarked at the grade-level. Benchmarks are specific statements of what students should know (*i.e.*,essential knowledge, skills, values or attitudes) at a specific grade-level or school level. They provide the basis for measuring students' attainment of a content standard as well as progress to the next grade of schooling.

Grade-level benchmarks:

- are evidenced-based;
- are rigorous and comparable to regional and global standards;
- are set at the grade level;
- are linked to the national content standards;
- are clear, measurable, observable and attainable;
- articulate grade level expectations of what students are able to demonstrate to indicate that they are making progress towards attaining the national content standards;
- provide teachers a clear basis for planning, teaching, and assessing lessons;
- state clearly what students should do with what they have learned at the end of each school-level;
- enable students' progress towards the attainment of national content standards to be measured, and
- enable PNG students' performance to be compared with the performance of students in other countries.

Learning Objectives

Learning or instructional objectives are precise statements of educational intent. They are formulated using a significant aspect or a topic derived from the benchmark, and is aligned with the educational goals, content standards, benchmarks, and performance standards. Learning objectives are stated in outcomes language that describe- the products or behaviours that will be provided by students. They are stated in terms of measurable and observable student behaviour. *For example,* students will be able to identify all the main towns of PNG using a map.

Performance Standards

Performance Standards are concrete statements of how well students must learn what is set out in the content standards, often called the **"be able to do"** of "what students should know and be able to do." Performance standards are the indicators of quality that specify how competent a student's demonstration or performance must be. They are explicit definitions of what students **must do to demonstrate proficiency or competency at a specific level on the**

content standards. Performance standards:

- measure students' performance and proficiency **(using performance indicators)** in the use of a specific knowledge, skill, value, or attitude in real life or related situations.
- provide the basis **(performance indicators)** for evaluating, reporting and monitoring students' level of proficiency in use of a specific knowledge, skills, value, or attitude.
- are used to plan for individual instruction to help students not yet meeting expectations **(desired level of mastery and proficiency)** to make adequate progress towards the full attainment of benchmarks and content standards.
- are used as the basis for measuring students' progress towards meeting grade-level benchmarks and content standards.

Proficiency Standards

Proficiency standards describe what all students in a particular grade or school level **can do** at the end of a strand, or unit. These standards are sometimes called evidence outcomes because they indicate if students can actually apply or use what they have learnt in real life or similar situations. They are also categorised as benchmarks because that is what all students are expected to do before exiting a grade or are deemed ready for the next grade.

As per presented above, should teachers wish to develop additional benchmarks to cater for their students learning needs. You are encouraged to follow the process below to develop them.

Approach for Setting National Content Standards and Grade - Level Benchmarks

Development of Additional Benchmarks

Teachers should develop additional benchmarks to meet the learning needs of their students. They should engage their students to learn about local, provincial, national and global issues that have not been catered for in the grade-level benchmarks but are important and can enhance students' understanding and application of the content. However, it is important to note that these benchmarks will not be nationally examined as they are not comparable. Only the benchmarks developed at the national level will be tested. This does not mean that teachers should not develop additional benchmarks. An innovative, reflective, creative and reflexive teacher will continuously reflect on his/her classroom practice and use evidence to provide challenging, relevant, and enjoyable learning opportunities for his/her students to build on the national expectations for students. Teachers should follow the following process when developing additional grade-level benchmarks.

Core Curriculum

Core curriculum refers to a core set of common learnings (knowledge, skills, values, and attitudes) that are integrated into the content standards and grade-level benchmarks for all subjects. The core curriculum includes:

- Cognitive skills (critical and creative thinking);
- Reasoning, problem-solving and decision-making skills;
- High level thinking skills (analysis, evaluation and synthesis);
- 21st Century skills;
- STEAM principles and skills;
- Seven Principles for Teaching Procedural and Technical Skills (Plan ahead, Demonstration, Observation of learner in action, Provide specific feedback, Encourage self-evaluation, Allow learner practice, Prepare to modify approach)
- Working Diagrams (sketching and technical drawing)
- Reading, writing and communication skills, and
- Essential values and attitudes.

Technology and Industrial Arts: Construction Technology teachers are expected to include the core learning's in their lesson planning, teaching and assessment of students in all their lessons. In addition to these are the essential core curriculums; OHS, designing, technical drawing, CAD Software and computer applications, engineering skills, methodology and construction materials, codes, standards and regulations, design process, design solutions and building structures in Construction Technology. Teachers may include other core curriculum concepts in relation to the subject to cater for students learning needs.

A practical example of integrating core curriculum in Teaching and Learning

Teachers can identify a set of core curriculum to teach in one lesson for example; in Technology and Industrial Arts: Construction Technology, students may be posed with an opportunity to find solutions on how technology can be used to utilise one of the core concepts of technology and industry in their area. The core concepts include; design process, design folio, design solutions, materials, processes, techniques, systems and safety.

Students will be required to use what they learnt in Construction Technology about designing, communication, the design process and how technology is engaging in people's livelihood in terms of designing and making products and marketing as a quicker and cheaper way of advertising and selling their products. They can use STEAM principles and skills in finding cause and solutions, use high level thinking skills to analyse and evaluate the effects and how to improve design products, use decision making and critical thinking skills to find the solutions for making and marketing a product.

They can be able to confidently and boldly communicate their findings and present intelligent and convincing arguments, which we can conclude that learning of the core curriculum is evident.

Science, Technology, Engineering, Arts and Mathematics

STEAM education is an integrated, multidisciplinary approach to learning that uses Science, Technology. Engineering, Arts and Mathematics as the basis for inquiring about how STEAM has and continues to change and impact the social, political, economic, cultural and environments contexts and identifying and solving authentic (real life) natural and physical environment problems by nitrating STEAM- based principles, processes, skills, values and attitudes to prepare them for careers, higher education and citizenship.

Construction Technology utilises both the goals of STEAM rather than just the goal of problem- solving. This is to ensure that all students are provided opportunities to learn, integrate and demonstrate proficiency on all essential STEAM principles, processes, skills, values and attitudes to prepare them for careers, higher education and citizenship.

Objectives:

Students will be able to:

i. Examine and use evidence to draw conclusions about how STEAM has and continues to change the social, political, economic, cultural and environmental contexts.
ii. Investigate and draw conclusions on the impact of STEAM solutions to problems on the social, political, economic, cultural and environments contexts
iii. Identify and solve problems using STEAM principles, skills, concepts, ideas and process
iv. Identify, analyse and select the best solution to address a problem
v. Build prototypes or model of solutions to problems.
vi. Replicate a problem solution by building models and explaining how the problem was or could be solved.
vii. Test and reflect on the best solution chosen to solve a problem
viii. Collaborate with others on a problem and provide a report on the process of problem solving used to solve the problem.
ix. Use skills and processes learnt from lessons to work on and complete STEAM related projects.
x. Demonstrate STEAM principles, skills, processes, concepts and ideas through simulation and modeling.
xi. Explain the significance of values and attitudes in problem solving.

STEAM Problem - Solving Methods and Approaches

Problem - solving involves the use of problem- solving methods and processes to identify and define a problem, gather information to understand its causes, draw conclusions, and use the evidence to design and implement solutions to address it. Even though, there are many different problem -solving methods and approaches; they share some of the steps of problem-solving, for example:

- Identifying the problem;
- Understanding the problem by collecting data;

- Analyse and interpret the data;
- Draw conclusions;
- Use data to consider possible solutions;
- Select the best solution;
- Test the effectiveness of the solution by trialing and evaluating it, and
- Review and improve the solution.

STEAM problem-solving processes go from simple and technical to advanced and knowledge- based processes. However, regardless of the type of process used students should be provided opportunities to learn the essential principles and processes of problem solving and more significantly, to design and create a product that addressed a real problem and meets a human need.

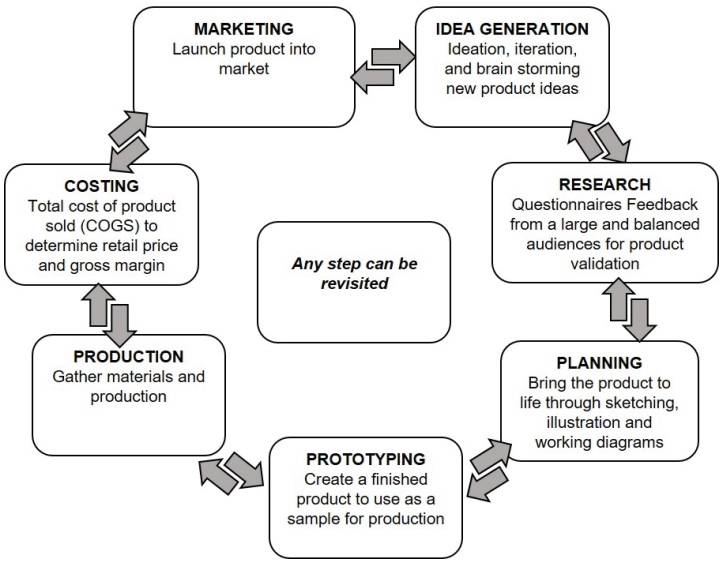
Engineering Design Process

Technological fields used the engineering design process to choose the best solution to solve the problem.

It is an open-ended problem solving process that involves the full planning and development of products or services to meet identified needs. It involves the following sequence of steps:

- Analyse the context and background, and clearly define the problem.
- Conduct research to determine design criteria, financial or other constraints, and availability of materials,
- Generate ideas for potential solutions, using processes such as brainstorming and sketching.
- Choose the best solution.
- Build a prototype or model.
- Test and evaluate the solution.
- Repeat steps as necessary to modify the design or correct faults.
- Reflect and report on the process.

The sequential engineering design process steps described above are illustrated in the diagram below.



Students should be guided through every step of the process so that they can explain it and its importance, and use the steps and the whole process proficiently to identify, investigate and solve problems. They should be provided with opportunities to practice and reflect on each step until they demonstrate the expected level of proficiency before moving on to the next one.

It involves the following sequence of steps;

Step 1: IDEA GENERATION
Step 2: RESEARCH
Step 3: PLANNING (DESIGN BRIEF)
Step 4: PROTOTYPING
Step 5: PRODUCTION
Step 6: COSTING
Step 7: MARKETING

Step 1: Idea Generation

- Ideation, iteration, and brain storming new product ideas

Students should be guided and provided opportunities to identify human made, natural and physical environment problems using their senses and describe what the problem is and its likely causes.

Example: *Residential backyard design that is not pleasing.*

Step 2: Research

- Questionnaires Feedback from a substantial and unbiased audience for product validation

After the problem is identified and described, several questions will be derived from a main issue question. The questionnaire will be formulated and then will be answered in the survey. This questionnaire will guide the researcher in conducting research and investigation for the appropriate solution to the problem.

Example: Main Question 'How can the residential backyard be designed include the elements of design that are aesthetically functional?'

Step 3: Planning (Design Brief)

- Bring the product to life through sketching, illustrations and working diagrams

Creating working sketches, illustrations and working diagrams helps the researcher to better understand his or her research problem, refine the research question and decide on investigation approach before the investigation is conducted.

Example: *Description of an Authentic Situation of an aesthetic and functional residential backyard design.*

The researcher may look into the various designs of backyards in the schools and surrounding residences outside of the school premises take pictures and produce sketches or other subject areas for tips or conduct online search on how to improve the design of residents' backyards from relevant websites. The researchers may even analyse information and past practices or similar but better regarding aesthetic and functional backyard designs.

Step 4: Prototyping

- Construct a scale model of a residential backyard design.

The researcher will make or develop a prototype of the solution and test how it would be used to solve the problem.

Example: Prototype

The illustration of sketches in the planning stage can be created in sketches and technical drafts or use CAD as the basic solution for residential back-yard design. He /she will complete a scale drawing, with annotation and development.

Step 5: Production

- Gather materials and production begins.

This step is the gathering of materials and producing of the product from the best prototype. This involves the identification of lists of materials, procedural steps with their respective tools or equipment to be used to produce the intended product.

It is obviously known during the production that certain procedural steps are needed to be done in certain order before the others because later steps depend on them being prioritized. In addition, concepts of other subjects needed for producing the product maybe gathered, integrated and utilised in the production of the product.

*Example***:** *Producing the product*

Step 6: COSTING

- Total cost of product sold to determine retail price and gross margin

This stage is known as product pricing which involves the calculation of the costs of materials used, labour cost, markup and selling price.

The selling price may be influenced by responses to the questions in the survey due to the interest of the buyers which will determine the cost of the product.

The cost for producing the item are:

1) Material unit cost: K____
2) Labor costs (No of Hours Spent X Your Rate): 10 hrs x K ___ = K____
3) Selling/Marketing cost: K____

A simple formula to calculate a good markup percentage for the project:
Example: Pricing the product

Step 7: MARKETING

- **Launch product into market**

This stage involves the marketing of the finished product. The potential buyers of the product are the targeted audience that were used in the research.

The finished product can be promoted using flyers, put out on public places and market page can be created on social media networks.

STEAM- Based Lesson Planning

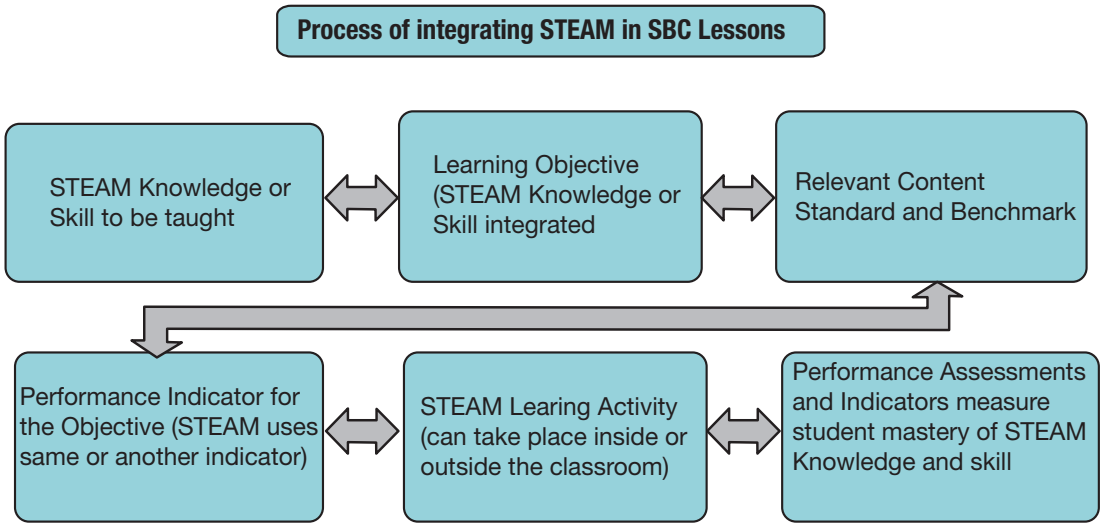
Effective STEAM lesson planning is the key to the achievement of the expected outcomes. STEAM Skills can be planned and taught using separate STEAM-based lesson plans or integrated into the standards- based lesson plans. To effectively do this, teachers should know how to write effective standards and STEAM-based lesson plans.

Developing STEAM-based Lesson Plans

An example of a standards- based lesson is provided below. Teachers should use this to guide them to integrate STEAM content and teaching, learning and assessment strategies into their standards- based lesson plans.

Integration of STEAM problem-solving skills into standards-based lesson plans

Process for Integrating STEAM Principles and Problem-Solving Skills into Standards-Based Lessons



Teachers should follow the steps given below when integrating STEAM problem-solving principles and skills into their standards-based lesson plans. (Refer to Appendices)

Step 1: Identify the STEAM knowledge or skill to be taught (From the table of KSAVs for each content standard and bench mark). **This could be already being captured in the learning objective stated in the standards-based lesson plan.**

Step 2: Develop and include a performance standard or indicator for measuring student mastery of the STEAM knowledge or skill (e.g. level of acceptable competency or proficiency) **if this is different from the one already stated in the lesson plan**

Step 3: Develop student learning activity (An activity that will provide students the opportunity to apply STEAM knowledge or skill specified by the learning objective and appropriate statement of standards). Activity can take place insideor outside the classroom and during or after school hours.

Step 4: Develop and use performance descriptors (standards or indicators) to analyze student STEAM related behaviors or products (results or outcomes), which provide evidence that the student has acquired and mastered the knowledge or skill of the learning objective specified by the indicator(s) of the standard(s).

STEAM-Based Assessment

STEAM-based assessment is closely linked to standards-based assessment where assessment is used to assess student's level of proficiency or competency of a specific knowledge, skill, value or attitude taught using a set of performance standards (indicators or descriptors). The link also includes the main components such as the purpose, the assessment principles and assessment strategies and tools.

In STEAM-based assessment, assessment is designed for what the students should know and be able to do. In STEAM learning students are assessed in a variety of ways including portfolios, project/problem-based assessment, backward designs, authenticity assessment, or other students centered approaches. When planning and designing the assessment, teachers should consider the authenticity of the assessment by designing an assessment that relates to a real world task or discipline specific attributes (such as simulation, role play, placement assessment, live projects, debates) should make the activity meaningful to the student, and therefore be motivating as well as developing employability skills and discipline specific attributes.

Effective STEAM-Based Assessment strategies

The following six sections describe six assessment tools and strategies shown to impact teaching and learning as well as help teachers foster a 21st Century learning environment in their classrooms.

1. **Rubrics**
2. **Performance-based assessment (PBAs)**
3. **Portfolios**
4. **Student self-assessment**
5. **Peer-assessment**
6. **Students response system (SRS)**

Although the list does not include all innovative assessment strategies, it includes what we think are the most common strategies, and ones that may be particularly relevant to the educational context of developing countries in this 21st Century. Many of the assessment strategies currently in use fit under one or more of the categories discussed. Furthermore, it is important to note that strategies also connect in a variety of ways.

1. Rubrics

Rubrics are both a tool to measure students' knowledge and ability as well as an assessment strategy. A rubric allows teachers to measure certain skills and abilities not measurable by standardized testing systems that assess direct knowledge at a fixed moment in time. Rubrics are also frequently used as part of other assessment strategies (portfolios, performances, projects, peer-review and self-assessment), they will be discussing in those sections as well.

2. Performance - Based Assessments

Performance-Based Assessments (PBA), also known as authentic assessment are generally used as a summative evaluation strategy to capture not only what students know about a topic, but if they have the skills to apply that knowledge in a; 'real-world' situation by asking them to create an end product. PBA pushes students to synthesize their knowledge and apply their skills to a potentially unfamiliar set of circumstances that is likely to occur beyond the confines of a controlled classroom setting. The implementation of performance-based assessment strategies can also impact other instructional strategies in the classroom.

3. Portfolio Assessment

Portfolios are a collection of student work gathered over time that is primary used as a summary evaluation method. The most salient characteristic of the portfolio assessment is that rather than being a snap shot of a student's knowledge at one point in time (like a single standardised test) it highlights student effort, development, and achievement over a period of time; portfolios measure as student's ability to apply knowledge rather than simply regurgitate. They are considered both student-centered and authentic assessment of learning.

4. Self-Assessment

Its main purpose is for students to identify their own strengths and weakness and to work to make improvements to meet specific criteria. Self-assessment occurs when students judge their own work to improve performance as they identify discrepancies between current and desired performance. In this way, self-assessment aligns well with standards-based education because it provides clear targets and specific criteria against which students or teachers can measure learning.

Self-assessment is used to promote self-regulation to help students reflect on their progress and to inform revisions and improvements on a project or paper. In order for self-assessment to be truly effective, four conditions must be in place, the self-assessment criteria, criteria is negotiated between the teachers and students, students are taught how to apply the criteria, students receive feedback on their self-assessments. Teachers then help students use assessment data to develop an action plan.

5. Peer Assessment

Peer assessment, much like self-assessment, is a formative assessment strategy that gives students a key role in evaluating learning. Peer assessment approaches can vary greatly but, essentially it is a process for learners to consider and give feedback to other learners about the quality or value of their work. Peer assessments can be used for a variety of products like papers, presentations, projects and or other skills behaviors. Peers assessment is understood as more than only a grading procedure and is also envisioned as teaching strategy since engaging in the process develops both the assessor and the assessees skills and knowledge. The primary goal for using peer assessment is to provide feedback to the learners. This strategy may be particularly relevant in the classrooms with many students per teacher since student time will be more plentiful than teacher time, although any single student's feedback may not be rich or in-depth as teachers feedback, the research suggests that peer assessment can improve learning.

6. Students Response system

Students response system (SRS), also known as classroom response (CRS), audience response system (ARS) is a general term that refers to a variety of technology-based formative assessment tools that can be used to gather student- level data instantly in the classroom through the combination of hardware, (voice recorders, PC, internet connection, projector and screen) and software.

Teachers can ask students a wide range of questions (both closed and open ended), where students can respond quickly and anonymously, and the teacher can display the data immediately and graphically. The use of technology also includes a use of video which examines how a range of strategies can be used to assess students understanding. The value of SRS comes from the teachers analysing information quickly and then devising real-time instructional solutions to maximise students learning. This includes a suggested approach to help teachers and trainers assess learning.

Essential Knowledge, Skills, Values, and Attitudes

Students' level of proficiency and progression towards the attainment of content standards for Technology and Industrial Arts subject will depend on their mastery and application of essential knowledge, skills, values, and attitudes in real life or related learning experiences and situations across the secondary curriculum.

Examples of the different types of knowledge, skills, values and attitudes, including processes, that all students are expected to learn and master as they progress through the grades are provided in;

- Technology and Industrial Arts syllabuses for grades 11&12 page 24-27

These knowledge, skills, values and attitudes have been integrated into the content standards, benchmarks and performance standards developed for Technology and Industrial Arts subject
Teachers are expected to plan and teach these in their lessons, and assess students' performance and proficiency, and progression towards the attainment of content standards.

Technology and Industrial Arts

Technology and Industrial Arts provides and instills in students the confidence to use a range of specific knowledge, skills, values and attitudes in various technologies. These are scoped and embedded within the strands curriculum content in the subject, with the intension to create related career pathways. The content in each strand encourage students to be proactive, competent, creative, responsible and reflective learners, enabling them to pursue career opportunities in respective fields of technology studied in this subject.

Provided herein are recognised knowledge for the subject which are applicable across the strands.

Types of common knowledge for Technology and Industrial Arts

These are specific content knowledge for the subject. They include;	
• Creativity • Branding • Communication skills • Technical expertise • Industry expertise • Critical thinking- • Information Technology skills • Innovation	• Building and Engineering Knowledge. • Physical Strength and Stamina. • Mathematical formulas in technology • Technology and Industrial Language Coordination. • Technology Skills. • Problem Solving Skills. • Prototype

Technology and Industrial Arts is a skills oriented subject, therefore embraces all the commonly recognised skills which can be used across the strands scoped in the content. Listed here for teacher's convenience are commonly recognised skills across the strands.

Types of Skills for Technology and Industrial Arts

These are specific content Skills for the strand. They include;	
• Creativity • Critical thinking • Technical knowledge • Commercial awareness of food industries/catering services • Research and data handling capacity • Critical analysis and interpretation of materials • Management skills • Organisational Skills. • Problem solving skills • Mathematical skills • Language Literacy skills • Leadership • Innovative skills • trans formational skills	• Food Server Skills • Focus Communication skills (approachability, circumstantial awareness, diligence, efficiency, thoroughness • Multitasking skills • Attention to detail skills (multitasking , approachability, • Technical Skills • Decision making skills • Coding • information technology soft skills • logical thinking • collaboration • teamwork • software engineering • software quality assurance • customer Service • Modeling

Types of Values

Personal engagement and civic engagement strategies help young people to acquire and apply skills and dispositions that will prepare them to become competent and responsible citizens.

1. Personal Values (importance, worth, usefulness, etc

Core values	Sustaining values
• Sanctity of life • Truth • Aesthetics • Honesty • Human • Dignity • Rationality • Creativity • Courage • Liberty • Affectivity • Individuality	• Self-esteem • Self-reflection • Self-discipline • Self-cultivation • Principal morality • Self-determination • Openness • Independence • Simplicity • Integrity • Enterprise • Sensitivity • Modesty • Perseverance

2. Social Values

Core Values	Sustaining Values
• Equality • Kindness • Benevolence • Love • Freedom • Common good • Mutuality • Justice • Trust • Interdependence • Sustainability • Betterment of human kind • Empowerment	• Plurality • Due process of law • Democracy • Freedom and liberty • Common will • Patriotism • Tolerance • Gender equity and social inclusion • Equal opportunities • Culture and civilization • Heritage • Human rights and responsibilities • Rationality • Sense of belonging • Solidarity • Peace and harmony • Safe and peaceful communities

Types of Attitudes

Attitudes - Ways of thinking and behaving, points of view	
• Optimistic • Participatory • Critical • Creative • Appreciative • Empathetic • Caring and concern • Positive • Confident • Cooperative	• Responsible • Adaptable to change • Open-minded • Diligent • With a desire to learn • With respect for self, life, equality and excellence, evidence, fair play, rule of law, different ways of life, beliefs and opinions, and the environment.

Construction Technology strand

The Construction Technology strand encourages students to “think out of the box”. This simply means to think openly and freely beyond the learning situation to bring about fresh creative ideas into the classroom lessons. This gives opportunity to the students to apply creativity and critical thinking to participate .Teachers must ensure that even students with rudimentary creativity skills end up improvising their designs, models of prototypes and products.

Types of knowledge for Construction Technology

These are specific content knowledge for the Strand. They include;	
• Technical drawing • Print and layout reading • Design • Construction Materials specifications • Constructions Systems • Constructions Processes • Construction techniques • Prototype • Constructions materials estimates and costs	• Designs of structures • Construction tools • Construction equipment • Construction tools, equipment and correct functions • OHS • Maintenance skills, • Storage skills • Construction supervisory skills • Project management Skills

Processes in Technology & Industrial Arts

Technology and Industrial Arts expounds on the classroom practices using processes for effective and evidence based lesson deliveries. The commended/ suggested processes are for teachers to use as the starting points planning skills or practice based lessons in any of the strands as presented in the subject syllabus.

Types of Processes - Inquiry processes for Technology & Industrial Arts subject

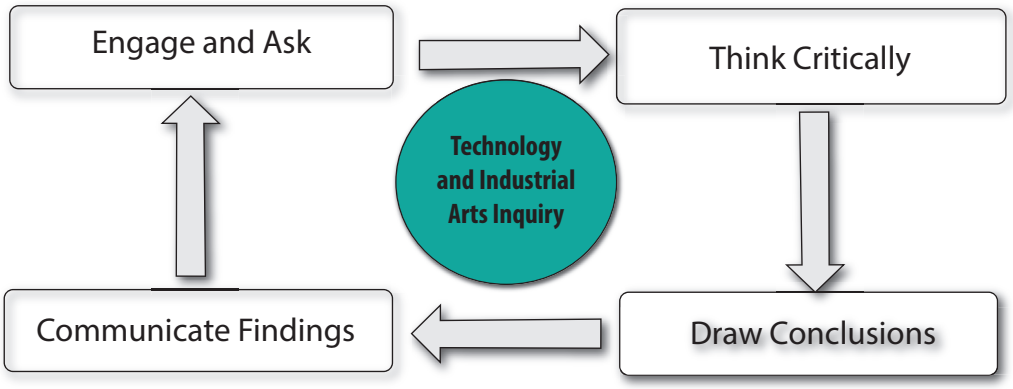
Technology & Industrial Arts Inquiry processes include:

- Gathering information
- Analysing information
- Evaluating information
- Making judgements
- Taking actions
- Instructional technology
- Integration process
- Project planning process
- Organisation of learning experiences

Technology & Industrial Arts Inquiry Processes

Engage and Ask	How will I engage my students in the topic and prompt them to ask questions? • Determine the enduring understandings about the topic being studied. • Engage your students with the topic by grabbing their interest with a hook connected to the enduring understandings. • Allow students to generate questions based upon the topic and hook. • Determine what questions will be essential to achieving the enduring understandings. (Student generated or teacher determined • With students, determine what other information is needed in order to fully answer the questions.
Think Critically	How will students access and analyse information about this topic? • Have students think about where they can find answers to the questions posed about the topic. • Gather and organize multiple primary and secondary sources. • Ensure that sources used expose students to different perspectives and viewpoints about the topic. • Students should use sources to collect, analyse, and interpret data. • Ensure students are analysing sources for credibility, bias, and perspective in order to identify gaps in the research.
Draw Conclusion	How will students synthesize ideas to answer the questions posed based on sources used? • Students should engage in civic discussion to answer the questions posed while respecting diverse opinions. • Engage students in evaluating possible courses of action and their consequences. • Students should make and justify an informed decision or choice and/or design an action plan supported by evidence from sources. • Have students evaluate the consequences of a decision or choice. • Allow students to make revisions based on feedback and further study.
Communicate Findings	How will students demonstrate what they have learned and take action on that learning? • Determine how students will apply what they have learned and share their findings with others. • Explore appropriate audiences for students to present conclusions. • Determine if there is an opportunity for students to take action and influence others to make more informed decisions. • Have students develop strategies to persuade others, including policy makers when applicable. • Prepare students to defend their analysis against alternative.

Below is how the Technology & Industrial Arts Inquiry Process will be taught in the classroom. Be specific as you make notes of the activities or prompts you will use to ensure students will have the opportunity to practice these skills as a requirement in the Grade 9 content standards.



Technology & Industrial Arts Enquiry

1. **Developing Questions and Planning Inquiries**
   a. *Constructing Essential Questions*
   - Address essential questions that reflect an enduring issue in the field
   b. *Constructing Supporting Questions*
   - Explain how supporting questions contribute to an enquiry.
   c. *Determining Helpful Sources*
   - Develop new supporting and essential questions through investigations, collaboration and using diverse sources.

2. **Evaluating Sources and Using Evidence**

a. *Gathering and Evaluating Sources*
- Gather and evaluate information from multiple sources while considering the origin, credibility, point of view, authority, structure, context and corroborative value of the sources.

b. *Developing Claims and Using Evidence*
Identify evidence that draws information from multiple sources to revise or strengthen claims.
- Communicating Conclusions and Taking Informed Action

c. *Communicating Conclusions*
- Construct and evaluate explanations and arguments using multiple sources and relevant, verified information.

d. *Critiquing Conclusions*
- Articulate explanations and arguments to a targeted audience in diverse setting.

e. *Taking Informed Action*
- Use interdisciplinary lenses to analyse the causes and effects of and identify solutions to local, regional or global concerns.
- Use deliberative processes and apply democratic strategies and procedures to address local, regional or concerns and take action in or out of school.

5. Literacy Skills

A strong emphasis must be placed on various types of literacy, from financial to technological, from media to mathematical, from content to cultural. Literacy may be defined as the ability of an individual to use information to function in society, to achieve goals and to develop her or his knowledge and potential. Teachers emphasise certain aspects of literacy over others, depending on the nature of the content and skills they want students to learn.

The following literacy skills are intended to be exemplary rather than definitive;

Types of Literacy Skills – Skills in basic literacy, digital literacy and financial literacy
• Define and apply discipline-based conceptual vocabulary • Describe people, places, and events, and the connections between and among them • Arrange events in chronological sequence • Differentiate fact from opinion • Determine an author's purpose • Determine and analyse similarities and differences • Analyse cause and effect relationships • Explore complex patterns, interactions and relationships • Differentiate between and among various options • he ability to locate, evaluate and use digital information. • The ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills • The ability to effectively and critically navigate, evaluate and create information using a range of digital technologies. • Making choices about personal finances and having the skills to make decisions that will have positive outcomes. • Effectively use financial skills • Improve personal financial management skills • Improve budgeting and investing skills • Create a savvy relationship with money application skills • Create a lifelong journey of learning for education is the key to success when it comes to money • Effective use financial skills • Improve personal financial management skills • Improve budgeting and investing skills • Create a savvy relationship with money application skills • Create a lifelong journey of learning for education is the key to success when it comes to money

6. Numeracy Skills

Numeracy skills refer to the ability to use, interpret and communicate mathematical information to solve real-world problems. These include the ability to understand basic math like addition, subtraction, division and multiplication. More advanced numeracy skills incorporate the use of graphical, spatial, statistical and algebraic concepts and the ability to interpret that data and apply it to real-world situations.

Types of Numeracy Skills – skills that are driven by the basic mathematical aspects
• Basic knowledge of numbers • Calculation skills • Budgeting • Interpreting mathematical information • Understanding the relationships between numbers • Understanding trends • Measurement and data analysis

7. High Level Thinking Skills

These skills include analysis, synthesis, and evaluation skills.

i. Analysis Skills – Analysis skills involve examining in detail and breaking information into parts by identifying motives or causes, underlying assumptions, hidden messages; making inferences and finding evidence to support generalisations, claims, and conclusions.

ii. Synthesis Skills – Synthesis skills involve changing or creating something new, compiling information together in a different way by combining elements in a new pattern proposing alternative solutions.

iii. Evaluation Skills – Evaluation skills involve justifying and presenting and defending opinions by making judgments about information, validity of ideas or quality of work based on set criteria.

Key Words				
Analyse	Differences	Find	Reproduce	Similar to
Appraise	Discover	Focus	Motivate	Simplify
Arrange	Discriminate	Function	Omit	Take part in
Assumption	Discussion	Group	Order	Test for
Breakdown	Distinction	Highlight	Organise	Themewebbing
Categorise	Distinguish	In-depth	Point out	Create
Cause & effect	Dissect	Inference	Research	Innovate
Choose	Divide	Inspect	See	Design
Classify	Establish	Isolate	Select	collaborate
Comparing	Examine	Investigate	Separate	recreate
				networking

Curriculum Integration

An integrated curriculum is described as one that connects different areas of study by cutting across subject-matter lines and emphasising unifying concepts. Integration focuses on making connections and linkages in content for students, allowing them to see the importance of all subjects in the curriculum. When students are able to see and understand the linkages between different subject matter, they engage in relevant, meaningful activities that can be connected to real life.

Curriculum integration is a holistic approach to learning , thus, curriculum integration in SBC will equip students with the essential 21st Century knowledge, skills, values and attitudes. Teachers must develop intriguing curriculum by going beyond the traditional teaching of content based or fragmented teaching to the teacher who is knowledge based and who should be perceived as a 21st Century innovative educator.

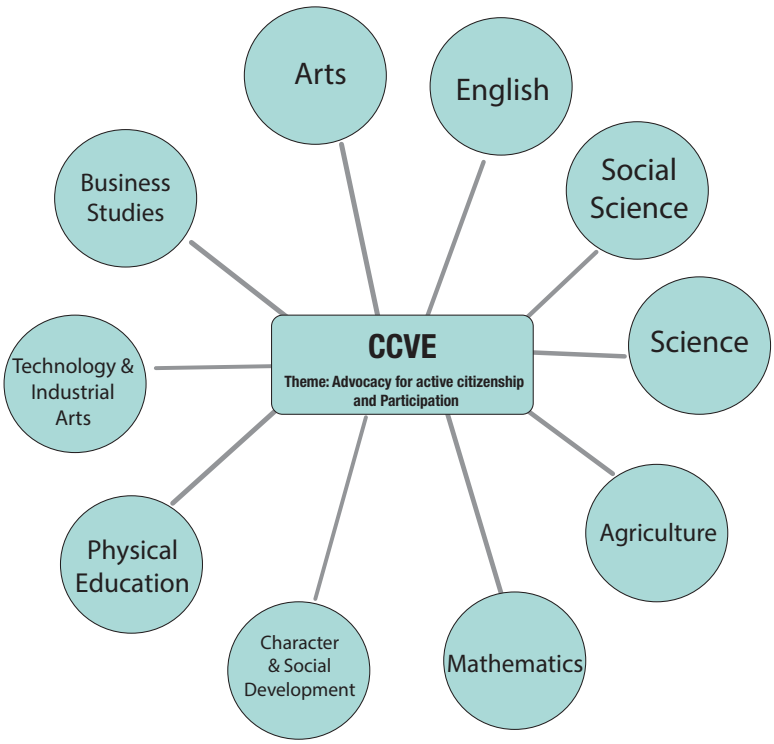
There are three approaches that SBC will engage to foster conducive learning for all students whereby they all can demonstrate proficiency at any point of exit. Adapting these approaches will have an immense impact on the lives of these students as they will not only see themselves as catalyst of change for a competitive PNG but also, comparable to the world standards as global citizens.

Engaging these three approaches in our curriculum will surely sharpen the knowledge and ability of each child, allowing them to see themselves as assets through their achievements and as agents of change contributing meaningfully to their country.

Integrated learning will bear a generation of knowledge-based populace who can solve problems and make proper decisions based on evidence. Thus, PNG can achieve its goals like the Medium Term Development Goals (MTDG) and aims such as the Vision 2050 for a happy, healthy and wealthy society whereby, all its citizens should have access and fair distribution to income, shelter, health, education and general goods and services improving the general standard of living for PNG in the long run.

1. Multidisciplinary Approach

In this approach, learning involves a theme or concept that will be taught right across all subject area of study by students. For instance, if the theme is “Food Production”, all subject areas create lessons or project-based learning and assessment as per their subjects around this theme. The content of the theme “Food Production” will be taught right across all the different subjects through the different Benchmarks as shown in the diagram and below.


CCVE
Theme: Advocacy for active citizenship and Participation
Arts
English
Social Science
Science
Agriculture
Mathematics
Character & Social Development
Physical Education
Technology & Industrial Arts
Business Studies

Sample Curriculum Integration Outline of Linkages

THEME: "ADVOCACY FOR ACTIVE CITIZENSHIP AND PARTICIPATION"		
SUBJECT: CHRISTIAN AND CITIZENSHIP VALUES EDUCATION		**GRADE: 12**
STRAND 3: CHRISTIAN CITIZENSHIP AND SOCIETY		
UNIT 1: Christian Civics Systems		
TOPIC: Christian civic organizations use technology to advocate for good health, better education and for protection of the natural environment and its sustainability.		
Subject	**Benchmark**	**Concept of focus to learn and assessed for the Theme**
CCVE	**12.3.1.4** Inquire and discuss how Christian civic Organizations use technology to advocate for good health, better education and for protection of the natural environment and its sustainability.	How Civic Organizations use technology to advocate for protection of the natural environment and its sustainability
Agriculture	**12.3.1.4.3** Suggest ways for improving problems that a□ect conservation in Papua New Guinea	Improving Conservation problems in PNG as Citizens
Arts	**12.3.3.2** Conduct research and create art-works to advocate for social change. **12.1.2.2** Use a range of techniques and technological tools in a variety of applications relating to music to communicate a theme.	Use data from research to create artwork to advocate for active Citizenship Use Music Technological Tools to communicate active Citizenship
Business Studies	**12.4.2.9.** Establish the e-business by creating a website or using a mobile application (apps) using the Apple operating system (App Store) or Google Android operating system (Google Play).	Create a website or a mobile appli-cation to as a platform to advocate for active Citizenship[p
Character and Social Development		
English	**12.2.6.2:** Take advantage of technology's capacity to link to other information and to display information flexibly and dynamically. **12.5.4.2:** Give a clearly articulated, well-structured presentation on a complex topic.	How to display Citizenship information flexibly and dynamically with use of technology. Do a clearly articulated, well-structured presentation on active Citizenship

Mathematics	**12.4.4.3** Use appropriate technology to aid concept development as a tool for problem solving. (General Maths) **12.1.1.5** Apply quadratic equations to solve real-world situations and complex number problems. (Advance Math)	Application of quadratic equations to solve real-world situations as part of active citizenship Use appropriate technology as a tool for problem solving when they engage as active citizens in real life situations
Physical Education	**12.2.2.2** Distinguish and illustrate sporting greats of PNG in respect to their contribution in the country	How they can actively participate as sporting greats to model active citizenship participation
Science	**12.2.1.6** Investigate human population growth by comparing recent and future population growth in developed and developing countries (Biology)	Use of data from investigations to compare human population growth and use the information to participate in informed decision making
Social Science	**12.1.4.6.** Critique various national and global strategies, agenda, and actions for addressing climate change. (Geography) **12.2.4.2.** Examine the different ways the United Nations promote change and maintain stability in different regions of the world. (Political Science) **12.3.3.1** Identify and appraise the different ways people from different cultures, religions, and ethnic and ideological backgrounds relate to each other (History)	Use of strategies to actively participate in addressing climate change Understanding of how UN maintains stability to be able to actively advocate for understanding of world peace Learn how common grounds of understanding and relationships minimizes differences in cultures, religions, and ethnic and ideological backgrounds and advocate for tolerance
TIA	**12.5.2.4;** Describe the characteristics of client site scripting and creating interactive menus (Computer Tech)	The use of site scripting to create interactive menus for advocacy on issues of national and global interest as part of active citizenship participation

Note: Assessment Project Planning for the theme

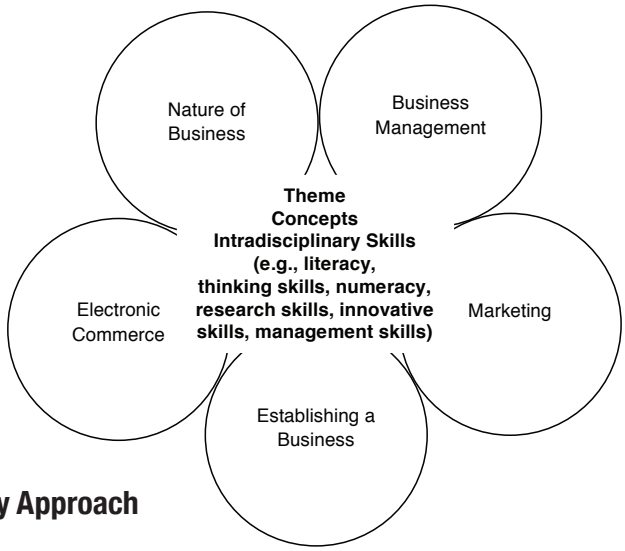
Planning for assessment will be a collaborative effort of all the subject teachers who wish their students to be part of the project with the CCVE subject Teacher as the overall coordinator of the Project and leading the Team.

See the process of this assessment in the Assessment Section.

2. Interdisciplinary Approach

This approach addresses learning similarly to the multidisciplinary approach of integrated learning whereby learning takes place within the subject area. However, it is termed interdisciplinary in that the core curriculum of learning is interwoven into each subject under study by the students. For instance; in Social Science under the strand of geography students write essay on internal migration however, apart from addressing the issues of this topic, they are to apply the skill of writing text types in their essay such as argumentative essay, informative, explanatory, descriptive, expository and narrative essay while writing their essay. They must be able to capture the mechanics of English skills such as grammar, punctuation and so forth. Though these skills are studied under English they are considered as core skills that cut across all subjects under study. For example; if Science students were to write about human development in biology then the application of writing skills has to be captured by the students in their writing. It is not seen as an English skill but a standard essential skill all students must know and do regardless.

Therefore, essential knowledge, skills, values and attitudes comprising the core curriculum are interwoven and provide an essential and holistic framework for preparing all students for careers, higher education and citizenship in this learning.



3. Intradisciplinary Approach

This approach involves teachers integrate sub disciplines within a subject area. For instance, within the subject Business Studies, the strands (disciplines) of Nature of Business, Business Management, Marketing, Establishing a Business and Electronic Business will all be captured studying theme concepts Interdisciplinary Skills in Business Studies. For example, under the management skills students will study the concepts of business management, business planning, marketing and sales, and electronic commerce. Thus, children's' awareness of the importance skills for businesses, understand the issues surrounding the rapid changing technology in business management and can address it confidently at each level of learning.

4.Trans-disciplinary Approach

In this approach learning goes beyond the subject area of study. Learning is organised around students' questions and concerns. That is, where there is a need for change to improve lives, students develop their own curriculum to effect these need.

The trans-disciplinary approach addresses real-life situations thus giving the opportunity to students to attain real life skills. This learning approach is more to do with Project–Based Learning also referred to as problem-based learning or place- based learning.

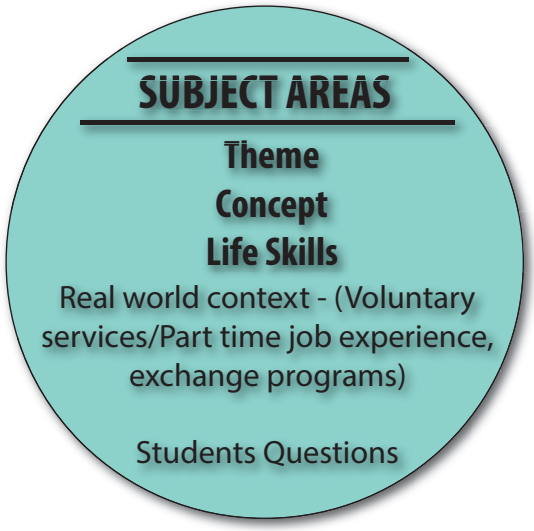
The three steps to planning project based curriculum (*Chard 1998)*.

1. Teachers and students select a topic of study based on student interests, curriculum standards, and local resources.
2. The teacher finds out what the students already know and helps them generate questions to explore. The teachers will also provide resources for students and opportunities to work in the field.
3. Students share their work with others in a culminating activity. Students display the results of their exploration and review and evaluate the project.

For instance; students may come up with slogans for school programs such as 'Our culture - clean city for a healthier PNG'. The main aim could be to curb betel nut chewing in public areas especially around bus stops and local markets. Here, students draw up their own instructions and criteria for assessment which is they have to clean the nearest bus stop or local market once a week throughout the year. They also design and create posters to educate the general public as their program continues. They can also involve the town council and media to assist them especially to carry out awareness.

Studies (Susan M. Drake and Rebecca C. Burns) have proven that Project based-programs achievements have led to the following:

- Students go far beyond the minimum effort.
- Make connections among different subject areas to answer open-ended questions.
- Retain what they have learnt.
- Apply learning to real-life problems.
- Have fewer discipline problems.
- Lower absenteeism (Curtis, 2002).



Teaching and Learning Strategies

Technology & Industrial Arts emphasises and embraces the use of cognitive, reasoning, decision-making, problem solving and higher level thinking skills to teach to enhance students' understanding of inter-disciplinary concepts and issues in relation to environment, geography, history, politics and economic within PNG and globally.

It aims to provide a meaningful pedagogical framework for teaching and learning essential and in demand knowledge, skills, values, and attitudes that are required for the preparation of students for careers, higher education and citizenship in the 21st Century.

Students must be prepared to gather and understand information, analyse issues critically, learn independently or collaboratively, organise and communicate information, draw and justify conclusions, create new knowledge, and act ethically.

Teaching and learning is a two-way interactive interaction between teacher and a student , a student to a student/students and occurs in any learning environment in or outdoors depending on the nature of teaching strategies learning activities and performance assessments teachers plan to use in the delivering of the lesson.

Technology and Industrial Arts teaching and learning takes on a **blended perception and practices** of its content delivering with envisioning intentions to reinforce evidence based learning. It embraces these in the classrooms whereby each technology strand content in the form of content standards, benchmarks and performance standards direct or determine the planning of the types of learning situations and activities, assessments throughout the school year.

These standards, including the specific knowledge skills and attitudes ,how they are planned for students learning and performance attainment purposes in the respective grade levels are through highly commended teaching, learning and assessing strategies. For example; using blended learning strategies. This is where/when the traditionally recognised strategies(teacher centred) is blended with using e-teaching/learning strategies(online using smart phones) to learn about properties of construction materials, in a Construction Technology strand lesson.

Teaching strategies

Find listed for your convenience are identified teaching strategies commended for TIA subject lesson deliveries lessons However teachers can blend these in with the existing or current teaching practices using technology.

- Use of multimedia for content research.
- Utilisation of social media for fact finding on a particular technology.
- Using variety of resources for meaningful teaching .
- Making most of games in electronic devices for learning.
- Use technology to empower students and reach out.

Learning Strategies

These are suggested learning strategies that can be used across the learning of all the five content strands in TIA subject.

- Using multiple types of instructional materials for learning.
- Incorporate technology for reinforcement and motivation for learning.
- Try new learning techniques for teaching and learning.
- Keep your traditional teaching methods.
- Vary your assessments.
- Mix up group work styles.
- Try a digital curriculum.

Classroom assessment strategies

- Find for your convenience suggested assessment strategies to assess. technology curriculum content.
- Clarifying learning intentions and criteria for success.
- Engineer effective classroom-based questioning and discussions on performance tasks that provoke or draw out evidence of learning.
- Constantly provide feedback that move learners forward.
- Present or address students as instructional resources for each other,
- Computer assisted video-based test.

All Teachers teaching TIA from grades 9-10 and Construction Technology in Grade 11 and 12 are encouraged to also add to this list for the good of their student's learning.

TIA Classroom

This classroom will be a learning environment prepared especially for the teaching and learning of TIA subject. As we are moving through the 21st century technology era, TIA classrooms must reflect shadow image to encourage the teaching and learning of all the strands in the subject content.

It is suggested that teachers and students could work together to ensure that this technology classroom tips could be accommodated. These are:

- Regularly keep updates on new advancements in technology.
- Ongoing Effective Evaluation on an Ongoing Basis.
- Make Technology a Treat & Not an Expectation.
- Monitor closely usage of electronic devices .
- Set ground rules for all.
- Share knowledge on how to get technical support.
- Communicate with parents.
- Familiarise yourself with the Technology First aid.
- Use of Technology by students.

These teaching and learning strategies will help teachers to;

- familiarise themselves with different methods of teaching in the classroom,
- develop an understanding of the role of a teacher for application of various methods in the classroom.

Successful teachers always keep in view that teaching must "be dynamic, challenging and in accordance with the learner's comprehension. He/she does not depend on any single method for making his/her teaching interesting, inspirational and effective".

Please find a list of the different teaching and learning strategies in the Appendices

These strategies;

- make learning more engaging,
- make learning more effective,
- make learning fun,
- encourage higher motivational level,
- improve attention spans,
- develop higher order thinking and reflective skills,
- improve communication skills,
- develop the spirit of teamwork /collaboration,
- develop leadership skills and qualities, and
- encourage discovery learning.

Therefore, teachers are encouraged to utilise the suggested strategies as well as others.

Strands, Units and Topics

This section of the teacher guide contains the Technology and Industrial Arts: Construction Technology content to be taught in grade 12. It consists of;

- a brief explanation of how the topics, learning objectives and lesson topics are derived.
- an overview of the content distributed according to the four terms in an academic year;
- the unit of work per strand

Technology and Industrial Arts is organized around five main strands – Textiles, Food, Construction, Communication, and Computer of which Construction Technology is one strand. These strands embed the content that students are expected to learn and master at each grade and school level. National content standards are benchmarked at each grade level, which allows for essential KSAVs to be reinforced and expanded throughout the grades.

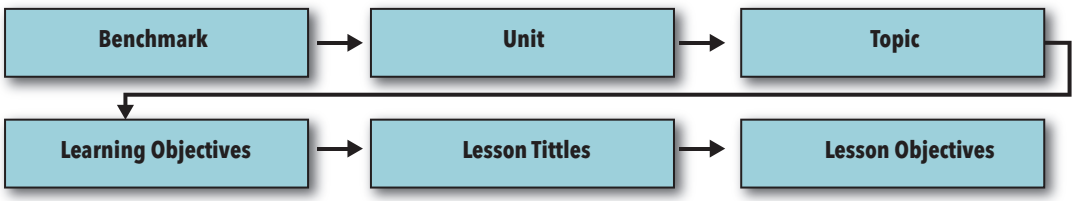
Benchmarks show grade level expectations of what students are able do to demonstrate that they are making progress towards attaining the content standard.

These grade-level benchmarks were then unpacked to identify the topics, learning objectives and the lesson topics. Below is a description of how topics were derived from the grade-level benchmarks.

Identifying topics from benchmarks

In order to identify the topic from the benchmark, we need to unpack the benchmark. When we unpack a benchmark, we are identifying what students will know and be able to do when they have mastered the benchmark.

1. Write out the benchmark that you want to unpack.
2. Write the verbs (skills/actions) – Higher order thinking skills
3. Underline or highlight the big idea (content) in the benchmark. The big idea (content) is the topic derived from the benchmark.
4. Write essential questions that would be engaging for students
5. Develop sub-topics from the big idea (topic)
6. Write learning objectives according to the sub-topics
7. Write lesson Topics from the learning objectives



Content Overview

The teaching and learning of Construction Technology in Grades 12 will follow the outline of content for the four terms in a year .

This is only a sample to guide teachers as to how they are going to plan and teach the five strands in Technology and Industrial Arts in a school year.

TERM	STRAND	UNIT	CONTENT STANDARD
1	**Textiles Technology**	**Fibres and Fabrics**	**CS1.1** Investigate the evolution, characteristics, designs and trends of fabrics and fabric designs, their construction, production, representation, regulation and marketing.
		Textiles and Clothing	**CS1.2** Integrate and apply principles and techniques in presenting fashion ideas and illustrations in pattern making and garment construction for a variety of needs and occasions
	Food Technology	**Food and Nutrition**	**CS2.1** Examine and analyse the characteristics and properties of different types of food and the social, economic, political, cultural and technological influences on their production and compliance with ethical principles and standards.
		Food Science	**CS2.2** Investigate and analyse the cultural, physical, chemical, nutritional, biological and sensory characteristics of food and how they influence the development and production of food to meet different demands (eg, health, occasions, lifestyle, business)
2	**Construction Technology**	**Building Technology**	**CS3.1** Investigate the history and theory of buildings and analyse the components and systems of buildings, occupational health and safety procedures, the properties of building materials and the processes in which those materials and equipment are used according to industry standards.
		Electrical Technology	**CS3.2** Analyse and apply the technological processes, concepts, principles and practices related to Electrical Technology and its social contribution with regard to economic growth, entrepreneurship, sustainability and as a tool for change, improving the quality of life responsive to individual, community and industrial needs.

		Plumbing Technology	**CS3.3** Investigate and analyse fundamental concepts of plumbing and theories, Occupational Health and Safety Regulations and standards ,trade drawing, demonstrations and applications of tools and materials specifications, installation of plumbing fittings and accessories in Drain, waste, vent system, and water (DWV) distribution system.
		Welding Technology	**CS3.4** Investigate and analyse safety procedures, print reading, measurement and layout, identify properties of metals, the welding techniques, cutting processes according to welding codes, inspections, testing principles and apply fundamentals of fabrication.
		Engineering Technology	**CS3.5** Investigate and analyse the historical and societal influences in Engineering by understanding the engineering principles, practices, the design process, the management, problem-solving and communication skills appropriate to any engineering field.
3	**Communication Technology**	Data Communication and Network	**CS4.1** Investigate and analyse communication technology utilising multi-media and the practices and systems in designing, installing, configuring and managing networks.
		Computer Security and Safety	**CS4.2** Investigate and analyse the ergonomics, social and ethical issues and the development of a monitoring and control system for both hardware, software and information security in society.
4	**Computer Technology**	Computer Architecture	**CS5.1** Explore and analyse computer fundamentals, the skills to manage and maintain; diagnose, troubleshoot and solve issues that encompass computer systems, networking, interfacing and programming as well as electronics and robotics and be aware of related environmental and societal issues.
		Computer Software	**CS5.2** Investigate and analyse computer system and application software, programming, algorithm, web design and databases, and develop and apply the skills and knowledge in the various software.

Strand: Construction Technology

This strand consists of five (5) units. They are;

UNITS	BENCHMARKS
Unit 1. Building Technology	**12.3.1.1** Explore and apply scientific fundamental of building structure **12.3.1.2** Apply and analyse building project management **12.3.1.3** Practice Auto CAD program in designing structure **12.3.1.4** Apply fundamental of OHS On- Site in building construction **12.3.1.5** Explore and apply appropriate Applied maths in building to estimate the cost of building **12.3.1.6** Design and construct building structure with correct procedure and regulations of Building
Unit 2: Electrical Technology	**12.3.2.1**. Read, analyse and interpret electrical circuit diagrams in design and construction. **12.3.2.2.** Describe the reasons for an earthing system and show how MEN system works to protect against the harmful effects of electricity. **12.3.2.3.** Employ correct handling and maintenance techniques in performing tasks using hand and power tools. **12.3.2.4.** Analyse the process of installing a circuit breaker and a meter box and install the different types of switching circuits for switch points to control light points. **12.3.2.5.** Safely conduct dead and live tests on circuits and apply electrical energy to assess and evaluate circuits. **12.3.2.6.** Apply knowledge and skills in troubleshooting, repairing and maintenance of electrical products, appliances and components of electrical systems.
Unit 3: Plumbing Technology	**12.3.3.1** Explore and apply Plumbing Project management principles and process **12.3.3.2** Describe and apply OHS- On-site **12.3.3**.3 Describe and apply Trade maths in Plumbing to estimate material cost **12.3.3.4** Adapt Installation of plumbing fittings and accessories, Water Distribution system, drain, waste, vent system

Unit 4: Welding Technology	**12.3.4.1.** Observe health and safety practices when handling materials, tools and equipment. **12.3.4.2.** Describe the design for the life cycle, taking into account economic costs, social and environmental impacts of the product, from the extraction of raw materials to eventual reuse or recycling of component materials. **12.3.4.3.** Practice identification and selection of suitable metal material for machining or welding with precision measurement. **12.3.4.4.** Use computer applications for planning, preparing and processing of materials. **12.3.4.5.** Assess procedures and standards for inspection of welding and machining quality. **12.3.4.6**. Evaluate welding and machining project creation in accordance to industry standards.
Unit 5: Engineering Technology	**12.3.5.1** Describe and analyse the nature of engineering in specific field and its importance to society **12.3.5.2** Demonstrate ability to scale drawing designs and employ architectural drafting skills to create design structures **12.3.5.3** Evaluate the scope of engineering and recognise current innovations and describe the relationship between properties , uses, applications of materials in engineering **12.3.5.4** Apply mathematical, scientific and graphical methods to solve of engineering practice **12.3.5.5** Identify and evaluate the social environmental and cultural implications of technological change in engineering

UNIT 1: BUILDING TECHNOLOGY

Units	Topics	Lesson Titles
1. Building Technology	**Topic 1. Fundamentals of Applied Science in Building**	1. Applied Science in Building 2. The Components of Applied Science 3. Types of Defects on Timber 4. Methods of Timber Treatment
	Topic 2. Building Project Management	1. Building Project Management 2. The Principles and Process of Project 3. The Role of a Project Manager
	Topic 3. Practice AutoCAD Program in Building	1. Purpose of AutoCAD Program 2. Types of AutoCAD program 3. Methods of Downloading CAD/Autodesk Software 4. Designing Domestic Building Using CAD Program
	Topic 4. OHS on-site Construction	1. Types of OHS On-Site 2. Hazard Communication On-Site 3. OHS on Setting Scaffolding 4. Personal Protective Equipment Use On-Site 5. Material Handling Safety
	Topic 5. Estimating Building Costs	1. Building Applied Maths 2. Methods of Calculating Substructure Members 3. Methods of Calculation Superstructure
	Topic 6. Processes and Procedures in Construction	1. Analysing Building Processes and Procedures 2. Method of Designing Gable Roof Using AutoCAD Program 3. Estimating the Cost of Material 4. Building Setting Out and Construction Process 5. Furniture Installation and Furnishing the Building

Grade 12

Construction Technology

Teaching Content

UNIT 1: Building Technology

Content Standard 3.1 Investigate the history and theory of buildings and analyse the components and systems of buildings, occupational health and safety procedures, the properties of building materials and the processes in which those materials and equipment are used according to industry standards.

Benchmark 12.3.1.1 Explore and apply scientific fundamental of building structure.

Topic 1: Fundamentals of Applied Science in Building

Learning Objectives

By the end of this topic, the students will be able to;

- Define applied science in building structures and analyse the components of applied science relationships to building structures.
- Explore the building failures and how they can be rectified.
- Define the types of defects on timber and explain the application of the methods of timber treatment.

Essential Questions:

1. What is applied science in building?
2. What are the components of applied science in building?
3. How do buildings work?
4. Why do buildings fail?
5. What are types of timber defects?
6. What are the methods of timber treatment?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Fundamentals of applied science in buildings.	Explore and analyse the main concepts of applied science in building.	Open-minded and appreciative of the application of science in building.	Appreciate the importance.

Content Background

Fundamentals of Applied Science in Building

Fundamentals of Applied science in building is basically referred to as applied sciences that are related to building or structures durability. The common factors that affect the building structure durability and life span of any structure are; ineffective construction management, design flaws, high temperatures, poorly evaluated expansions and lack of maintenance.

What is building and its function?

The basic function of a building is to provide structurally sound and environmentally controlled spaces to house and protect occupants and contents. If this basic function is not achieved, it is because some aspect of the building has failed. Since man first began to build, there have been times when our buildings have not met expectations. Common problems include leaks, unsightly cracks or sagging, and in rare instances, total collapse. Modern building codes have greatly reduced, but cannot totally eliminate, the risk of being hurt or killed in a structural collapse.

Failures of basic building functions can range from defects in single components such as windows, to extensive deficiencies in an entire exterior wall system, to the inability of Heating, Ventilation and

Air Conditioning (HVAC) systems to properly condition the air. The source of these deficiencies can include inadequate design, improper execution of the work, defective materials, or simply normal and expected aging perhaps coupled with lack of maintenance. Building deficiencies such as water infiltration, excessive building movement, or premature component failures have become more common as buildings have become more complex.

Building performance

A building's performance (or efficiency) is a measure of how well it functions in relation to designated criteria such as physical, social or environmental considerations. For example, a building's physical efficiency might be evaluated by assessing parameters such as heat loss, energy use, water use, water tightness, structural performance, fire performance and so on. It can also measure whether the resources necessary to design and construct a building have been used effectively.
Assessments can be made for all building types and are particularly important in housing. Concerns about how buildings perform date back at least as far as Neolithic times. Cave dwellers would assess their habitat against criteria such as; shelter from the elements, safety against animal attack, conspicuity, and solar orientation. Similar concerns have preoccupied people ever since, but the list has grown with increasing construction complexity and tighter regulatory requirements

When constructing building structures the building regulations of a country are consulted and approval granted. These regulations set out the minimum requirements for specific aspects of building design and construction.

The way some buildings perform may not live up to the designers intentions. he difference between anticipated and actual performance may be significant and to the detriment of the occupiers, owners and environment. This is known as the performance gap which, if significant may result in aspects of the construction having to be redone and can lead to legal proceedings.
What are performance characteristics of a building?

A high performing building includes these characteristics: Sustainable design with a proper balance of aesthetics, accessibility, cost-effectiveness, safety, and security, superior indoor air quality, based on the specific requirements of the space, energy efficient design and performance, reduced greenhouse gas emissions, optimal lighting and acoustics, thermal comfort and appropriate humidity levels are the characteristics of building performance as considerations.

Defects in Timber

There are various types of defects in timber as a construction material. These defects in timber can be due to natural forces, fungi, insects, and during seasoning and conversion. These types of defects in wood are discussed in detail.

Trees give us the timber, which is converted into the required form and finally used. Before reaching this final stage, timber comes across many critical stages like growing without defects, cutting at the right time, seasoning, converting, and using. Different types of defects occur in timber at these various stages.

Types of Defects in Timber as a Construction Material

In general, the defects in timber are mainly due to:

1. Natural forces
2. Fungi
3. During Seasoning
4. During conversion
5. Insects
6. Defects in timber due to Natural Forces
7. Wind cracks
8. Shakes
9. Twisted fibers
10. Upsets
11. Rind galls
12. Burls
13. Water stain
14. Chemical stain
15. Deadwood
16. Knots
17. Coarse grain
18. Foxiness
19. Druxiness
20. Callus

1. Wind Cracks in Timber

If the wood is exposed continuously to the high-speed winds, the outer surface shrinks and forms crack externally, which are called wind cracks.

Figure1.1a: Timber Defects; Wind Cracks in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

2. Twisted Fibers in Timbers

When the tree in its younger age is exposed to high-speed winds, the fibers of wood gets twisted. This type of wood is not suitable for sawing. So, this can be used for making poles, posts, etc

Figure1.1b: Timber Defects; Twisted Fibers in Timbers
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

3. Upsets

Upsets, a defect of timber in which the fibers of the wood are crushed and compressed by fast blowing winds or inappropriate chopping of trees.

Figure1.1c: Timber Defects; Upsets
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

4. Rind Galls

Rind galls are curved swellings of trees which are formed at a point where a branch of the trees is improperly removed or fell down.

Figure1.1d: Timber Defects; Rind Galls
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

5. Burls

Burls are uneven projections on the body of the tree during its growth. These are mainly due to the effect of shocks and injuries received by the tree during its young age.

Figure1.1e: Timber Defects; Burls
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

6. Water Stain

When the wood is in contact with water for some time, the water will damage the color of the wood and forms a stain on its surface. This defect is called as water stain.

Figure1.1f: Timber Defects; Water Stain
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

7. Chemical Stain

Chemical stain is formed on the wood by the action of any external chemical agents like reaction by the gases present in the atmosphere etc. The stain area gets discolored in this defect

Figure1.1g: Timber Defects; Chemical Stain
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

8. Dead Wood

The wood obtained from the cutting of the dead tree is light in weight and is actually defected. It is reddish in color and its strength is very less.

Figure1.1h: Timber Defects; Chemical Stain
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

9. Knots in Timber

The central part or stem of a tree is majorly used in the conversion of timber. Branches from the stem are removed, and the whole rounded stem is taken. But the base of branches forms a mark on the stem, which results in dark-colored stains on the surface after conversion. This dark-colored stains are due to the continuity of wood fibers. These dark-colored rings are known as knots.

Figure1.1i: Timber Defects; Knots in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

10. Coarse Grain Defect in Timber

The age of a tree can be known by the number of annual rings. For fast-growing trees, the gap between the annual rings is very large. This type of tree is called as coarse-grained tress, and timber obtained from them is of less strength

Figure1.1j: Timber Defects; Coarse Grain Defect in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

11. Timber Foxiness

When the timber is stored without proper ventilation, the trees growing near the banks of water bodies and over matured trees may exhibit this type of defect. Foxiness is generally indicated by red or yellow spots

Figure1.1k: Timber Defects; Timber Foxiness
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

12. Druxiness

Druxiness is a defect of timber in which the top surface of timber indicates white spots. These spots will give the access to fungi.

Figure1.1l: Timber Defects; Druxiness
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

13. Callus

The wound of the tree is covered by soft skin, which is called a callus.

Figure1.1m: Timber Defects; Callus
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

Defects in timber due to Fungi

1. Dry rot
2. Wet rot
3. Brown rot
4. White rot
5. Blue stain
6. Heart rot
7. Sap stain

1. Dry Rot in Timber

Dry rot is caused by a certain type of fungi that eats wood for their living. They make food by converting timber into dry powder form. This occurs mainly when there is no ventilation of air or if the wood improperly seasoned.
Absence of sunlight, dampness, presence of sap will increase the growth of dry rot, causing fungi.
This can be prevented by using well-seasoned wood and also by painting the timber surface with copper sulfate.

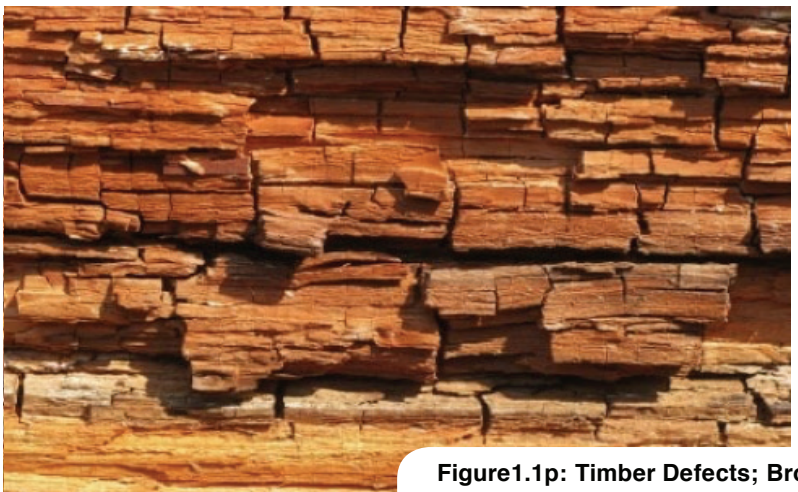
Figure1.1n: Timber Defects; Dry Rot in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

2. Wet Rot in Timber

Wet rot is caused by fungi that decompose the timber and convert it into a grayish-brown powder form. Wet rot causing fungi growths mainly when there are alternate dry and wet conditions of timber

Figure1.1o: Timber Defects; Wet Rot in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

3. Brown Rot in Timber



The cellulose compounds of the wood are consumed by certain types of fungi, which then makes the wood brownish, and this defect is called brown rot.

Figure1.1p: Timber Defects; Brown Rot in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

4. White Rot in Timber

Some types of fungi attack lignin of timber and leaves cellulose compounds; hence the wood will turn into white color, which is called white rot.

Figure1.1q: Timber Defects; White Rot in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

5. Blue Stain in Timber

Blue stain is a defect caused by some kind of fungi, which makes the timber bluish.

Figure1.1r: Timber Defects; Blue Stain in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

6. Heart Rot in Timber

Heart rot is generated in the trees when fungi attack the heartwood through its newly formed branch. This type of fungi makes the tree hollow by consuming heartwood. This defect is known as heart rot.

Figure1.1s: Timber Defects; Heart Rot in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

7. Sap Stain in Timber

When the moisture content in the timber is more than 25%, some types of fungi attack the sapwood and make it discolored. This type of defect is known as a sap stain.

Figure1.1t: Timber Defects; Sap Stain in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

Defects in Timber During Conversion

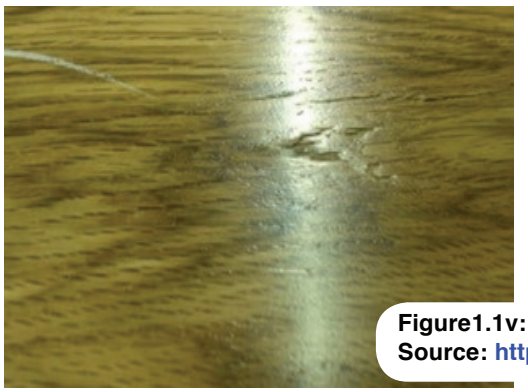
1. Diagonal grain
2. Torn grain
3. Chip mark
4. Wane

1. Diagonal Grain Defect in Timber

During the conversion of timber, different cutting saws are used. The cutting should be done properly. If there is any improper cutting by the saw, then a diagonal grains will appear.

Figure1.1u: Timber Defects; Diagonal Grain Defect in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

2. Torn Grain



In the conversion, many tools are used. If any of the tools or any other heavy things are dropped accidentally on the finished surface of timber it will cause small depression, which is called torn grain.

Figure1.1v: Timber Defects; Torn Grain
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

3. Chip Mark

When the timber is cut through the planning machine, the parts of the machine may form chip marks on it. Usually, they are indicated by chips on the finished surface.

Figure1.1w: Timber Defects; Chip Mark
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

4. Wane

The edge part of the timber log contains a rounded edge on one side because of its original rounded surface. This rounded edge is called wane.

Figure1.1x: Timber Defects; Wane
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

Defects in timber due to Insects

1. Termites
2. Beetles
3. Marine borers

1. Termites in Timber

Figure1.1y: Timber Defects; Termites in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timb

Termites also known as white ants which form a colony inside the timber and eat the core part of the timber rapidly. They do not disturb the outer layer of timber, so one cannot identify their presence. The trees in tropical and sub-tropical regions are mostly affected by these termites.

However, some trees like teak, Sal, etc. cannot be attacked by termites because of the presence of termite preventing chemicals in their cellulose part.

2. Beetles in Timber

Beetles are a type of insects that destroy the sapwood of the tree and make a tunnel-like hole from the bark. Usually, the diameter of the hole is around 2 mm. They convert sapwood into powder form, and larvae of these beetles use these holes. Almost all hardwood trees can be prone to damage by these beetles.

Figure1.1z: Timber Defects; Beetles in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

3. Marine Borers in Timber

Marine borers are found near coastal areas. They do not consume wood, but they make large holes of diameter up to 25mm in the timber to live inside it. They excavated up to 60mm deep in the wood. The wood attacked by marine borers is of less strength and discolored. They can attack all types of trees present in their region.

Figure 1.1zi: Timber Defects; Marine Borers in Timber
Source: https://theconstructor.org/building/types-of-defects-in-timber/21521/

What Are the Methods of Timber Treatment?

All timber pests are fundamentally nature's forest scavengers. Once a tree is felled, whether by age or by axe, the timber, from a natural standpoint is, "dead" and ready for destruction. Most timber preservatives are essentially fungicides and need the addition of an insecticide to make them suitable for use against termites and other insects. Timber should be adequately seasoned (dried) before treatment with a preservative. Pressure/vacuum impregnation is the most effective method of application. Timbers vary in their susceptibility to attack by insects and fungi with some being naturally long-lasting. Others are less durable but it is important to note that all timber that is kept dry (i.e. below a moisture content of 20%) will not sustain a fungal attack.

There are three main types of timber preservatives: tar oils, waterborne and organic solvent-borne. Waterborne and organic solvent types are most widely used for the protection of building timbers. Their primary function is to penetrate and be retained usually in a 'shell' of the outer few millimeters of timber, to guard against stain, decay, mould growth and insect attack. The preservative treatment for timber is to be decided based on its end use i.e., – whether for external or internal works.

Types of Timber preservatives:

- **Tar Oil Preservatives**

Creosote, a by-product of coal, is the most commonly used tar oil. Because of its smell and dark colour, and inability to take any painted finish, it is generally only suitable for external purposes such as sleepers, fence posts, piers and transmission poles. It reduces moisture absorption and offers very effective protection against fungal and insect attack.

- **Water-Borne Preservatives**

The two types of water-borne preservatives used, boron compounds for green timber and combinations of copper, chromium and arsenic (CCA) for seasoned timber are both water-soluble. Most water-borne preservatives are applied by vacuum/pressure impregnation. After impregnation, the more commonly used copper-chromium-arsenic (CCA) become fixed and insoluble in the wood, resulting in high durability. They have high resistance to attack by fungi and insects. The preservative gives light coloured wood a light grey/green hue and is liable to cause some slight swelling. They are usually odourless and can be decorated over.

CCAs are relatively safe. The chemicals are fixed to the wood fibers during the treatment process so that they will not leach out. But the criticism over the chemical arsenic in the past few years has led to its ban in countries like the United states and thus, prompted the development of alternatives.

Boron compounds are effective against timber rotting fungi and termites. However, it is effective only against green timber. This is because, other kinds of timber have low moisture content and thus, cannot easily diffuse the preservative. Since the preservative is not chemically fixed within the timber, boron treated timber is not used for outdoor use where it is exposed to prolonged rain.

- **Organic Solvent Type Preservatives**

Organic solvent preservatives can be applied by vacuum/pressure impregnation treatments. They do not cause any change in the moisture content or the dimension of the timber. They have good penetration and they are very effective against fungal attacks. They are non-corrosive and most types can be painted over when the solvent has evaporated. They contain ingredients of low water solubility that are dissolved in volatile solvents such as white spirit or solvent naphtha that evaporate, leaving the fungicide and insecticide in the timber.

Application of Preservatives:

Various methods can be used for the application of preservatives. For any chemical protection, a suitable concentration of the appropriate preservative must be applied. The use of a wrong type of preservative or a low concentration will lead to failure and mistrust. If treated timber is to be used in the open, then non-leachable preservatives should be used.

There are many traditional timber treatments used in India. One such is the application of cashew shell oil, which has a palliative effect. Another method is to apply saturated saltwater on timber. For the timber idols in temples, special preparation for treatment is done using various vegetable additives.

- **Brushing And Spraying**

Brushing and spraying of timber are rarely carried out as a preservative treatment. These methods have only a temporary effect, because of the very low penetration of the preservatives. The zone of timber can be easily broken by cutting, drilling or abrasion.

- **Open–Tank Method**

A simple method that has a good outcome and is economical is the open-tank method. Timber cut to required sizes is soaked in a solution of water-soluble preservatives for a sufficient period of time. The solution gets into the timber by diffusion through the ends and sides. The duration of treatment depends mainly on the kind of preservative chosen, the timber species, and the condition of timber. The size of the tank is determined by the length of the piece to be treated. Application of enamel paint is not a preservative treatment. Its only advantage is that it repels water.

- **Pressure Treatment**

Pressure treatment of timber is carried out either with water based preservatives or with creosote. It is expensive but efficient. The material must be air dried to ensure the necessary penetration, for the pressure treatment. The treatment is done in a pressure plant equipped with pressure cylinders, gauges, storage tanks, vacuum and pressure pumps. The preservative is forced into the timber by means of the pressurized cylinder. Pressure treatment creates a shell of protection around a piece of lumber – the outermost half inch or so is infused with the preservative, but the center of has little or none. For this reason, if you cut a piece of pressure treated wood, you should apply timber preservatives to the surfaces exposed by the timber.

Untreated timber deteriorates quickly when exposed outdoors. In their natural unfinished state, the timber is more prone to fungal and insect attacks. This is why timber preservation or treatment becomes a vital part in construction. One should carefully choose from the different types of timber treatments available, according to the purpose intended for the wood. Checking the quality of timber after the treatment is also essential during construction to ensure that it is safe from rots and insect attacks.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of timber defects. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Applied Science in Building

Teaching Strategies
Students engage in brainstorming exercise to discover applied science in building.
They then are allowed to design guiding questions that will enable them to conduct research on applied science in building.
Discuss in groups on the research findings.
Teacher introduces the lesson to student's on defining applied science in building.

Learning Strategies
Activity 1: Brainstorming activity to define applied science in building.
Activity 2: Conduct research on define applied science in building.
Activity 3: Discussions and presentation of research findings.

Resources
Define applied science in Building tutorial
Building Construction PDF, Building construction text book

Lesson 2: The Components of Applied Science

Teaching Strategies
Students engage in brainstorming exercise to discover the components of applied Science.
They then are allowed to design guiding questions that will enable them to conduct research on the components of applied science.
Discuss in groups on the research findings.
Teacher introduces students to the components of applied science.

Learning Strategies
Activity 1: Brainstorming activity on the components of applied science.
Activity 2: Conduct research on the components of applied science.
Activity 3: Discussions and presentation of research findings.

Resources
The components of Applied Science tutorials
Building Construction PDF, Building construction textbook.

Lesson 3: Types of Defects on Timber

Teaching Strategies
Students engage in brainstorming exercise to discover types of defects on timber.
They then are allowed to design guiding questions that will enable them to conduct research on types of defects on timber.
Discuss in groups on the research findings.
Teacher introduces students to the types of defects on timber.

Learning Strategies
Activity 1: Brainstorming activity on the types of defects on timber.
Activity 2: Conduct research on the types of defects on timber.
Activity 3: Discussions and presentation of research findings types of defects on timber.

Resources
Types of defects on timber tutorials and practical lesson
Building construction Text books, Building textbooks on PDF

Lesson 4: Methods of Timber Treatment

Teaching Strategies
Students engage in brainstorming exercise to discover methods of timber treatment.
They then are allowed to design guiding questions that will enable them to conduct research on methods of timber treatment.
Discuss in groups on the research findings methods of timber treatment.
Teacher introduces the lesson to students on methods of timber treatment.

Learning Strategies
Activity 1: Brainstorming activity on methods of timber treatment.
Activity 2: Conduct research on methods of timber treatment.
Activity 3: Discussions and presentation of research findings the methods of timber treatment

Resources
Methods of timber treatment tutorials
Building construction Text books, Building textbooks on PDF

STEAM Activity Students work in groups to create simple chemicals using patrol or salt water to treat timber.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to understand the fundamentals of applied science in building.
Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Define applied science in building
2. The components of applied science
3. The types defects on timber

Performance Assessment Scoring
Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1.Define Applied Science in Building	Define applied science in building very well with specific examples.	Define applied science in building very well.	Adequately define applied science in building.	Poorly define applied science in building.
2.Identify and explain the components of applied science.	Exceptionally identify and explain the components of applied science.	Identify and explain the components of applied science very well	Adequately identify and explain the components of applied science.	Poorly identify and explain the components of applied science.
3.Name and explain the types defects on timber	Name and explain all the types defects on timber using pictures	Name and explain all the types defects on timber	Name and explain some types defects on timber	Name and explain a few types defects on timber

UNIT 1. Building Technology

Content Standard 3.1 Investigate the history and theory of buildings and analyse the components and systems of buildings, occupational health and safety procedures, the properties of building materials and the processes in which those materials and equipment are used according to industry standards.

Benchmark 12.3.1.2 Apply and analyse building project management.

Topic 2: Building Project Management

Learning Objectives

By the end of this topic, the students will be able to;

- Analyse the successful principles and processes of project management.
- Analyse the roles of project manager and site supervisor.

Essential Questions:

1. What is successful building project management?
2. What are the principles and processes of successful project management?
3. What are the roles of project manager and site supervisor?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
The principles and processes of a project.	Apply and analyse the principles of building project management.	Responsibly adapt to new concepts of leadership in project management	Appreciate the principles of building project and management.

Content Background

Project Management is about making things happen. Building project management is the successful accomplishment of building project management tasks that are involved in the fundamental aspects of building system, management team and specialised expertise in managing projects in win –win situation. In order to be successful in project management we need to consider certain factors and measures as follows; management skills and techniques, principal and processes in project management. Besides these, we explore the roles of project manager and site supervisor administering the construction project.

What Are the Principles of Project Management?

The principles of project management are the fundamental rules that should be followed for the successful management of projects. The principles that successful project managers follow are;

- Formal project management structure,
- Invested and engaged project sponsor,
- Clear and objective goals and outcomes,
- Documented roles and responsibilities,
- Strong change management,
- Risk management,
- Mature value delivery capabilities,
- Performance management baseline,
- Communication plan.

Let's take a look at each of these in a bit more detail.

1. Formal structure
Projects need to have a formalised structure, including processes, procedures, and tools. If you've ever tried to complete a project without a formalised structure ("off the books"), you know how hard it can be to control it and provide the attention it deserves. A project should have a project charter, project plan, and a designated project team to successfully prioritise and manage the project.

2. Project sponsor
An effective project sponsor is critical to the success of a project. Sponsors champion your project and act as a spokesperson to other executives. Having an engaged sponsor makes it easier to communicate progress, escalate issues to overcome roadblocks, and guide stakeholders through decision-making processes.

3. Goals and outcomes
Without precise requirements and approval criteria, it will be difficult to measure a project's success. You may think that your final product does everything requested, only to have the customer or user complain that you left out a critical component. The most common factor behind failed projects is a lack of clear goals. Project requirements and approval criteria should be determined and documented at the beginning of the project. These must be reviewed and approved by all key stakeholders, including the sponsor and customer.

4. Roles and responsibilities
Two forms should be used to document and define the roles and responsibilities of everyone involved with a project. For project team members, RACI or RASCI is used to determine duties and expectations. RASCI stands for:

- R: Responsible
- A: Accountable
- S: Sign-off authority (not always used)
- C: Consulted
- I: Involved

In a RACI chart, team members are listed along the top, with tasks along the sides. Each member is assigned a letter (R, A, C, and I) according to their role for each job. A stakeholder register documents stakeholders outside the primary team, as well as important information such as the following:

- Communication preferences (type and frequency)
- Contact information
- Level of influence on the project
- Engagement level with the project
- Their role within the company
- Other relevant details or notes

5. Management of project changes
A project needs a well-defined scope to ensure the outcome meets customer expectations. Without strong change management, a project could suffer from scope creep and gradually grow beyond the initial project guidelines. To give an example, team members or stakeholders may want to add additional features to a product. However, if you don't carefully control changes, you could end up with a great product that costs twice what you expected and is delivered six months late.

6. Risk management
Since we cannot execute projects in a bubble, they all face some risks. Risk can affect your resources, technology, or processes. It's important to manage risk to minimise or eliminate its impact on your projects. This involves identifying, evaluating, and monitoring risks and deciding upon action plans to implement if they occur.

7. Value delivery capabilities
Your value delivery capabilities are the project tools, processes, and procedures that help you deliver value to your customers. This can include your project systems, like your scheduling software. If you have established and tested approaches for delivering successful projects, you'll be better equipped than if you're starting from scratch. The more mature your processes and procedures are, the more likely your project will be a success.

8. Performance management baseline
Projects typically have three basic components: cost, schedule, and scope. Each of these components should have a baseline or plan against which performance can be measured. When these baselines are integrated, it's called a performance management baseline — then, if you have a change in any one of these components, its impact will be reflected in the others.
Say you have a scope change. With your performance management baseline, you can see how this will impact your project schedule and cost, allowing you to better monitor the overall effect of changes on a project. A performance management baseline improves decision-making, as you can view the whole picture and identify all impacts of potential decisions.

9. Communication
If you've worked in project management for a while, you may have heard the saying that project management is 90% communication. A project's success requires communication of project activities, risks, issues, and status, both within the project team and with other stakeholders. Communication is essential for a variety of reasons, including:

- Keeping stakeholders engaged
- Coordinating tasks and schedules
- Decision-making and problem-solving
- Identifying and resolving conflicts
- Escalating risks and issues

The Project manager
The art of project management is strongly influenced by the line of work. In some areas of work, project management is a full-time job, overseeing large teams and multiple, complex projects. Whereas in others, teams are small and task distribution is pretty straightforward.
When it comes to managing creative work, the project manager is often also a team lead—and a team mediator. When everybody has ideas to contribute, managing a creative team requires the team leader to assume the role of a funnel. The team pours their ideas out and team leader need to combine all of them into something that makes sense.
These ideas aren't always compatible, so finding a common ground can be difficult. One needs to make sure that stakeholders have a say during the development phase and visibility throughout the process, but you also need to make sure the project is finished on time.

Poor planning can doom a project before work even begins. Changing expectations, shrinking budgets, and frustrating miscommunications can derail even the simplest project—and make life stressful for everyone involved.
A thorough project plan can prevent scope creep, overblown budgets, and missed goals. But actually sitting down and planning a project can be an overwhelming task. How does one accurately predict how long tasks will take? How does one translate stakeholder expectations into concrete deliverables? What if something goes wrong?
What is needed to create a successful project management plan?

Essential Components of a Project Management Plan

A thorough project plan includes these elements:

- **Project Definition Statement:** This is the 'what' and 'why' of your project: a short statement summarising the purpose, goals, and final deliverable(s).
- **Execution Strategy:** Explain the 'how' of your project. What methodology will you use? Will delivery happen in a single launch, or released in stages?
- **Scope:** What is (and isn't) included in your project? Include your work breakdown structure and key deliverables.
- **Schedule:** Depending on how well defined your project is, this can be either a high-level overview of when specific items will be completed, or it can include your detailed Gantt chart complete with milestones and delivery dates.
- **Organisation Chart:** An overview of the hierarchy of the project team, roles, and responsibilities. If the project involves multiple teams or departments, this should cover how those teams will work together, who the stakeholders are, and who's leading each deliverable.
- **RACI Chart:** This chart helps the team leader determine specifically *who* will do *what* for your project. It's a matrix of all a project's activities, paired with all the roles involved, including who's Responsible (assigned to complete the work), Accountable (has yes/no/veto power), Consulted (needs to approve or contribute), and Informed (needs to know about the action or decision). At each intersection of activity and role, a specific person is assigned for each role.

A RACI chart example

Here's a visual to illustrate the concept:

Step	Project Initiation	Project Executive	Project Manager	Business Analyst	Technical Architect	Application Developers
1	Task 1	C	A/R	C	I	I
2	Task 2	A	I	R	C	I
3	Task 3	A	I	R	C	I
4	Task 4	C	A	I	R	I

Figure 1.2a: A RACI Chart example
Source: https://www.teamgantt.com/signup?utm_source=What-is-a-gantt-chart&utm_medium=popup&utm_campaign=Top%20Blog%20Posts

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of building project management. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Building Project Management

Teaching Strategies
Students engage in brainstorming exercise to discover building project management.
They then are allowed to design guiding questions that will enable them to conduct research on successful building project management.
Discuss in groups on the research findings on building project management.
Teacher introduces lesson to students on building project management.

Learning Strategies
Activity 1: Brainstorming activity on building project management.
Activity 2: Conduct research on building project management.
Activity 3: Discussions and presentation of research findings on building project management.

Resources
Successful building project management tutorials.
Construction Management text books, Successful project management e-book,

Lesson 2: Principles and Processes of Project Management

Teaching Strategies
Engage students in brainstorming of principles and processes of project management.
Engage students in the discussion principles and processes of project management.
Teacher introduces students to the principles and processes of project management.

Learning Strategies
Activity 1: Brainstorming activity on principles and processes of project management.
Activity 2: Conduct research on principles and processes of project management.
Activity 3: Discussions and presentation of research findings principles and processes of project management.

Resources
Successful building project management tutorials
Construction Management text books, Successful project management e-book,

Lesson 3: The Roles of Project Manager and Site Supervisor

Teaching Strategies
Engage students in brainstorming of the roles of project manager and site supervisor.
Engage students in discussion the roles of project manager and site supervisor.
Teacher introduces students to the roles of project manager and site supervisor.

Learning Strategies
Activity 1: Brainstorming activity on the roles of project manager and site supervisor.
Activity 2: Conduct research on the roles of project manager and site supervisor.
Activity 3: Discussions and presentation of research findings the roles of project manager and site supervisor.

Resources
Successful building project management textbook.
Construction project management textbook.

STEAM Activity Students work in groups to create an activity incorporating the use of CAD.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to successful building project management. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Define successful building project management.
2. Analyse the principles and processes of project management.
3. Analyse and describe the roles of project manager and site supervisor.

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
Analyse building project management	Analyse building project management competently with clear examples of each stage.	Analyse building project management competently.	Analyse building project management partially.	Analyse building project management poorly.
Analyse the principles and processes of project management	Analyse the principles and processes of project management competently.	Analyse the principles and processes of project management satisfactorily.	Analyse the principles and processes of project management partially.	Analyse the principles and processes of project management poorly.
Analyse and describe the roles of project manager and site supervisor	Analyse and describe the roles of project manager and site supervisor using a flow chart.	Analyse and describe the roles of project manager and site supervisor	Analyse and describe the roles of project manager and site supervisor partially with no examples.	Analyse and describe the roles of project manager and site supervisor poorly.

UNIT 1: Building Technology

Content Standard 3.1 Investigate the history and theory of buildings and analyse the components and systems of buildings, occupational health and safety procedures, the properties of building materials and the processes in which those materials and equipment are used according to industry standards.

Benchmark 12.3.1.3 Practice Auto CAD program in designing structure.

Topic 3: AutoCAD Program in Building

Learning Objectives

By the end of this topic, the students will be able to;

- Investigate different types of AutoCAD program.
- Apply correct methods/steps of downloading Autodesk software.
- Apply correct method of designing domestic building using Autodesk program of a two-bed room house (floor plan, front/side elevations)

Essential Questions:

1. How do we practice AutoCAD program in Building?
2. What are the types of AutoCAD program?
3. What are the methods used to download AutoCAD/Autodesk software?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
AutoCAD program in Building	Practice to be competent in designing using CAD.	Perseverance in using CAD to design.	Value the importance of using CAD as software for competence.

Content Background

Practice AutoCAD program in Building

Practice AutoCAD program in building is the practical applications of AutoCAD software program that are suitable to design building plan (floor plan, front & side elevations) before construction begin. It is the practical Application on how the AutoCAD is used from the basic steps of sketching a plan to an Advance drawing. Besides these, teacher/Instructor will Identify different types of AutoCAD program, apply correct methods to download and install AutoCAD software and how to use these softwares to design domestic building of two-bedroom house.

AutoCAD can create any 2D drawing and 3D model or construction that can be drawn using AUTOCAD software. The program also allows the user to group or layer objects, keep objects in a database for future use, and manipulate properties of objects, such as size, shape, and location.

Computer-aided design software lets you design 2-D and 3-D drawings and models, replacing traditional pencil-and-paper drafting to create blueprints with easily altered electronic files.

- AutoCAD program in Building
- Types of AutoCAD program
- Methods used to download AutoCAD/Autodesk software
- Designing Domestic building of two Bed room house

AutoCAD program in Building- AutoCAD program in building is the Automatic computer Aided-drafting program used to design a building plan or structures in 2D or 3D model using computers. AutoCAD can create any 2D drawing and 3D model or construction that can be drawn by hand. The program also allows the user to group or layer objects, keep objects in a database for future use, and manipulate properties of objects, such as size, shape, and location.
Computer-aided design software lets you design 2-D and 3-D drawings and models, replacing traditional pencil-and-paper drafting to create blueprints with easily altered electronic files

Types of AutoCAD program- There are different types of AutoCAD program used to design structures, music, and animation etc. using CAD program. Teacher will be exploring the software programs that are suitable for designing buildings or structures to equip students with vital skills to design and construct structures. Below are the suitable AutoCAD SOFTWARE to be used;

1. AutoCAD
2. Free CAD
3. Autodesk Revit
4. Autodesk Design Review
5. Methods used to download and install AutoCAD/Autodesk software- methods used to download and Install AutoCAD program has been summarised below;

AutoCAD Free Trial Versions & AutoCAD LT Educational Version
1. Go to the Autodesk Education Community.
2. Choose AutoCAD.
3. Create an Autodesk account.
4. Then, click DOWNLOAD NOW.
5. Select the desired version, your operating system, and your preferred language.

Install AutoCAD
Step 1: Go onto the AUTODESK website. Access the Autodesk website.
Step 2: Students and Educators.
Step 3: Access free software.
Step 4: Sign in to your Autodesk account.
Step 5: Downloading AutoCAD.
Step 6: License service agreement.

Step 7: Autodesk Download Manager.
Step 8: Downloading Software.

Designing Domestic building plan of two Bedroom house.
Create a Sketch

1. To create a sketch in a part or assembly file, do one of the following: On the 3D Model tab, click Start 2D Sketch or Start 3D Sketch. Right-click in the browser and choose New Sketch or New 3D Sketch.

2. To create a sketch in a drawing file, click Place Views tab > Start Sketch
https://designscad.com/downloads/two-bedroom-house-2d-dwg-block-autocad/

An example of AUTO CAD image

House-Ground Floor Plan 2D 418

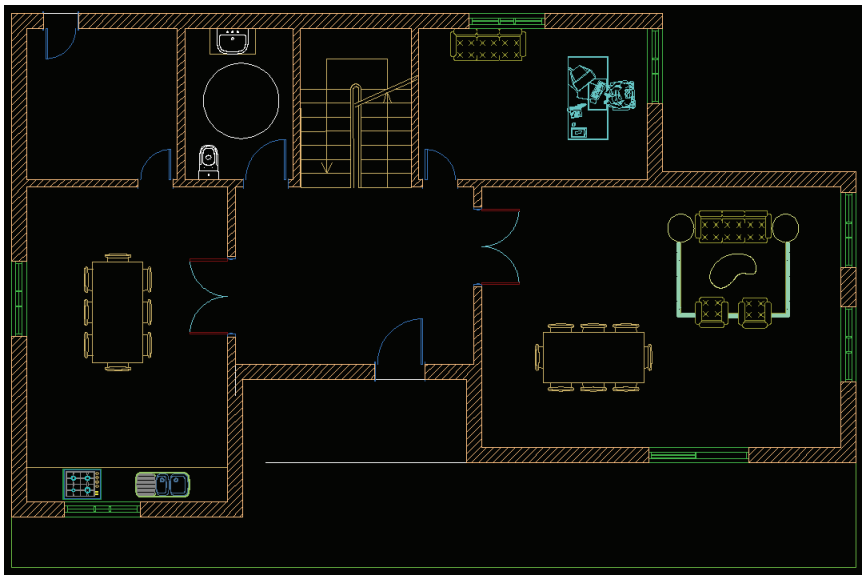


Figure 1.2a: House-Ground Floor Plan 2D 418
Source: https://designscad.com/downloads/two-bedroom-house-2d-dwg-block-autocad/

House First Floor Plan 2D 418

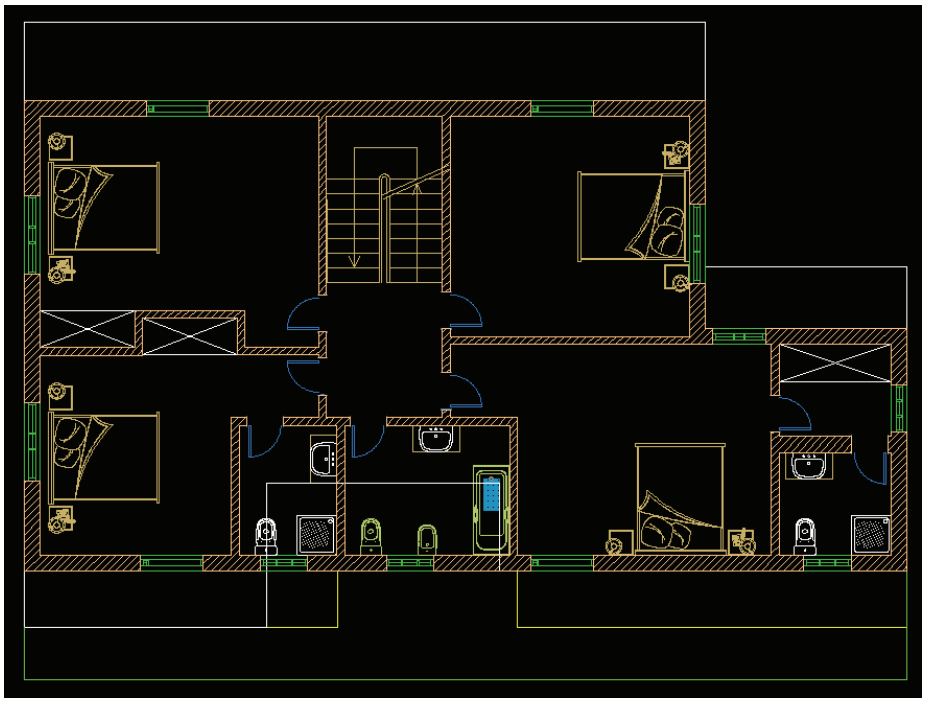


Figure 1.3b: House First Floor Plan 2D 418
Source: https://designscad.com/downloads/two-bedroom-house-2d-dwg-block-autocad/

House Elevation 2D 418

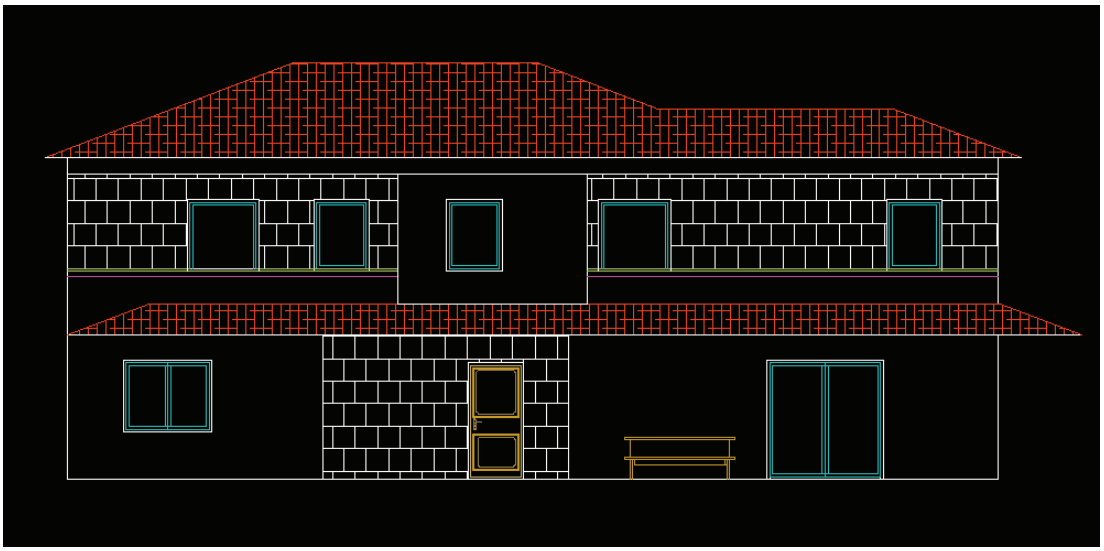


Figure 1.3c: House Elevation 2D 418
Source: https://designscad.com/downloads/two-bedroom-house-2d-dwg-block-autocad/

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to enable students to practice AutoCAD program in building. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1 Purpose of AutoCAD Program

Teaching Strategies

Students engage in brainstorming exercise to understand the purpose of AutoCAD program in building.
They then are allowed to design guiding questions that will enable them to conduct research to define AutoCAD program in building.
Discuss in groups on the research findings on the practices of AutoCAD program in building.
Teacher introduces to students the lesson on defining AutoCAD program in building.

Learning Strategies

Activity 1: Brainstorming activity to define AutoCAD program in building.
Activity 2: Conduct research to define AutoCAD program in building.
Activity 3: Discussions and presentation of research findings practice AutoCAD program in building.

Resources

AutoCAD software manual Books
Autodesk software e- Book
Autodesk software 2020 version

Lesson 2: Types of AutoCAD Program

Teaching Strategies
Engage students in brainstorming of types of AutoCAD program.
Engage students in the discussion types of AutoCAD program.
Teacher introduces lesson to students on types of AutoCAD program.

Learning Strategies
Activity 1: Brainstorming activity on types of AutoCAD program.
Activity 2: Conduct research on types of AutoCAD program.
Activity 3: Discussions and presentation of research findings the types of AutoCAD program.

Resources
AutoCAD software manual Books
Autodesk software e- Book
Autodesk software2020 version

Lesson 3: Methods of Downloading AutoCAD/Autodesk Software

Teaching Strategies
Engage students in brainstorming of methods of downloading AutoCAD/ Autodesk software program.
Engage students in the discussion methods of downloading AutoCAD/ Autodesk software program.
Teacher introduces students to methods of downloading AutoCAD/ Autodesk software program.

Learning Strategies
Activity 1: Brainstorming activity methods of downloading & install AutoCAD/ Autodesk software.
Activity 2: Conduct research on methods of downloading AutoCAD/ Autodesk software Program.
Activity 3: Discussions and presentation of research findings downloading & install AutoCAD/ Autodesk software.

Resources
AutoCAD software manual Books
Autodesk software e- Book
Autodesk software2020 version

NOTE: This is a Practical lesson to be imparted to students in the drafting room/lab and should be taught on how to sketch building plans (floor plan, front &side elevation).

Lesson 4: Designing Domestic Building of Two Bed Room House using Autodesk Software

Teaching Strategies
Engage students in brainstorming about designing domestic building of a two-bedroom house using Autodesk software.
Engage students in the discussion designing domestic building of two-bedroom house using Autodesk software.
Teacher introduces students to methods of designing domestic building of a two-bedroom house using Autodesk software.

Learning Strategies
Conduct research with guiding questions that will lead to discovering methods of designing domestic building of two-bedroom house using Autodesk software.

Activity 1: Brainstorming activity on designing domestic building of two bed room house using Autodesk software.
Activity 2: Conduct research on designing domestic building of two bed room house using Autodesk software.
Activity 3: Discussions and presentation of research findings methods of designing domestic building of two-bed room house using Autodesk software.

Resources
AutoCAD software manual Books
Autodesk software e- Book
Autodesk software 2020 version

NOTE: This is a Practical lesson to be imparted to students in the drafting room/lab and should be taught on how to sketch building plans (floor plan, front &side elevation).

STEAM Activity Students work in groups to designing domestic building of two bed room house using Autodesk software (Model of two-bedroom house Gable roof)

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to practice AutoCAD program in building. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Define AutoCAD program
2. Identify different types of AutoCAD program
3. Apply correct methods/steps of downloading and Installing Autodesk software
4. Apply correct method of designing domestic building using Autodesk program of a two bed room house (floor plan, front/side elevations)

Performance Assessment Scoring
Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
Define AutoCAD program	Excellently define AutoCAD program	Define AutoCAD program very well.	Partially define AutoCAD program	Cannot define AutoCAD program
Identify different types of AutoCAD program	Excellently identify different types of AutoCAD program	Identify different types of AutoCAD program very well,	Partially identify different types of AutoCAD program	Identify different types of AutoCAD program
Apply correct methods/steps of downloading and Installing AutoCAD software	Excellently apply correct methods/steps of downloading and Installing AutoCAD software	Very well apply correct methods/steps of downloading and Installing AutoCAD software	Partially apply correct methods/steps of downloading and Installing AutoCAD software	Cannot apply correct methods/steps of downloading and Installing AutoCAD software
Apply correct method of designing domestic building using AutoCAD program of a two-bedroom house (floor plan, front/side elevations	Excellently apply correct method of designing domestic building using AutoCAD program of a two-bedroom house (floor plan, front/side elevations	Apply very well the correct method of designing domestic building using AutoCAD program of a two-bedroom house (floor plan, front/side elevations	Partially apply correct method of designing domestic building using AutoCAD program of a two-bedroom house (floor plan, front/side elevations	Cannot apply correct method of designing domestic building using AutoCAD program of a two-bedroom house (floor plan, front/side elevations

UNIT 1. Building Technology

Content Standard 3.1 Investigate the history and theory of buildings and analyse the components and systems of buildings, occupational health and safety procedures, the properties of building materials and the processes in which those materials and equipment are used according to industry standards.

Benchmark 12.3.1.4 Apply fundamental of OHS On- Site in building construction

Topic 4: OHS on-site in Construction

Learning Objectives

By the end of this topic, the students will be able to;

- Analyse the types of OHS on-site and comprehend Hazard communication on site
- Define basic steps on setting out basic scaffolding
- Apply correct procedures on using PPE use on-site
- Analyse the correct procedures on handling materials during construction

Essential Questions:

1. What are the types of OHS On-Site?
2. What is hazard communication On–site?
3. What are OHS applied on setting out scaffold?
4. What are the common Personal Protective Equipment (PPE) used On–Site?
5. How is OHS applied when handling materials during construction?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge:	Skills:	Attitudes:	Values:
Types of OHS On-Site and Hazard communication on site	Taking care and applying OHS	Responsibly apply safety practices in consideration of self, others, equipment and the environment.	Safety cautious when on site

Content Background

Occupational Health and safety (OHS) on a construction site is health and safety practices that are involved in the actual construction when working with equipment and tools, working individually or in groups. That involves hazard communication on-site, identifications of hazards Personal Protective equipment (PPE) use on site, material handling safety and safe working practices in all tasks to be carried out.

Figure 1.4a: OHS on Construction Site
Source: https://www.ask-ehs.com/blog/occupational-health-safety-construction-industry/

Besides these, OHS on setting scaffolding must be reviewed to be aware the safety measures that are applied when setting out scaffold.

The construction industry is one of the most employment-generating industries therefore, attention to matters of occupational health and safety of workers and employees in these important. since construction activities are very diverse and complex, these activities can be observed at risk. Therefore, the effects and consequences of noncompliance events for event safety and interest groups would be costly and sometimes irrecoverable.

Hazard communication on site

Construction accidents can cause economic and social damage to individuals and to society. The result causes of construction accidents, impacts the financial and human resources that are part of the community which economic production factors and the pressures and psychological distress that injured workers and their families and society would prevent. Thus, although a good understanding of the extent and pattern of accidents in the construction industry in the world but there is a review of the full range of management factors and individual workshop.

Occupational Health and Safety – Construction Industry

Construction industry, often termed as 'high-risk', has a significant impact on the health and safety of the workers. Though it is common to see a construction worker work at heights with equipment and building materials, these scenarios are plagued by potentially dangerous situations and poor working conditions. They are exposed to hazards that are difficult to quantify. Different job sites have different procedures and conditions – identifying the source(s) that poses challenges to Occupational Health and safety OHS of the workforce remains critical. Apart from fatalities, there are workers who suffer from work-related health hazard and suffer non-fatal injuries. The scale and severity should be enough for the stakeholders to ensure the safety and health of their workforce.
To promote and maintain safety in the workplace, knowledge about the primary causes of accidents help assess the level of safety.

Figure 1.4b: Primary hazards in a Construction Industry
Source: https://www.ask-ehs.com/blog/occupational-health-safety-construction-industry/

Primary hazards in a Construction Industry

Health and safety is a multi-step process which includes the workers at the site, nearby people, supervisors, managers etc. **Effective management of activities and competent site supervision are essence in maintaining healthy and safe conditions.** In construction activities especially, greater the risk, greater the degree of hazard control and supervision is required.
Before the work starts, competent safety personnel should:

- Identify and devise risks and their management strategy
- Ensure training – site specific and job-specific
- See that the workforce has access to PPEs and know how to use them
-
- Observe, inspect and report that agreed safe work methods are implemented, site-wide

Upon arrival at the site, employees, contractors and visitors should receive information about the site hazards and steps taken to control those risks. Also, briefing them about the hazards, PPEs, welfare facilities and site rules can ensure that the work in progress is smooth and efficient.

Much of the construction works include scaffolds, and collective fall prevention becomes a necessity. **They must be equipped with guardrails, toe boards and brick guards. Personal prevention such as podium steps, can be used to prevent falls while working at height.** If the weather seems inappropriate, emergency and rescue procedures should be well-defined in advance to avoid adverse effect on workers. All working platforms must be checked for safe conditions and should be inspected for slip and trip hazards. Other preventive measures that make safe conditions certain are:

1. Regular inspections of the site and the machineries to detect hazards in the first place
2. Selection of the right PPE (respirators, helmets) to avoid inhalation of asbestos, dust and fibre with provision for appropriate trainings.
3. Avoid repetitive motions and use long-handled tools to reduce the need of bending down.
4. Make sure that workers are protected from wet concrete (provide PPE and proper washing
   facilities)
5. Ensure safe dismantling procedures are in place
6. Site traffic (for vehicles or moving equipment) should be planned and managed to avoid fatalities onsite
7. Forklifts should be used carefully in material handling
8. Confirm site wide **implementation**
9. Pneumatic silencers should be used to reduce noise; electrical hazards (faulty wiring) must be checked and firefighting equipment should be in place

Incorporating health and safety checks can keep a tab on the worker progress and well-being. Risk assessments, **health and safety trainings**, corrective and preventive measures all should be the part of the checklist of a construction company.

Occupational health and safety in the construction industry is a system for monitoring occupational health issues in the construction industry. It is dealt with application of labor standards in the workplace. There are numerous OHS inspection difficulties that are common to the construction industry and other industries, but there are also many issues that are unique to this sector.
Occupational health issues in the construction industry are very common – what an inspection should aim to do is educate their workers on important ideas and OHS concerns pertaining to the building sector. **Visitor induction training** programs are key to performing such roles with efficacy. In addition, improve some competencies that they will both need to fulfill their roles, which for managers primarily entail overseeing an OHS inspection program in the construction industry. For the field inspectors, it can entail completing on-site OSH inspection visits.
This is useful to other people working in OHS in the construction sector, along with managers in labour inspection offices and field inspectors.

These could be the internal staff of businesses in the construction sector, including managers, OSH specialists, supervisors, or workers, as well as trainers and advisers on OSH issues who work for the government, employers', and workers' organizations, professional or industrial bodies, training institutions, or unions.

The mission of contributing to safe working conditions, participating in the detection of risk and danger is a matter for all; so employees must also communicate hazardous conditions when they encounter. It is good to be proactive instead of reactive in terms of health. Ensuring occupational health and safety in the construction industry is crucial for the well-being of workers and the success of construction projects. Therefore, it is important to implement effective occupational health and safety measures and promote a safety culture in the construction industry.

Personal Protective Equipment (PPE) use On –Site

In construction, different site personnel have its own responsibilities. These employees are working together to achieve a common goal which is to complete the construction project that they are involved in. From blue collar to white collar job responsibilities, each had their own contribution to get the project done. Site construction involves a vigorous activity. These activities are often prone to accidents, risks and maybe hazard to the lives of the workers involved in a construction project. Nevertheless, the safety of each individual working in a construction environment is the primary priority to be achieved.

Just like safety in structural design is a must, work environmental protection should also be taken seriously. In doing so, each worker's PPE or Personal Protective Equipment should be strictly implemented at the site at any cost in any given time. To satisfy PPE standards, each worker should wear proper construction attire to reduce or at least prevent and protect them against the safety risks to be able to achieve Health and Safety Environment throughout the course of the construction.

Here are the lists of Personal Protective Equipment (PPE) in Construction that every construction personnel should observe:

1. Head Protection/Safety Helmets/Hard Hat

In construction worksite, there is a higher chance of possible head injury due to falling debris and other related accidents. Site Engineers and all construction personnel involved in site activities should wear a safety helmet or hard hat before entering the work site and it should be 'wear at all times'.

The safety helmets/hard hat shall meet the specifications in accordance to international standards. Safety helmets/hard hats should be inspected by the safety officer to ensure that it is safe and reliable to use. It should be free from cracks and proper shock-absorbing lining of the helmet should be in good condition.

These are recommended head protections that meet the international standards. Color-coded hard hats are available according to usage.

Figure 1.4c: Head Protection/Safety Helmets/Hard HatSource: https://www.thestructuralworld.com/2019/05/09/personal-protective-equipment-ppe-in-construction/#google_vignette

2. Foot Protection/Safety Shoes

Safety shoes should be worn by all of the construction personnel at the worksite to protect their feet for possible injuries. The safety shoes to be used shall be determined according to potential hazards and according to the nature of work. It shall comply with the safety standard and specification. For worksite safety shoes with steel toe cap covering and steel sole should be considered, although an equivalent material is also acceptable as long as it follows the safety standards. If the personnel are working in electrical installation, non-contractive footwear shall be used.

These are recommended safety shoes that are approved by safety international standards.

Figure 1.4d: Foot Protection/Safety Shoes
Source: https://www.thestructuralworld.com/2019/05/09/personal-protective-equipment-ppe-in-construction/#google_vignette

3. Protective Clothing/Reflected Vests

Every construction personnel should wear adequate and suitable protective clothing to protect them from possible hazard due to weather changes, electricity, impacts, and other risks. For Site Engineers a reflected vest is recommended to maintain visibility when doing site inspections and other site activities.

These are recommended reflected vests that are approved by safety international standards.

Figure 1.4e: Protective Clothing/Reflected Vests
Source: https://www.thestructuralworld.com/2019/05/09/personal-protective-equipment-ppe-in-construction/#google_vignette

4. Eyes and Face Protections

Construction employees shall be provided with eye and face protection equipment when their job had a potential risk of exposing the eyes and face from hazard. They are the machines operators, welder, bar bender and the like. Those workers whose vision requires the use of medical spectacles shall be protected by eyeglasses with protected lenses, goggles that can be worn without disturbing their work activity.

Eyes and face protection equipment shall be free from structural and optical defects. Just like other PPE, it should also pass the required safety standards.

Figure 1.4f: Eyes and Face Protections
Source: https://www.thestructuralworld.com/2019/05/09/personal-protective-equipment-ppe-in-construction/#google_vignette

5. Hand Protection

All personnel handling rough, sharp and excessive coarse material such as reinforcement bars, rods, pre-cast concrete, toxic, electric and hot materials shall be protected by safety gloves. The material of these hand protections shall be suitable against the hazard of doing such activities. Site employees shall be protected by the different type of gloves according to their job description. For example, chrome leather gloves should be used when handling sandblasting and other materials. Gloves that are made of fabrics are used for handling rough materials. Insulated rubber gloves should be used by electricians.
The different types of safety gloves recommended by international standard.

Figure 1.4g: Hand Protection
Source: https://www.thestructuralworld.com/2019/05/09/personal-protective-equipment-ppe-in-construction/#google_vignette

6. Hearing Protection

In the event that noise levels in worksite are too much to handle, ear protected gear are also needed by the site personnel. Ear protected hazard inserted into the ear in the form of a headset, foam earplug and earmuffs shall be in accordance with international safety standards. Plain cotton to be placed in the ear just to block construction noise is prohibited to use.

The following are the hearing protection equipment that is recommended by international standard.

Figure 1.4h: Hearing Protection
Source: https://www.thestructuralworld.com/2019/05/09/personal-protective-equipment-ppe-in-construction/#google_vignette

7. Safety Belts/Safety Harness

Site employees working at an elevated level to about 2m or more shall be provided by safety harness or belts to protect them from accidental fall. Anchorage point of the safety harness shall be placed above the head of the worker and not less than 5 meters from the ground level. This point should be strong enough to carry a force of not less than 5000 pounds (2275kg). The material should be made of nylon or equivalent to at least 1cm thick. The hooks attached should be fitted with a double locking device that can be open only by pressing the two parts at the same time for safety purposes.

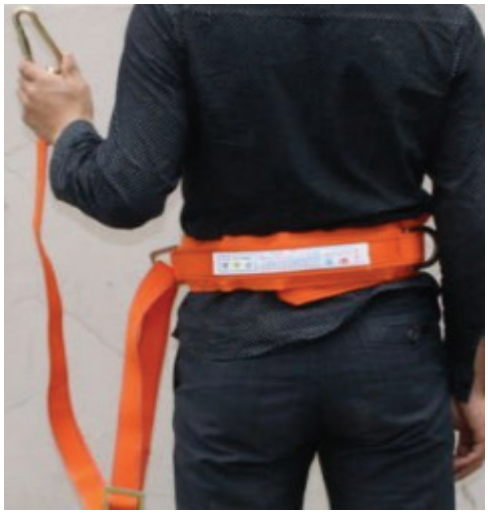


Figure 1.4i: Safety Belts/Safety Harness
Source: https://www.thestructuralworld.com/2019/05/09/personal-protective-equipment-ppe-in-construction/#google_vignette

PPE is a very important aspect to look at in site construction. Observing the above lists of personal protected equipment is a must in the construction site and it should be strictly observed at all times. This is to avoid hazards caused by physical, mechanical and chemical aspects to ensure for the construction team to create a safe and sound construction environment

OHS on setting scaffolding

A vast number of those in the construction industry use scaffolding on a daily basis. According to OSHA, nearly 65 percent of workers in the construction industry work on scaffolds frequently. From steel erectors to building equipment installers, bricklayers, window washers, carpenters, and painters, just to name a few, nearly 2.3 million construction workers frequently work on scaffolds. Construction sites are inherently unstable environments, with movement of workers, materials, etc. and changing landscapes of scaffold-related injuries. Following are some basic guidelines for workers who use scaffolds:

About Scaffolding

A scaffold is defined as an elevated, temporary work platform. The three basic types of scaffolds are:

- Supported scaffolds, which consist of one or more platforms supported by rigid, load-Bearing members, such as poles, legs, frames, outriggers, etc. Common types of supported scaffolds are frame, system, mobile (rolling), etc.
- Suspended scaffolds, which are one or more platforms suspended by ropes or other non-rigid, overhead support. Suspended scaffolds are often used when washing windows or to access bridges and other structures when overhead support is the best option.
- Other scaffolds, principally man lifts, cherry pickers, scissor lifts, etc., are sometimes thought of as vehicles or machinery but can be regarded as another type of supported scaffold.

Scaffolding Good Practices

Preventing Scaffolding Accidents

When using supported scaffolds:

- Prior to use, inspect the scaffold to ensure it has not been altered and is in safe working condition.
- Erected scaffolds and platforms should be inspected continuously by those using them.
- Exercise caution when entering or leaving a work platform.
- Do not overload scaffolds. Follow manufacturer's safe working load recommendations.
- Do not jump onto planks or platforms.
- Do not use ladders or makeshift devices to increase the working height of a scaffold.
- Do not plank guardrails to increase the height of a scaffold.
- Climb in access areas only, and use both hands.
- Where required, use proper personal fall arrest equipment, and use it prope

When using suspended scaffolds:

- Use all equipment and all devices in accordance with the manufacturer's instructions.
- Do not overload, modify, or substitute equipment.
- Before commencing work operations, preload wire rope and equipment with the working load, then retighten wire rope clips and recheck rigging to manufacturer's

working load, then retighten wire rope clips and recheck rigging to manufacturer's recommendations.

- Inspect all rigging equipment and suspended scaffold systems daily.
- Inspect wire rope during each ascent or descent for damage.
- Use care to prevent damage to equipment by corrosive or other damaging substances.
- Clean and service equipment regularly.
- Always maintain at least four (4) wraps of wire rope on drum type hoists.
- Do not join platforms unless the installation was designed for that purpose.
- Move suspended scaffolds horizontally only when they are not occupied.
- When rigging for another drop, ensure sufficient wire rope is available before moving the suspended scaffold system horizontally.

The most common scaffold hazards are:

- falls from elevation;
- collapse/overturning of the scaffold;
- being struck by falling tools, work materials, or debris; and
- electrocution, principally due to proximity of the scaffold to overhead power lines.

Materials Handling Safety in Construction

In the construction industry, the term 'material handling' refers to the delivery, movement, storage and control of materials and other products. This forms part of the logistics management of a project.

Types of plant used for material handling on site include; hydraulic excavators, telescopic handlers, cranes, forklift trucks, lifting devices, conveyor systems and so on.

From receipt and inspection of materials, through to storage, assembly and use, the material handling system should be well-coordinated and organised so that everyone on site is aware of how it works. When handling materials, safety should be the primary consideration. Pre-start inspections are critical, load limits should not be exceeded, method statements should be followed, and it may be necessary for a banksman to direct material movements around the site.

Figure 1.4j: Material handling
Source:
https://www.google.com/search?q=poster%20material%20handling%20safety

It is important to follow best practice guidelines when designing a material handling system for a construction project. For example:

- The proposed system of material handling should be defined in terms of needs, objectives and functional specification.
- Methods and processes should be standardised to avoid confusion.
- Unnecessary handling or movement should be reduced or eliminated.
- Working conditions and methods should have worker safety as the primary objective.
- Unit loads should be optimised, to reduce work and risk.
- Storage areas should be kept organised and clean, maximising density as much as possible and eliminating damage to materials.
- Sites should be kept safe, clean and easy to move around.
- Deliveries should be received and handled promptly.
- Site waste management plans should be created and maintained.
- Automated material handling technologies should be used where practicable.
- Safety equipment such as PPE should be available.

Incorrect manual handling is a common factor in work related injuries. This can be because of

- The weight of the item being handled
- The repetitive nature of the movement
- Where the item is moved to and from
- The posture of the individual. Any twisting, bending, stretching or other awkward position may exacerbate problems.

Safety for material handling gear means the proper fit and use of personal protection, to include, eye protection, steel toed boots, and other personal safety equipment. Material handling safety equipment included the proper tools should be used in moving material.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of OHS on a construction site. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Types of OHS On-Site Construction

Teaching Strategies
Students engage in brainstorming exercise to discover types of OHS on-site construction.
They then are allowed to design guiding questions that will enable them to conduct research on types of OHS on-site construction and legislations of different countries in regulation OHS on the construction sites.
Discussions in groups on the research findings.
Teacher introduces to students on building project management.

Learning Strategies
Activity 1: Brainstorming activity on types of OHS on-site construction.
Activity 2: Conduct research on types of OHS on-site construction and legislations of different countries in regulation OHS on the construction sites.
Activity 3: Discussions and presentation of research findings.

Resources
OHS Text books, Library resources
Construction Management text books,

Lesson 2: Hazard Communication On-Site

Teaching Strategies
Engage students in brainstorming of hazard communication on-site.
Engage students in the discussion of hazard communication on-site.
Teacher introduces students to hazard communication on-site.

Learning Strategies
Activity 1: Brainstorming activity on hazard communication on-site.
Activity 2: Conduct research hazard communication on-site.
Activity 3: Discussions and presentation of research findings.

Resources
OHS Text books, Library resources
Construction Management text books,

Lesson 3 OHS on Setting Scaffolding

Teaching Strategies
Engage students in brainstorming of OHS on setting scaffolding.
Engage students in the discussion of OHS on setting scaffolding.
Teacher introduces students to OHS on setting scaffolding.

Learning Strategies
Activity 1: Brainstorming activity on OHS on setting scaffolding.
Activity 2: Conduct research on OHS on setting scaffolding.
Activity 3: Discussions and presentation of research findings.

Resources
OHS Text books, Library resources
Construction Management text books,

Lesson 4: Personal Protective Equipment (PPE) Use On-Site

Teaching Strategies
Engage students in brainstorming of Personal Protective Equipment (PPE) use on-site.
Engage students in the discussion of Personal Protective Equipment (PPE) use on-site.
Teacher introduces students to OHS on setting scaffolding.

Learning Strategies

Conduct research with guiding questions that will lead to discovering Personal Protective Equipment (PPE) use on site.

Activity 1: Brainstorming activity on Personal Protective Equipment (PPE) use on-site.
Activity 2: Conduct research on Personal Protective Equipment (PPE) use on-site.
Activity 3: Discussions and presentation of research findings.

Resources
OHS Text books, Library resources
Construction Management text books,

Lesson 5: Material Handling Safety

Teaching Strategies
Engage students in brainstorming of material handling safety.
Engage students in the discussion of material handling safety.
Teacher introduces students to material handling safety.

Learning Strategies
Conduct research with guiding questions that will lead to discovering material handling safety.

Activity 1: Brainstorming activity on material handling safety.
Activity 2: Conduct research on material handling safety.
Activity 3: Discussions and presentation of research findings.

Resources
OHS Text books, Library resources
Construction Management text books,

STEAM Activity Students work in groups to create an activity incorporating concepts of OHS in construction.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to OHS on-site Construction. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Analyse the types of OHS on-site
2. Define the Hazard communication on-site.
3. Define basic steps on setting out basic scaffolding
4. Apply correct procedures on using PPE use on-site
5. Analyse the correct procedures on handling materials during construction

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
Analyse the types of OHS on-site	Exceptionally analyse the types of OHS on-site excellently	Very good analysis the types of OHS on-site very well.	Partially analyse the types of OHS on-site poorly	No analysis the types of OHS on-site very poorly
Define the Hazard communication on site	Define the hazard communication on-site excellently	Define the hazard communication on-site very well.	Define the hazard communication on site poorly	Define the hazard communication on-site very poorly
Define basic steps on setting out basic scaffolding	Define basic steps on setting out basic scaffolding excellently.	Define basic steps on setting out basic scaffolding	Define basic steps on setting out basic scaffolding	Define basic steps on setting out basic scaffolding
Apply correct procedures on using PPE use on-site	Apply correct procedures on using PPE use on-site very excellently.	Apply correct procedures on using PPE use on-site very well.	Apply correct procedures on using PPE use on-site poorly	Apply correct procedures on using PPE use on-site very poorly
Analyse the correct procedures on handling materials during construction	Analyse the correct procedures on handling materials during construction excellently.	Analyse the correct procedures on handling materials during construction very well.	poorly Analyse the correct procedures on handling materials during construction	Analyse the correct procedures on handling materials during construction very poorly.

UNIT 1: Building Technology

Content Standard 3.1 Investigate the history and theory of buildings and analyse the components and systems of buildings, occupational health and safety procedures, the properties of building materials and the processes in which those materials and equipment are used according to industry standards.

Benchmark 12.3.1.5 Explore and apply appropriate applied maths in building to estimate the cost of building.

Topic 5: Estimating Costs of Building

Learning Objectives

By the end of this topic, the students will be able to;

- Define building applied math.
- Apply correct methods or formulae to calculate substructure members.
- Apply correct methods and formulae to calculate superstructure formulae members.

Essential Questions:

1. What is building applied math?
2. What are the methods and formulae to calculate sub-structure?
3. What are the methods and formulae to calculate super-structure?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge:	Skills:	Attitudes:	Values:
Building Applied Math	Explore and apply building math	Participate and critically calculate substructure and superstructure members using correct formulae.	Appreciative and tolerance of learning building math

Content Background

A construction cost estimate is exactly what it sounds like: an estimate of the cost of building any kind of structure. Whether it's a simple building addition or a major piece of public infrastructure, people want to know the cost before they begin. For contractors, architects, and project managers alike, it's essential to understand how to estimate costs. Introduction to building applied math is basically to use the correct formulae to calculate the size of openings; doors and windows, stairs construction, wall framing material, and roof framing etc. to estimate the cost of materials in particular building. The estimation of material are grouped in two; formulae to calculate substructure members, superstructure members.

Every building—schools, libraries, houses, apartment complexes, movie theaters, is the product of mathematical principles applied to design and construction. Before construction workers can build a habitable structure, an architect has to design it. Geometry, algebra, and trigonometry all play a crucial role in architectural design. Architects apply these math forms to plan their blueprints or initial sketch designs. They also calculate the probability of issues the construction team could run into as they bring the design vision to life.
Since ancient times, architects have used geometric principles to plan the shapes and spatial forms of buildings. In 300 B.C., the Greek mathematician Euclid defined a mathematical law of nature called the Golden Ratio. For more than two thousand years, architects have used this formula to design proportions in buildings that look pleasing to the human eye and feel balanced. It is also known as the Golden Constant because it manifests literally everywhere. The Golden Ratio still serves as a basic geometric principle in architecture. You could even call it a timeless archetype, as it evokes in human beings a universal sense of harmony when they see or stand in a building designed with this principle. And perhaps not surprisingly, we see the Golden Ratio demonstrated throughout "architectures" of the natural world.

Calculating ratio is essential, as well, when it's time to construct a building from the architectural blueprints. For example, it's important to get the proportions right between the height and length of a roof. To do that, building professionals divide the length by the height to get the correct ratio.
The Pythagorean Theorem, formulated in the 6th century B.C., has also come into play for centuries to calculate the size and shape of a structure. This theorem enables builders to accurately measure right angles. It states that in a triangle the square of the hypotenuse (the long side opposite the right angle) is equal to the sum of the squares of the other two sides. The most remarkable ancient architecture of all may be the pyramids of Egypt, constructed between 2700 B.C. and 1700 B.C. Most of them were built and scaled at about a 51-degree angle. The Egyptians clearly and mysteriously possessed knowledge of geometry, as evidenced by the accuracy of pyramid construction. Just in case you're curious about the geometry and triangle mathematics that ancient Egyptians applied to build their pyramids. In the modern world, builders use math every day to do their work. Construction workers add, subtract, divide, multiply, and work with fractions. They measure the area, volume, length, and width. How much steel do they need for an office building? How much weight in books and furniture will the library floors need to bear? Even building a small single-family home calls for careful calculations of square footage, wall angles, roofs, and room sizes. How many square yards of carpet? How much water do you need to fill up a swimming pool?

In the real world of building construction there are many rich problems which can be used to build sense making and reasoning skills for students.
An example.

The Pythagorean Theorem is used extensively in designing and building structures, especially roofs. Gable roofs, for example, are made by placing two right triangles together. Specialized terms help to explain the triangle relationships in roof construction.

Terminology

The span is the length from the outside wall to the outside wall of a building. Because construction is often made up of multiple layers of wood, building plans often provided detailed descriptions to make clear where to begin or end measurements.

The RUN is one-half the span. Units of run are typically based on 12 inches.

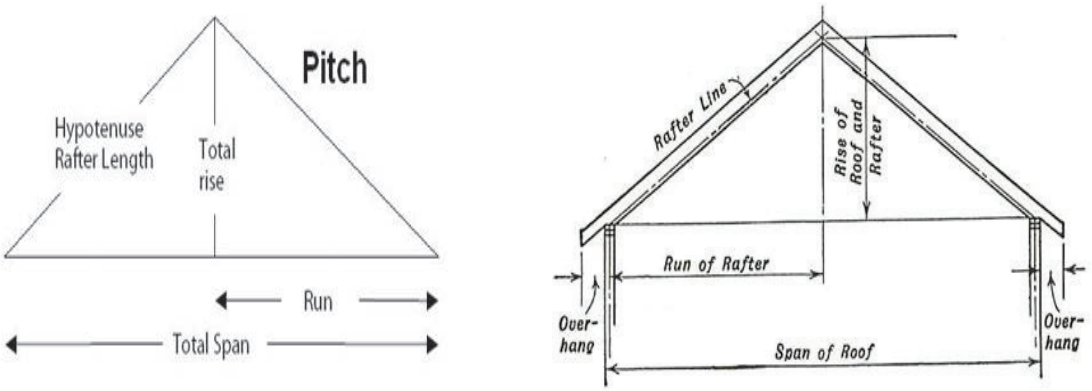


Figure 1.5a: Pitch
Source:http://jwilson.coe.uga.edu/EMAT6680Su09/King/Roofing/Application%20of%20%20Mathematics%20in%20Construction.html

Carpenters do not refer to the angle of a roof as 30^0 or 60^0, but prefer to use the pitch of the roof. The pitch is a ratio of vertical to horizontal measurements. If a plan calls for a 6/12 pitch roof, then the architect wants the slope of the roof to go up six inches for every 12 inches of horizontal run. Carpenters prefer to use Pitch in calculations instead of rise and run.

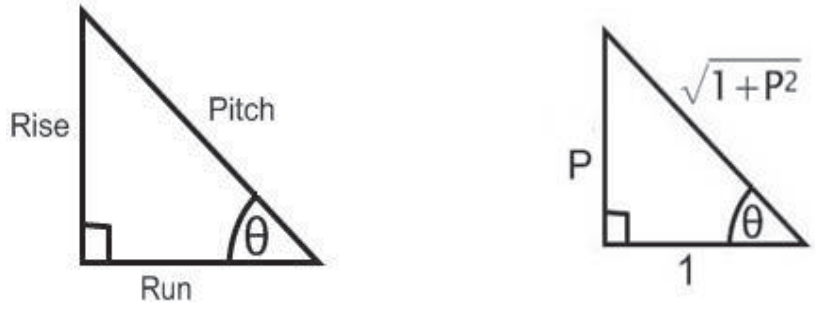


Figure 1.5b: Pitch
Source:http://jwilson.coe.uga.edu/EMAT6680Su09/King/Roofing/Application%20of%20%20Mathematics%20in%20Construction.html

Key Formulas:

Length of rafter = $\sqrt{(rise)^2+(run)^2}$

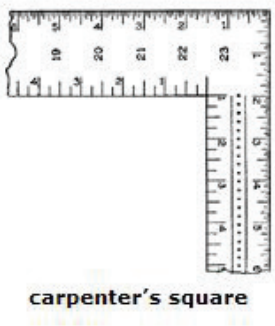
$$\tan\theta = \frac{rise}{run} = Pitch = \frac{P}{1}$$

Suppose a roof has a rise of 18 inches and a run of 15 feet. How long is the rafter?

$$\text{Length of rafter} = \sqrt{(1.5')^2 + (15')} = 15.075$$

Only very simple tools are needed to cut roof rafters such as a saw, framing square (or carpenters square) and a tape measure.

The framing square is made up of two legs joined at the heel to form a right angle. The longer leg of the framing square is called the body and the shorter one leg is called the tongue. To measure a 10/20 roof pitch, place the 10 on the tongue and the 20 on the body. When a piece of lumber is added to a carpenter's square, it becomes a right triangle.



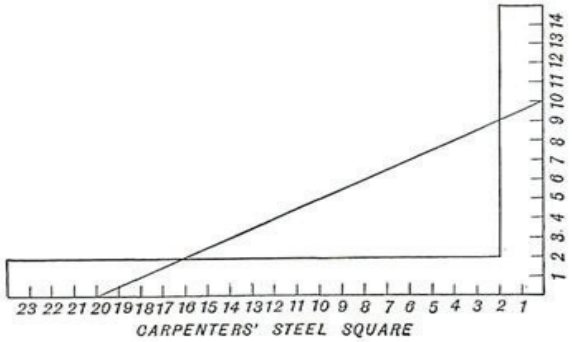


Figure 1.5c: Carpenters square
Source:http://jwilson.coe.uga.edu/EMAT6680Su09/King/Roofing/Application%20of%20%20Mathematics%20in%20Construction.html

Math Application

A Gable is a triangle formed by a sloping roof. A building may be front-gabled or side-gabled.

Consider structures where two roofs intersect as shown here.

Figure 1.5d: A Gable is a triangle formed by a sloping roof
Source:http://jwilson.coe.uga.edu/EMAT6680Su09/King/Roofing/Application%20of%20%20Mathematics%20in%20Construction.html

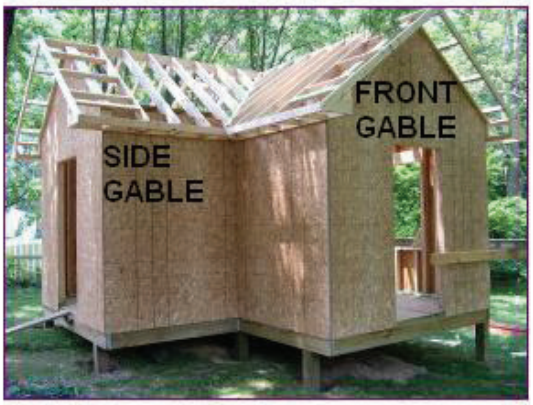


Figure 1.5e: A Gable is a triangle formed by a sloping roof
Source:http://jwilson.coe.uga.edu/EMAT6680Su09/King/Roofing/Application%20of%20%20Mathematics%20in%20Construction.html

When two roofs intersect, a valley rafter is formed.

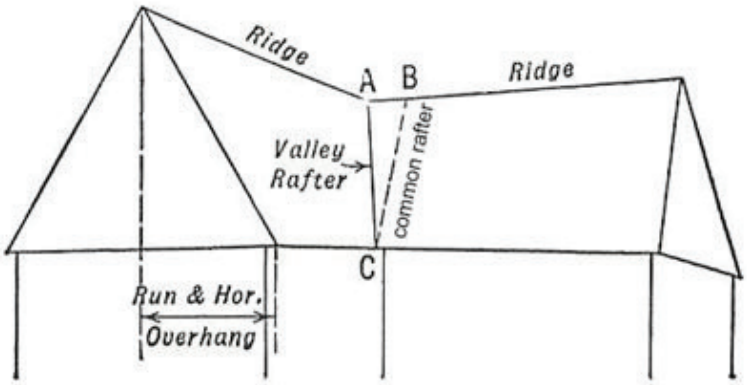


Figure 1.5f: Roofs intersect to form valley rafter
Source:http://jwilson.coe.uga.edu/EMAT6680Su09/King/Roofing/Application%20of%20%20Mathematics%20in%20Construction.html

The valley formed from the two common rafters and can be thought of as the diagonal in a rectangular solid.

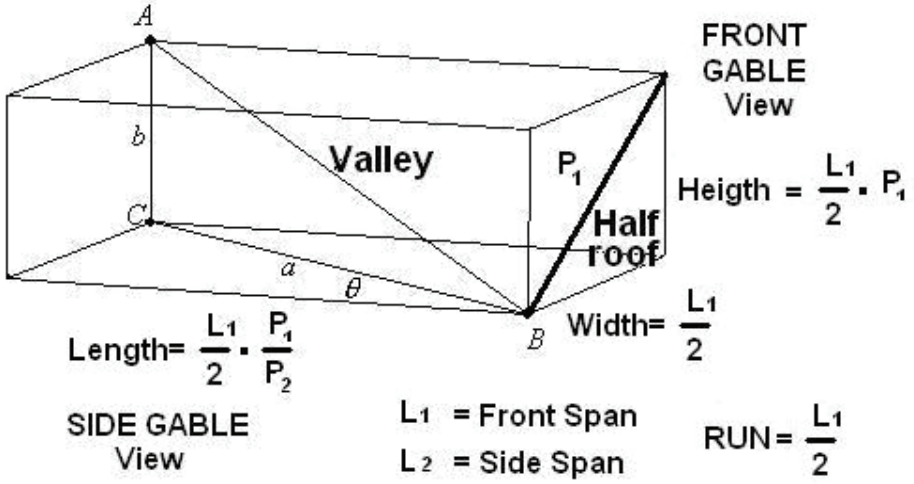


Figure 1.5g: Math application on forming gable roof
Source:http://jwilson.coe.uga.edu/EMAT6680Su09/King/Roofing/Application%20of%20%20Mathematics%20in%20Construction.html

From geometry we know that right triangles are similar therefore the sides of one triangle is proportional to the sides of the other. When the Pitch of the two intersecting roofs are not the same, see Gable picture, then the valley rafter calculation will involve a proportion.

$$Length = \frac{Span}{2} \bullet \frac{Pitch\ 1}{Pitch\ 2}$$

Other formulas needed to work with Roofs are as follows:

$$\tan\theta = \frac{H}{0.5L} \qquad H = 0.5L\tan\theta \qquad H = 0.5LP$$

$$\text{Slope Factor} = \sqrt{P^2+1} = \sqrt{\tan^2(pitch\ angle)+1}$$

Fnd the length of the valley rafter given the following measurements.

L_1=8 feet, L_2=10 feet, Pitch 1 = 1, Pitch 2 = 0.8, $a = \sqrt{4^2 + (4 \bullet \frac{1}{0.8})^2} = \sqrt{281} = 16.76$

Length of Valley rafter= $a = \sqrt{4^2 + (16.76)^2} = 17.23$

A Geometry Sketchpad showing intersecting roofs with different pitches is attached. Included in the sketch is the placement of the Rectangular Solid whose diagonal forms the roof valley. Click here.

The next diagram can be used to create a paper version of intersecting roofs and corresponding valley rafter.

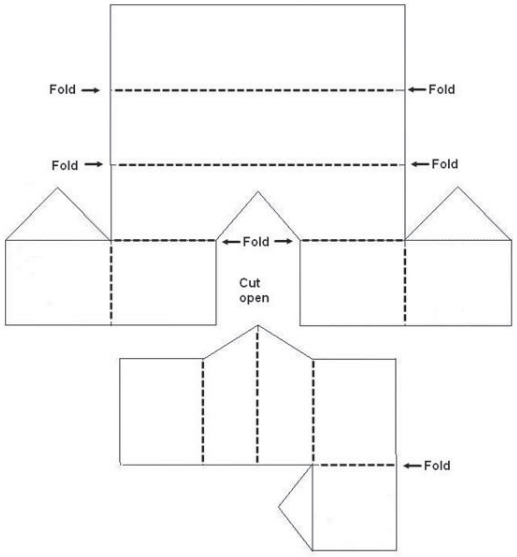


Figure 1.5h: intersecting roofs and corresponding valley rafter.
Source:http://jwilson.coe.uga.edu/EMAT6680Su09/King/Roofing/Application%20of%20%20Mathematics%20in%20Construction.html

Types of Construction Cost Estimate

The first thing to understand about a construction cost estimate is that it's an *estimate*. As the project progresses, challenges may arise that may push the price up. Conversely, you may also find ways to save money or materials. As a result, it's normal for the same project to have multiple estimates over its lifespan.

According to the American Society of Professional Estimators, there are five levels of estimate. Each level is more accurate than the last, and provides a higher level of detail.

- **Level 1** is called an Order of Magnitude Estimate. This is a preliminary "back of the napkin" calculation that's only directionally accurate. A Level 1 estimate is useful for determining whether a project is feasible, but not much else.
- **Level 2** is called a Schematic Design Estimate. This estimate is made based on the schematic design. It's useful for construction companies to determine whether it's worth looking closer at any given job.
- **Level 3** is called a Design Development Estimate. This is a rough estimate drawn up based on the initial design.
- **Level 4** is called a Construction Document Estimate. This estimate is based on proposed blueprints and building specifications.
- **Level 5** is called a Bid Estimate. This is a contractor's final estimate, based on all available Blueprints, plans, and material costs. This is the definitive estimate ultimately presented to the customer.

That's one way of classifying estimates. Another way is to look at how you're going to use the estimate. For example, are you trying to build a quote for a customer, or analyze your project for internal purposes? In that case, we can divide estimates into three categories: design estimates, bid estimates, and control estimates.

Design estimates include the order of magnitude estimate to determine how the project can proceed. For example, imagine you're bidding on a bridge. You'll want to know whether a suspension bridge is feasible, or whether a cantilever or other design would be better. As the design develops, engineers can create a more detailed estimate based on the early blueprints. This isn't a final number, but it gives you a ballpark figure to start from.
Bid estimates are made by contractors based on the specific project design. Contractors take into account the cost of materials, labor, and other factors. Potential customers then use these estimates to determine which contractor to hire.
Control estimates are an ongoing estimate used by the contractor during the construction process. It works similarly to a budget, in that you're tracking actual expenses versus planned expenses. This provides visibility, so project managers can control costs and react to unexpected events.

Three Methods

Unit Pricing

Unit pricing is the most common pricing method for many products and services. For example, suppose you're a hardwood floor refinisher. You charge a base rate per square foot, which is the unit price. The trick is to make considerations for both direct and indirect costs.

Unit cost estimating is best for determining direct costs. You know how much your labor costs per hour. You know how much materials cost by the ton, or the by the pallet. Start by pricing out those unit costs, and you'll have the bulk of your estimate complete in short order. At that point, all you'll have to do is account for indirect costs.

Let's say you need to hire a subcontractor to do some electrical work. You'll also need to pay for a follow-up inspection. And if you're running a crew of your own, you'll also have supervision costs. Many projects will also require other types of overhead. For example, most construction sites require safety fencing. This wouldn't fall under the category of unit pricing, but it's still an indirect cost.

As you might imagine, indirect costs can be harder to estimate than direct costs. As a result, it's a good idea to use software to help you keep track of everything. Using paper and pencil is a surefire way to make a mistake.

Square Footage Pricing

Sometimes, having a fast quote is more important than having an accurate one. For example, you may need to enter a bid before a certain deadline. In this case, a quick and dirty estimate is exactly what you need.

Now, it might sound risky to provide a rough, ballpark number as an official bid. But bids usually go through negotiations, and the customer is liable to ask for a discount anyway. Along the same lines, architects invariably run over budget with their initial design. This means sending the project back for revision.

All of this to say that the price you bid is never going to be the final project cost. It's going to change along the way, probably substantially. As a result, you can get away with providing a ballpark figure.

Square footage pricing means looking at the project square footage and the basic scope of work, and throwing out a rough estimate. The benefit of this method is that you can submit many more quotes than you could by making more precise estimates.

Imagine a square footage estimate takes an hour to create, while a more accurate estimate takes 10 hours. In that time, you could either submit 10 bids or 1. Which would you prefer?

The Rule of Two

The Rule of Two method is a slightly different way of creating a rough estimate. Like the other methods we've mentioned, it works best for direct costs. Indirect costs tend to be harder to predict, and vary more from job to job.

The Rule of Two relies on the principle that labor accounts for about half of any construction project. If you're an experienced contractor, you probably have a rough idea of how many man-hours a job will take. If you can do the job in five days with a three-man crew, you can easily calculate your labor costs. Double that amount, add 10%, and you've got yourself a rough estimate.

As with any other construction estimation method, the Rule of Two will only get you so far. Every job site has different conditions, and every project has its unique hiccups. You'll invariably have to adjust your estimate along the way. But that's a normal part of the construction process, and it's something you should expect.

A good construction cost estimate takes the guesswork out of your budgeting.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to introduction to building applied math. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Building Applied Math

Teaching Strategies
Students engage in brainstorming exercise to discover define building applied math
They then are allowed to design guiding questions that will enable them to conduct research on building applied math.
Discussions in groups on the research findings.
Teacher introduces students to building applied math.

Learning Strategies
Activity 1: Brainstorming activity define building applied math.
Activity 2: Conduct research on define building applied math
Activity 3: Discussions and presentation of research findings

Resources
Building Cost Estimation book, Construction estimation book, construction e-book PDF

Lesson 2: Methods of Calculating Sub-structure Members

Teaching Strategies
Engage students in brainstorming of methods of calculating sub-structure members.
Engage students in the discussion on methods of calculating sub-structure members.
Teacher introduces students to methods of calculating sub-structure members.

Learning Strategies
Activity 1: Brainstorming activity on methods of calculating sub-structure members.
Activity 2: Conduct research on methods of calculating sub-structure members.
Activity 3: Discussions and presentation of research findings.

Resources
Building Cost Estimation book, Construction estimation book, construction e-book PDF

Lesson 3: Methods of Calculation Superstructure Members

Teaching Strategies
Engage students in brainstorming of methods of calculation superstructure members.
Engage students in the discussion methods of calculation superstructure members.
Teacher introduces students to methods of calculation superstructure members.

Learning Strategies
Activity 1: Brainstorming activity on methods of calculation superstructure members.
Activity 2: Conduct research on methods of calculation superstructure members.
Activity 3: Discussions and presentation of research findings.

Resources
Building Cost Estimation book, Construction estimation book, construction e-book PDF

STEAM Activity Students work in groups to design a building (3bedroom) use methods and formulae to calculate sub-structure, super-structure members cost and build a model.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to Introduction to Building Applied Math . Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Define building Applied math
2. Apply correct methods or formulae to calculate substructure members
3. Apply correct methods and formulae to calculate superstructure members

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
Define building applied math	Define building applied math excellently with clear examples	Define building applied math correctly	Define building applied math partially	Define building applied math very poorly
Apply correct methods or formulae to calculate substructure members	Apply correct methods or formulae to calculate substructure members excellently with clear examples	Apply correct methods or formulae to calculate substructure members correctly	Apply correct methods or formulae to calculate substructure members partially	Apply correct methods or formulae to calculate substructure members very poorly
Apply correct methods and formulae to calculate superstructure	Apply correct methods and formulae to calculate superstructure excellently with clear examples	Apply correct methods and formulae to calculate superstructure correctly	Apply correct methods and formulae to calculate superstructure partially	Apply correct methods and formulae to calculate superstructure very poorly

UNIT 1. Building Technology

Content Standard 3.1 Investigate the history and theory of buildings and analyse the components and systems of buildings, occupational health and safety procedures, the properties of building materials and the processes in which those materials and equipment are used according to industry standards.

Benchmark 12.3.1.6 Design and construct building structure with correct procedure and regulations of building.

Topic 6: Processes and Procedures in Construction

Learning Objectives

By the end of this topic, the students will be able to;

- Analyse building processes and procedures in construction.
- Apply correct method of designing Gable roof using AutoCAD.
- Analyse the basic steps on estimating cost of materials of two-bedroom house.
- Apply the design process in the layout, construction and furnishings of the two-bedroom house.

Essential Questions:

1. What are the building processes and procedures in construction?
2. How are houses designed?
3. What is material cost estimation?
4. What are the furniture and furnishing materials for a house?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Building Structure procedures and regulations	Analyse and practice the processes and procedures in construction	Open-minded, critical and creative in applying the correct methods involved in designing and constructing buildings.	Value the importance and competency

Content Background

Processes and procedures in construction

The design and construct building with correct processes and procedures is the application and implementation of how the project be executed in reality by following the Construction processes and procedures from the start of the project to the completion of the project.

Building Construction Process from Start to Finish (Step By Step Guide)

A perfect understanding of the basics of building construction is the first step to a successful construction project. Constructing a building is puzzling regardless of the type of building. Aside from the time, efforts, and investment involved, care should be taken in planning the purpose of construction and its use. Hence, the process of constructing a building starts with its plan. There are important steps to use in planning your housing project efficiently and in a better way.
We aim to provide you with a better understanding of construction in a simplified manner. And have categorized them into two parts; the pre-construction stage and the construction stage.

Building Construction Process Step by Step

The Pre-Construction Stage

- Building plan
- Budget estimation
- Land acquisition
- Documentation

Figure 1.6a: The Pre-Construction Stage
Source: https://www.maramani.com/blogs/home-design-ideas/building-construction-process

The Construction Stage

- Site clearing
- Foundation
- Plinth beam or slab
- Superstructure
- Brick masonry work
- The lintel
- Roofing coating
- Electrical and plumbing
- Exterior and interior finishing
- Flooring
- Painting

1. Building plan

Your building plan is the most crucial aspect of building construction. When you are about to embark on a large-scale project such as constructing a building, it is vital that you lay out a plan for your building.

The reason is that it helps you to anticipate the features and functions of different parts of your construction process. You need a team of professionals to carry out this task to achieve the best results. Architects, civil engineers, electricians, and plumbers play an essential role in planning a successful building construction project.

2. Budget estimation

Constructing a building is a considerable investment, which involves setting aside a specific budget. After planning is done, the details are given to a building estimator to carry out a survey and estimate the cost of materials, types of machinery, and labor required to complete the building project.

The cost of materials will be determined by the quantity and quality of fabric needed. At this stage, if the financial capability is limited, it is advised not to proceed further or get a loan from financial firms. Otherwise, there might be a cash crunch situation.

3. Land acquisition

Another essential requirement in setting up a building is to acquire a piece of land. It's important to put several factors in mind; the size of the building, location, and so on. The size will determine how large the required piece of land should be. As for the location, it is important to build a factory or industry closer to where its raw materials are available – to save the cost of production.

4. Documentation

Thousands of buildings are demolished every day due to a lack of appropriate evidence and documents as proof of ownership. The building authorities permission must be sought and have the project registered when embarking on a building construction project to avoid such circumstances.

Ensure that a document showing the transfer/purchase of the acquired piece of land acquired adequately appended by the transferor and legal authorities is obtained.

Documents required might include but are not limited to, land survey report, land soil test report, land purchase/transfer document, architecture drawings, structural report, and certificate of undertaking by a civil engineer.

The Construction Stage

1. Site clearing

The designated land area meant for constructing a particular building is known as a 'site.' In situations where the piece of land has been abandoned for a long time, it's likely to have trees, weeds, and debris on the land. The first thing to do here is to get rid of such items that might obstruct construction.

On a large piece of land that cannot be cleared using crude implements, you can hire companies in charge to operate bulldozers, excavators, or land mowers to do the job.

Figure 1.6b: Site clearing
Source: https://www.maramani.com/blogs/home-design-ideas/building-construction-process

2. Foundation

The foundation is the lowermost part of the building where the building meets the soil. It constitutes part of the building's invisible structure. There's no underestimating the importance of erecting a solid foundation for a building. It is the most crucial part of building structure because the other parts of the building rely on the foundation's strength to hold. If the foundation is weak, it will collapse someday no matter the quality and quantity of materials used to erect the building.

Figure 1.6c: Foundation
Source: https://www.maramani.com/blogs/home-design-ideas/building-construction-process

Construction engineers understand this aspect. Hence, they put in their best effort in terms of material and human resources to ensure that the foundation is strengthened to the peak.

3. Plinth beam and slab

Upon successfully constructing the foundation, another reinforcement known as the "plinth beam and slab" is added to the top. The purpose of reinforcing the foundation with the plinth beam and slab is to protect the foundation from dampness and prevent its cracks from reaching the wall. It will help the foundation to remain strong in the event of an earthquake.

4. Superstructure

A superstructure provides support for the beam and slab. Members of the superstructure include the column designed to strengthen the load mounted upon the building's foundation.

The columns are constructed up to the slab level and frame for further construction. A waterproof coating is added to stop water from entering the slab and casting.

5. Bricklaying

This is where the visible portion of the building is constructed. Depending on the owner's choice, different kinds of blocks or bricks can erect the building walls. Materials such as concrete blocks and fly ash bricks are used according to the structure laid down by the architect in the building plan. The cement mortar mixer is used to mix cement and sand used to hold the bricks together as they are arranged by the masonry. The structure of the windows and doors are carved out by the masonry when erecting
the building wall.

Figure 1.6d: Bricklaying
Source: https://www.maramani.com/blogs/home-design-ideas/building-construction-process

6. The Lintel
After erecting your wall, the lintel is built on top of the wall. Like the plinth beam and slab, a lintel is a beam placed across door and window openings. It is used as a support for the load of the structure placed above it.

7. Roof coating
The load that the lintel supports is the roofing structure. Roof refers to the framing of the uppermost layer of the house to shape covering, protection from harsh weather, and decoration and beautification. The building is taking shape at this level, and one can tell what dimension the building will look like. Different types of roofing materials can add decoration to a home.

8. Electrical and plumbing

Modern homes have their wires and pipes hidden away from sight. This is because they were installed at this stage of building construction and hidden between the walls and slabs; only the endpoint of the pipes and sockets are visible.

Figure 1.6e: Electrical and plumbing
Source: https://www.maramani.com/blogs/home-design-ideas/building-construction-process

9. Exterior and interior finishing

Plastering work commences after electrical and plumbing work has been completed. A mixture of cement and sand is used to plaster the exterior part of the building. It is coated with a thickness of 13 mm and sometimes about 20 mm thickness. Plastering can make the building structurally strong, protect it from the effect of weather, and make it look attractive. The interior design is done by experts according to the procedure laid by the architect.

10. Flooring

At this point, the building construction is coming to an end. Flooring works begin after the exterior and interior décor is completed. There are various types of flooring according to their uses, economy, and required level of finishing. Ceramic tiles, vitrified tiles, clay tiles, granite, marble, wood, and epoxy flooring are some of the best options.

11. Painting

This is the final work on a building. Painting is used to beautify the building and protect is from the effects of water and sun. Latex paints are highly water-resistant. Hence, they are favorites for painting the exterior wall of homes. For decoration, a perfect mixture of different colors while painting can magnify the beauty of a building.

Figure 1.6f: Painting
Source:https://www.maramani.com/blogs/home-design-ideas/building-construction-process

Conclusion

Constructing a building is a large-scale and lifetime investment. This is why the real estate business is one of the most significant investments ever. The demand for housing will continue to increase as the population of a given area increases. Therefore, it is crucial to meet this demand with an equilibrium amount of supply of housing facilities. This is an insight into what it takes to construct a building.

Furniture fixtures and equipment (FF&E)

FF&E refers to the procurement of equipment. This might be procured separately to the main construction contract (or elements of them), particularly by clients that already have systems in place for procuring fixed and loose furniture, fittings and equipment; for example schools, universities, or hospitals.

It is very important under such circumstances to define very clearly which contract every element of FF&E is within (for example, there may still be unusual or large items that it may be more sensible to procure under the main contract). It is also important to ensure that any building work required for the installation of such items is identified and procured, that any services required (such as power or drainage) are identified and that the installation of FF&E is properly integrated into the main contract. Requirements that affect the main contract might include:

- Built-in equipment requiring mechanical or electrical connections, such as fume cupboards or drinks stations. A description of built-in equipment should include; location, size, and requirements for power, air, water, drainage and telecommunications connection.
- Built-in equipment that does not require services such as cupboards or shelving. These should be described in terms of their location and size.
- Stand-alone loose furniture and equipment requiring services, such as washing machines, coffee machines and scanning equipment in hospitals. These should be described in terms of their location, size, and requirements for power, air, water, drainage and telecommunications connection.
- Stand-alone loose furniture and equipment not requiring services such as tables and chairs. These should be described in terms of their location and size.

It is also important that any elements that are outside of the main contract are included in the client's cost plans.

FF&E can be procured from specialist suppliers, or suppliers with whom the client already has a long term relationship. This may include maintenance arrangements.

Some elements may be specially designed by FF&E designers or sourced by FF&E consultants. There is also a need for a carefully managed FF&E inventory and logistical planning to ensure items are available on-site at the right time.

In managing the procurement of FF&E, consultants take on the complicated and time-consuming task of coordinating with the design team, external vendors and internal departments for the following:

- Programming and planning.
- Sourcing.
- Project procurement strategy and risk analysis.
- Request for proposal (RFP) document development.
- RFP process management.
- Contract negotiation and buy-out.
- Order expediting and tracking.
- Installation, product acceptance and close-out.

Furnishings

Furnishings, sometimes referred to as soft furnishings or upholstery, are components that incorporate soft material and help create a pleasant and comfortable environment, and complement the furniture and fittings inside buildings. Furnishings can be made of fabric, chenille, velvet, silk, fur, faux-fur, cloth, foam, rubber, and so on.
Common types of furnishings include:

- Curtains.
- Cushions.
- Bedding and mattresses.
- Wall hangings and tapestries.
- Rugs.
- Chair coverings.
- Sofas.
- Bean bags.
- Carpets.
- Doormats.
- Window Coverings.
-

Furnishings should be carefully selected and designed to enhance the quality of a room, often adding colour, texture and elegance to furniture. The soft material of some furnishings can also enhance the energy efficiency of a room by retaining heat and keeping it warm. They may also improve the sound insulation properties as soft materials absorb sound waves more effectively than hard surfaces which reflect sound back into the space and can result in echoes (or a longer reverberation time).

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to Design and construct building with correct processes and procedures. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant

to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Analysing building processes and procedures

Teaching Strategies
Students engage in brainstorming exercise to discover building processes and procedures.
They then are allowed to design guiding questions that will enable them to conduct research on analysing building processes and procedures.
Discussions in groups on the research findings on building processes and procedures.
Teacher introduces students to analysing building processes and procedures.

Learning Strategies
Activity 1: Brainstorming activity on analysing building processes and procedures.
Activity 2: Conduct research on analysing building processes and procedures.
Activity 3: Discussions and presentation of research findings on analysing building processes and procedures.

Resources
Building construction book, Construction Book, construction pdf book

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Lesson 2: **Method of designing Gable roof using AutoCAD program**

Teaching Strategies
Engage students in brainstorming about the method of designing Gable roof using AutoCAD program.
Engage students in the discussion about the method of designing Gable roof using AutoCAD program.
Teacher introduces students to the method of designing Gable roof using AutoCAD program (Autodesk 2020 version).

Learning Strategies
Activity 1: Brainstorming activity on the method of designing gable roof using AutoCAD program.
Activity 2: Conduct research on the method of designing gable roof using AutoCAD program.
Activity 3: Discussions and presentation of research findings on the method of designing gable roof using AutoCAD program (Autodesk 2020 version).

Resources
Building Construction text book,

Note: Practical lessons should be carried out to demonstrate on how to design two bedroom house (gable roof) using Autodesk 2020 version and processes involved in designing (floor plan & front & side elevations) immediately after theory lessons are imparted to students.

Lesson 3: Estimate the Costs of Material

Teaching Strategies
Engage students in brainstorming to estimate the cost of material.
Engage students in the discussion to estimate the cost of material.
Teacher introduces students to estimating the cost of material of a two-bedroom house from the plan (Autodesk plan).

Learning Strategies
Activity 1: Brainstorming activity to estimate the cost of material.
Activity 2: Conduct research to estimate the cost of material.
Activity 3: Discussions and presentation of research findings to estimate the cost of material.

Resources
Building Construction text book

Note: Practical lessons should be carried out to demonstrate on how to estimate two bedroom house from the plan and formulae involved in estimating cost of material immediately after theory lessons are imparted to students

Lesson 4: Building Setting Out and Construction Process

Teaching Strategies
Engage students in brainstorming building setting out and construction processes.
Engage students in the discussion of building setting out and construction processes.
Teacher introduces students to building setting out and construction processes.

Learning Strategies
Conduct a research with guiding questions that will lead to discovering building setting out and construction process.

Activity 1: Brainstorming activity building setting out and construction process.
Activity 2: Conduct research on building setting out and construction processes.
Activity 3: Discussions and presentation of research findings on building setting out and construction process.

Resources
Building Construction text book, Construction Books,

Note: Practical lessons should be imparted to students to demonstrate how building setting out is done and processes involved during construction immediately after the theory lessons. Student should be constructing a two bedroom house project in groups as a (model) based on the plan and assessment be done in groups after completion of a project.

Lesson 5: Furniture Installation and Furnishing the Building

Teaching Strategies

Engage students in brainstorming furniture Installation and furnishing the building.
Engage students in the discussion of furniture Installation, furnishing the building and basic techniques on constructing furniture.
Teacher introduces students to furniture Installation and furnishing the building and demonstrate techniques on constructing furniture, (chairs, dining tables, cupboard, bed etc.)

Learning Strategies

Conduct a research with guiding questions that will lead to discovering furniture Installation, furnishing the building and basic techniques on constructing furniture before installation.

Activity 1: Brainstorming activity on furniture installation to the building and furnishing the building.
Activity 2: Conduct research on the basic techniques of furnishing the building.
Activity 3: Conduct research on the basic techniques of constructing furniture before installation processes.
Activity 4: Discussions and presentation of research findings on furniture installation, furnishing building and techniques on constructing furniture.

Resources

Building Construction text book, Construction Estimating Books**,**

Note: Practical lessons should be carried out to demonstrate on how to construct furniture; (chairs, dining table, cupboards, etc.) immediately after theory lessons are imparted to students.

STEAM Activity Students work in groups to construct a two-bedroom brick house model by following the correct building processes and procedures. E.g. Use Autodesk software 2020 to design a two-bedroom gable roof, estimate the cost of materials, setting out a profile, laying foundation, construct substructure members and superstructure members(wall & roofing framing),construct furniture fittings and applying furnishing,(paint).

Note; Building Inspection 1&3 be carried out @foundation to framing construction processes should be emphasised to students.

Assessment

The main purpose of assessment is to find out if students can use the skill of synthesis to Design and construct building with correct processes and procedures
Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment

1. Analyse building processes and procedures in construction
2. Apply correct method of designing Gable roof using AutoCAD/Autodesk
3. Analyse the basic steps on estimating cost of materials of a two-bedroom house
4. Apply correct method of setting out/laying out of two-bedroom house from the Plan.
5. Construct furniture and install them in the two-bedroom house according to the Plan.
6. Apply correct furnishing materials (paints/varnish) in two-bedroom House

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
Analyse building processes and procedures in construction	Competently analyse building processes and procedures in construction	Correctly analyse building processes and procedures in construction	Satisfactorily analyse building processes and procedures in construction	Incompetently analyse building processes and procedures in construction
Apply correct method of designing Gable roof using AutoCAD/Autodesk	Apply correct method of designing Gable roof using AutoCAD/Autodesk with sophistication and creativity.	Apply correct method of designing Gable roof using AutoCAD/Autodesk competently.	Apply correct method of designing Gable roof using AutoCAD/Autodesk satisfactorily.	Apply correct method of designing Gable roof using AutoCAD/Autodesk but incompetent.
Analyse the basic steps on estimating cost of materials of two-bedroom house	Analyse the basic steps on estimating cost of materials of a two-bedroom house accurately and competent.	Analyse the basic steps on estimating cost of materials of a two-bedroom house correctly.	Analyse the basic steps on estimating cost of materials of a two-bedroom house satisfactorily.	Analyse the basic steps on estimating cost of materials of a two-bedroom house but incompetent.
Apply correct method of setting out/laying out of two-bedroom house from the Plan.	Apply correct method of setting out/laying out of a two-bedroom house from the plan competently considering all elements of design.	Apply correct method of setting out/laying out of a two-bedroom house from the plan competently.	Apply correct method of setting out/laying out of a two-bedroom house from the plan satisfactorily.	Apply correct method of setting out/laying out of a two-bedroom house from the plan poorly and incompetent.
Construct furniture and install them in the two bedroom house according to the Plan.	Construct furniture and install them in the two-bedroom house according to the plan competently applying skills of construction.	Construct furniture and install them in the two-bedroom house according to the plan competently.	Construct furniture and install them in the two-bedroom house according to the plan satisfactorily.	Construct furniture and install them in the two-bedroom house according to the plan poorly and incompetent.
Apply correct furnishing materials (paints/varnish) in two-bedroom House	Apply correct furnishing materials (paints/varnish) in a two-bedroom house competently considering all element of design.	Apply correct furnishing materials (paints/varnish) in a two-bedroom house competently.	Apply correct furnishing materials (paints/varnish) in a two-bedroom house satisfactorily.	Apply correct furnishing materials (paints/varnish) in a two-bedroom house poorly and incompetent.

Unit 2 Electrical Technology

Unit	Topic	Lesson Titles
2.ElectricTechnology	Topic 1. Design of Electrical Circuits.	1. Components of Building Structures 2. Electrical Floor Plans. 3. Circuit Diagrams for Products and Appliances
	Topic 2. Earthing Systems	1. Earthing System 2. MEN Earthing System 3. Earth Faults 4. Earthing System for Selection and Installation
	Topic 3. Hand and Power Tools	1. Functions and Handling Techniques of Hand and Power Tools 2. Maintenance of Hand and Power Tools
	****Topic 4. Circuit Installations**	1. Light circuits 2. Socket Outlets Circuits 3. Appliance Circuits
	****Topic 5. Circuits Testing and Verification**	1. Testing Safety 2. Testing Principles 3. Testing Devices 4. Verification and Compliance 5. Fault Finding and Performance Testing.
	****Topic 6. Maintenance**	1. Repairing and Troubleshooting of Electrical Products and Systems 2. Procedures of Daily Maintenance,

NOTE TO TEACHERS

**** Topics 4, 5 and 6,**

- Should only be implemented in accredited schools such as a Technical Secondary School.
- Should only be taught by certified electrical tradesman.

This is due to laws and regulations in relation to licensing.

UNIT 2: Electrical Technology

Content Standard 3.2 Investigate, analyse and apply the technological processes, concepts, principles and practices related to Electrical Technology and its social contribution with regard to economic growth, entrepreneurship, sustainability and as a tool for change, improving quality of life responsive to individual, community and industrial needs.

Benchmark 12.3.2.1 Read, analyse and interpret electrical circuit diagrams in design and construction.

Topic 1: Design and Construction of Electrical Circuits

Learning Objectives
By the end of this topic, the students will be able to;

- Define circuit design and construction.
- Design circuits using computer software.
- Construct circuits using breadboards, circuit kits and manuals.
- Analyse circuits using ohms and Kirchhoff's laws.

Essential Questions:
1. What is circuit design and construction?
2. How do we design and construct circuits?
3. How do we analyse circuits?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Electrical Circuits	Read, Analyse, Interpret electrical circuits	Responsible and safety cautious in the practice of designing electric circuits.	Appreciate and value

Content Background

Circuit Design and Construction
The process of circuit design can cover systems ranging from complex electronic systems all the way down to the individual transistors within an integrated circuit For simple circuits the design process can often be done by one person without needing a planned or structured design process, but for more complex designs, teams of designers following a systematic approach with intelligently guided computer simulation are becoming increasingly common. In integrated circuit design automation, the term "circuit design" often refers to the step of the design cycle which outputs the schematics of the integrated circuit. Typically this is the step between logic design and physical design.

The different stages of circuit design and construction.

- Process
- Specification
- Design
- Cost
- Verification and testing
- Prototyping
- Results

Process
Formal circuit design usually involves a number of stages. Sometimes, a design specification is written after liaising with the customer. A technical proposal may be written to meet the requirements of the customer specification. The next stage involves synthesizing on paper a schematic circuit diagram, an abstract electrical circuit that will meet the specifications. A calculation of the component values to meet the operating specifications under specified conditions should be made. Simulations may be performed to verify the correctness of the design.

A breadboard or other prototype version of the design for testing against specification may be built. It may involve the making of any alterations to the circuit to achieve compliance. A choice as to a method of construction as well as all the parts and materials to be used must be made. There is a presentation of component and layout information to draughts persons, and layout and mechanical engineers, for prototype production. This is followed by the testing or type-testing a number of prototypes to ensure compliance with customer requirements. Usually there is a signing and approval of the final manufacturing drawings and there may be post-design services.

Specification
The process of circuit design begins with the specification, which states the functionality that the finished design must provide, but does not indicate how it is to be achieved .The initial specification is basically a technically detailed description of what the customer wants the finished circuit to achieve and can include a variety of electrical requirements, such as what signals the circuit will receive, what signals it must output, what power supplies are available and how much power it is permitted to consume. The specification can (and normally does) also set some of the physical parameters that the design must meet, such as size, weight, moisture resistance, temperature range, thermal output, vibration tolerance and acceleration tolerance. As the design process progresses the designer(s) will frequently return to the specification and alter it to take account of the progress of the design. This can involve tightening specifications that the customer has supplied, and adding tests that the circuit must pass in order to be accepted.

The Design

The design process involves moving from the specification at the start, to a plan that contains all the information needed to be physically constructed at the end, this normally happens by passing through a number of stages, although in very simple circuit it may be done in a single step. The process normally begins with the conversion of the specification into a block diagram of the various functions that the circuit must perform, at this stage the contents of each block are not considered, only what each block must do, this is sometimes referred to as a "black box" design. Each block is then considered in more detail, still at an abstract stage, but with a lot more focus on the details of the electrical functions to be provided. Finally the individual circuit components are chosen to carry out each function in the overall design, at this stage the physical layout and electrical connections of each component are also decided, this layout commonly taking the form of artwork for the production of a printed circuit board or Integrated circuit. This stage is typically extremely time consuming because of the vast array of choices available. A practical constraint on the design at this stage is that of standardization, while a certain value of component may be calculated for use in some location in a circuit, if that value cannot be purchased from a supplier, then the problem has still not been solved. To avoid this certain amount of 'catalogue engineering' can be applied to solve the more mundane tasks within an overall design.

Cost

Proper design philosophy and structure incorporates economic and technical considerations and keeps them in balance at all times, and right from the start. Balance is the key concept here; just as many delays and pitfalls can come from ill-considered cost cutting as with cost overruns. Good accounting tools (and a design culture that fosters their use) is imperative for a successful project. "Manufacturing costs shrink as design costs soar," is often quoted as a truism in circuit design, particularly for ICs.

Verification and testing

Once a circuit has been designed, it must be both verified and tested. Verification is the process of going through each stage of a design and ensuring that it will do what the specification requires it to do. This is frequently a highly mathematical process and can involve large-scale computer simulations of the design. In any complicated design it is very likely that problems will be found at this stage and may involve a large amount of the design work be redone in order to fix them. Testing is the real-world counterpart to verification. Testing involves physically building at least a prototype of the design and then (in combination with the test procedures in the specification or added to it) checking the circuit really does do what it was designed to.

Prototyping
Prototyping is a means of exploring ideas before an investment is made in them. Depending on the scope of the prototype and the level of detail required, prototypes can be built at any time during the project. Sometimes they are created early in the project, during the planning and specification phase, commonly using a process known as bread boarding; that's when the need for exploration is greatest, and when the time investment needed is most viable. Later in the cycle packaging mock-ups are used to explore appearance and usability, an occasionally a circuit will need to be modified to take these factors into account.

Results
As circuit design is the process of working out the physical form that an electronic circuit will take, the result of the circuit design process is the instructions on how to construct the physical electronic circuit. This will normally take the form of blueprints describing the size, shape, connectors, etc., in use, and artwork or CAM file for manufacturing a printed circuit board or integrated circuit

Circuit Analysis
Circuit analysis, or solving a circuit, means figuring out voltages and currents in each element. Here's an overview of circuit analysis, with some context for the various tools and methods we use to analyse circuits. (*The general strategy of circuit analysis is to create and solve a system of independent equations. Written by Willy McAllister.)*

The tools used in Circuit Analysis
- Element equations (Ohm's Law, etc.)
- Schematics (wires, nodes, branches, loops, and meshes)
- Simplifying series and parallel resistors
- Kirchhoff's Laws for current and voltage

The general strategy for circuit analysis
- After simplifying a circuit as much as possible, all circuit analysis methods are some versions of
  the following strategy:
- Create a set of independent equations based on the elements and circuit connections.
- Solve the system of simultaneous equations for the independent variables (voltages or currents). This often involves using techniques from linear algebra.
- Solve the remaining individual element voltages and currents.

Electrical Circuit Drawing
A **circuit diagram** (or: wiring diagram, electrical diagram, elementary diagram, electronic schematic) is a graphical representation of an electrical circuit. A pictorial circuit diagram uses simple images of components, while a schematic diagram shows the components and interconnections of the circuit using standardized symbolic representations. The presentation of the interconnections between circuit components in the schematic diagram does not necessarily correspond to the physical arrangements in the finished device.[1]

Unlike a block diagram or layout diagram, a circuit diagram shows the actual electrical connections. A drawing meant to depict the physical arrangement of the wires and the components they connect is called *artwork* or *layout*, *physical design*, or *wiring diagram*.

Circuit diagrams are used for the design (circuit design), construction (such as Printed Circuit Board layout), and maintenance of electrical and electronic equipment.

Circuit diagrams are pictures with symbols that have differed from country to country and have changed over time, but are now to a large extent internationally standardized. Simple components often had symbols intended to represent some feature of the physical construction of the device. Electrical circuits are usually drawn using specific symbols to represent each circuit component.

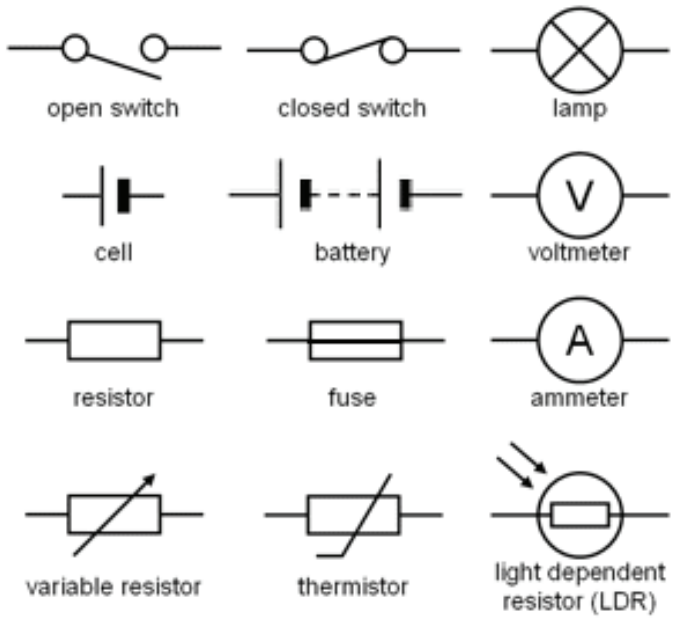


Figure 2.1a: Electrical circuit symbols
Source: https://www.pathwayz.org/Tree/Plain/CIRCUIT+DIAGRAMS

The wires that connect each circuit component are always drawn using straight lines that connect at right-angled corners. For instance, a single cell and a light bulb would be drawn like this.

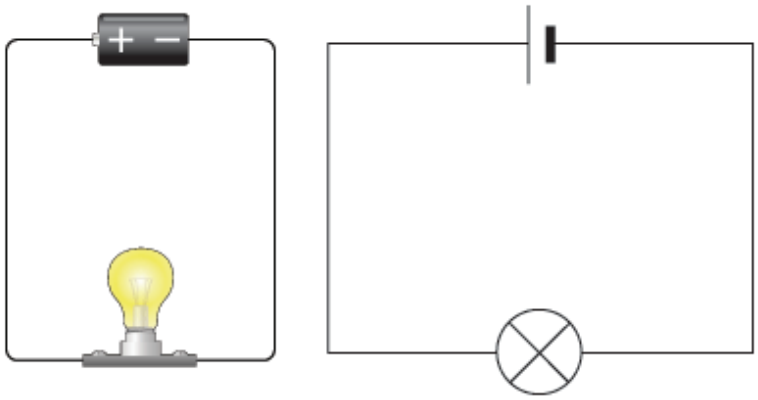


Figure 2.1b: Circuit Components
Source: https://www.pathwayz.org/Tree/Plain/CIRCUIT+DIAGRAMS

Teaching and Learning Strategies
Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of designing and constructing electrical circuits. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Circuit Design and Construction

Lesson Objective: Students will be able to:
1. Identify the components of a circuit design and construction.

Essential Knowledge, Skills, Values and Attitudes

Knowledge	Skills	Values	Attitudes
Circuit design and construction	Identify and explain the components of circuit design and construction.	Consideration for safety.	Participatory to every task to understand circuit design and construction.

Teaching Strategies
Students engage in brainstorming exercise to discover how circuits are designed and constructed.
Students are engaged with computers to use designing software to construct and design circuits.
Students are also engaged with breadboards, circuit kits to put the designed circuit into physical structure on breadboards or circuit kits.

Learning Strategies
Activity 1: Brainstorming activity on Circuit design and construction
Activity 2: Students are engaged with computers to design and simulate circuits
Activity 3: Students put together designed circuit using breadboards and circuit kits.

Teacher	Student
Introduction	
Present a circuit diagram of an electrical appliance and let students identify what it is and why they say what it is. Lead students to the lesson topic which is Circuit design and construction	Students study the model presented and work out what it is and why is called what it is. While identifying, they move forward to discovering the lesson topic
Body	
Modelling	
Brainstorm on what is circuit design and construction.	Students brainstorm in groups and in classes what circuit design and construction is.
Guided Practice	
Engage students in design circuits using computer software	Students are engaged to design circuits using computer software in pairs
Independent Practice	
Engage students to construct physical circuits using breadboards, circuit kits and even use manuals to assist them. Facilitate students' circuit presentation and testing	Construct designed circuits using circuit kits, breadboards aided with manuals. Present constructed circuit as a class discussion
Conclusion	
Conclude lesson with main concepts being explained	Take lesson notes
Assessment	
Assess presentation activity	Complete assessment task.

Resources
Pethebridge K & Neeson I ,2010, page 227
Breadboards, circuit kits, operational manual for electrical appliances

Lesson 2: Circuit Analysis

Teaching Strategies
Conduct circuit analysis on a circuit using Ohm's law, Kirchhoff's Law and with the aid of the circuit manual (a drill or any electrical equipment manual)
Solve circuit quantities while analysing circuit presented.

Learning Strategies
Activity 1: Students are engaged small groups with circuit problems to solve and analyse using Ohm's and Kirchhoff's law.
Activity 2: The teacher goes around to assisting groups in analysing circuits. And individuals volunteer to present their groups activity.

Resources
Manuals, handouts and exercise books

STEAM Activity Students work in groups to create an activity incorporating concepts of circuit design and construction.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to explain circuit design and construction and even circuit analysis. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
By the end of this topic, the students will be able to;
1. Define circuit design and construction.
2. Design circuits using computer software.
3. Construct circuits using breadboards, circuit kits and manuals.
4. Analyse circuits using Ohms and Kirchhoff's laws.

Performance Assessment Scoring
Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	**Advanced**	**Meet Standard**	**Progressing**	**Not Yet**
1. Define circuit design and construction	Accurately define circuit design and construction	Correctly define circuit design and construction	Poorly define circuit design and construction	Cannot define circuit design and construction
2. Design circuits using computer software	Accurately design circuits using computer software	Correctly. design circuits using computer software	Poorly design circuits using computer software	Cannot design circuits using computer software
3. Construct circuits Using breadboards, circuit kits and manuals	Accurately construct circuits using breadboards, circuit kits and manuals	Correctly construct circuits using breadboards, circuit kits and manuals	Poorly construct circuits using breadboards, circuit kits and manuals	Cannot construct circuits using breadboards, circuit kits and manuals
4. Analyse circuits using ohms and Kirchhoff's laws	Accurately analyse circuits using ohms and Kirchhoff's laws	Correctly analyse circuits using ohms and Kirchhoff's laws	Poorly analyse circuits using ohms and Kirchhoff's laws	Cannot analyse circuits using ohms and Kirchhoff's laws

UNIT 2: Electrical Technology

Content Standard 3.2 Investigate, analyse and apply the technological processes, concepts, principles and practices related to Electrical Technology and its social contribution with regard to economic growth, entrepreneurship, sustainability and as a tool for change, improving quality of life responsive to individual, community and industrial needs.

Benchmark 12.3.2.2 Describe the reasons for an earthing system and show how MEN system works to protect against the harmful effects of electricity.

Topic 1: Earthing Systems

Learning Objectives
By the end of this topic, the students will be able to;

- Explain earthing system and an MEN system
- Define earth faults
- Identify earthing system for selection and installation.

Essential Questions:
1. What is earthing system?
2. What does MEN stand for and what is it?
3. How does a MEN system function?
4. What are the harmful effects of electricity?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Earthing system, MEN system, and harmful effects of electricity.	Describe with examples, show or demonstrate MEN system.	Practice Care and responsibility when working with earthing systems.	Appreciate, careful and vigilance

Content Background

Introduction to Earthing system
The process of transferring the immediate discharge of the electrical energy directly to the earth by the help of the low resistance wire is known as the electrical earthing. The electrical earthing is done by connecting the non-current carrying part of the equipment or neutral of supply system to the ground. Mostly, the galvanised iron is used for the earthing. The earthing provides the simple path to the leakage current. The short circuit current of the equipment passes to the earth which has zero potential. Thus, protects the system and equipment from damage.

Types of Electrical Earthing
The electrical equipment mainly consists of two non-current carrying parts. These parts are neutral of the system or frame of the electrical equipment. From the earthing of these two non-current carrying parts of the electrical system earthing can be classified into two types.

Neutral Earthing and Equipment Earthing.
In neutral earthing, the neutral of the system is directly connected to earth by the help of the GI wire. The neutral earthing is also called the system earthing. Such type of earthing is mostly provided to the system which has star winding. For example, the neutral earthing is provided in the generator, transformer, motor etc.

Equipment Earthing, Such type of earthing is provided to the electrical equipment. The noncurrent carrying part of the equipment like their metallic frame is connected to the earth by the help of the conducting wire. If any fault occurs in the apparatus, the short-circuit current to pass the earth by the help of wire. Thus, protect the system from damage. Importance of Earthing; the earthing is essential because of the following reasons;

- The earthing protects the personnel from the short-circuit current.
- The earthing provides the easiest path to the flow of short-circuit current even after the failure of the insulation.
- The earthing protects the apparatus and personnel from the high voltage surges and
- lightning discharge.
- Earthing can be done by electrically connecting the respective parts in the installation to some system of electrical conductors or electrodes placed near the soil or below the ground level. The earthing mat or electrode under the ground level have flat iron riser through which all the non-current-carrying metallic parts of the equipment are connected.

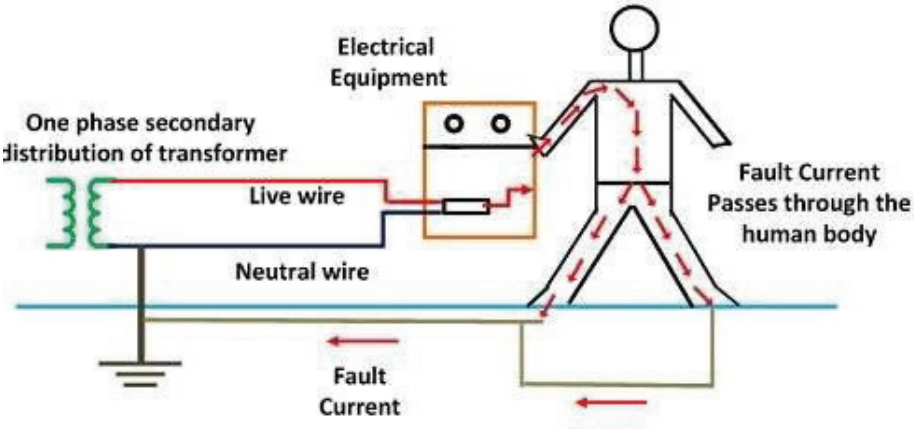


Figure 2.2a: Electrical system without Earthing
Source: https://circuitglobe.com/electrical-earthing.html

When the fault occurs the fault current from the equipment flows through the earthing system to the earth and thereby protect the equipment from the fault current. At the time of the fault, the earth mat conductors rise to the voltage which is equal to the resistance of the earth mat multiplied by a ground fault.

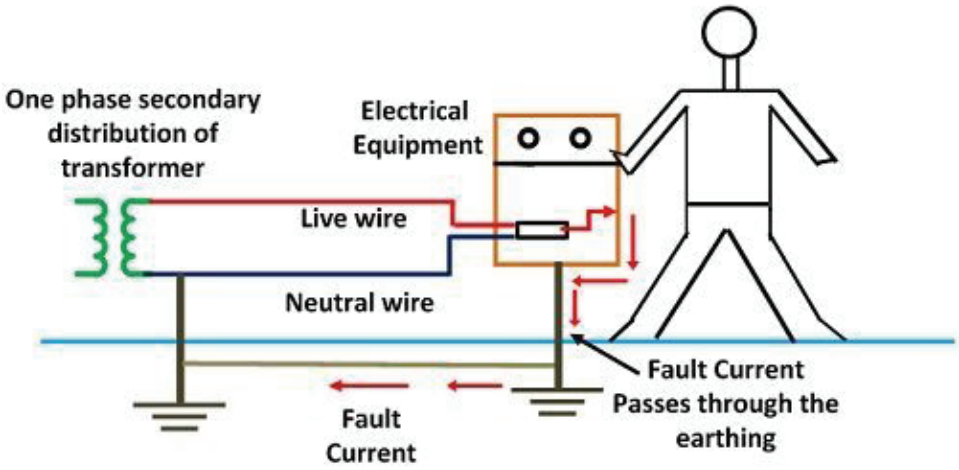


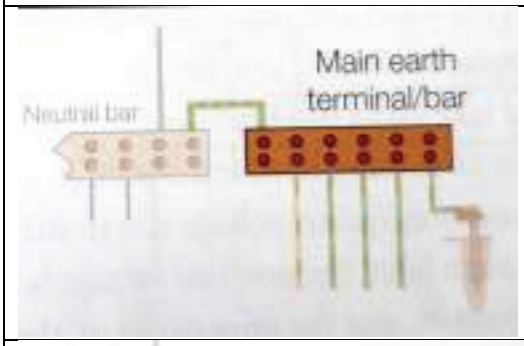
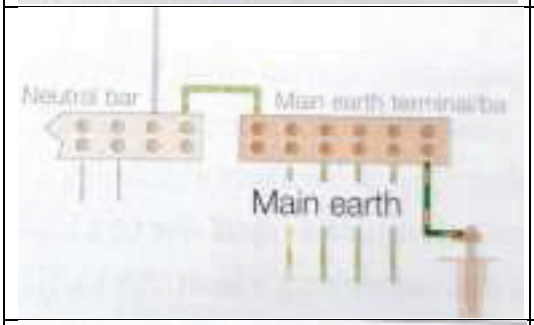
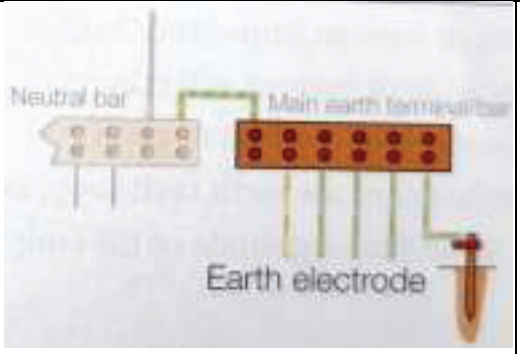
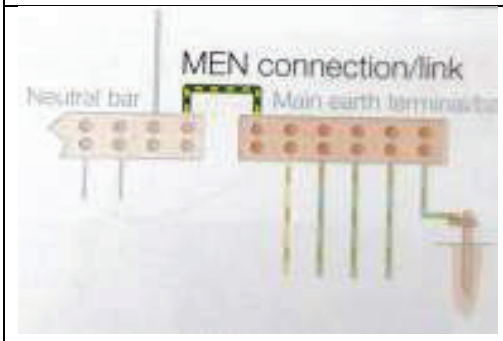
Figure 2.2b: Electrical System with Earthing
Source: https://circuitglobe.com/electrical-earthing.html

The contacting assembly is called earthing. The metallic conductors connecting the parts of the installation with the earthing are called electrical connection. The earthing and the earthing connection together called the earthing system.

MEN earthing system

The *Wiring Rules* requirements for proactive earthing are centred on the multiple earthed neutral (MEN) distribution system. In MEN system, the parts of each installation that are required to be earthed are connected to earth within the installation to the neutral conductor of the supply. The MEN system is a current-operated system. The system operates to isolate the faulty section of an installation when the value of the fault current is sufficient to operate the circuit protective devices; that is, to trip the circuit breaker or rupture the fuse.

Components of the MEN earthing system

Component	Function	Wiring Rules References
	The main earth terminal is the point where all parts required to be earthed are connected to earth via the main earthing conductor and earth electrode. The main earth terminal may be a soldered connection, a single terminal or a terminal at an earth bar.	Clause 5.3.4
	Main Earthing conductor connects the main earth terminal at the main switchboard to the earth electrode and thus to the mass earth	Table 5.1 Clause 5.3.3.2 Clause 5.5.1.2 Clause 5.5.1.3
	The earth electrode is a rod, cable or metal strip embedded in the earth as a means of connecting to the general mass of earth the parts of the electrical installation that are required to be earthed. The most common earth electrodes consist of a copper-sheathed steel rod driven into the ground. A number of alternatives are acceptable, such as a metallic strip buried horizontally in a trench or concrete footing or floor slab buried directly in the ground.	Clause 5.3.6
	The MEN connection or link is a conductor (generally a green-and yellow insulated cable) that connects the main earth terminal to the neutral link. At this point the separate protective earthing conductors and the neutral conductors in an installation are combined with the supply neutral to become a protective earth-neutral conductor. Most commonly the MEN link is at the main switchboard, but for a larger installation it could be in a substation.	Clause 5.3.5

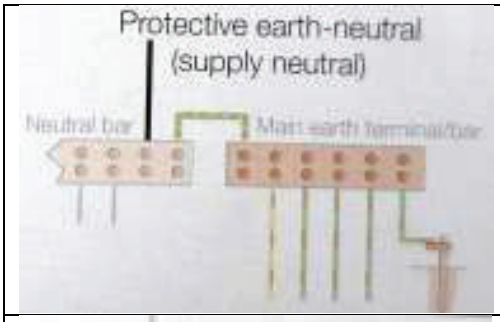
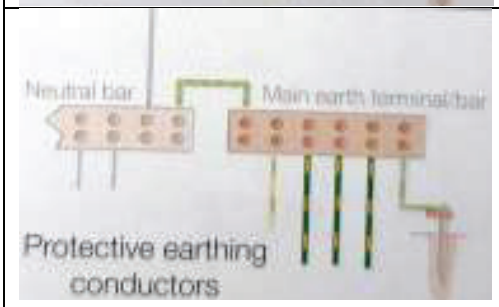
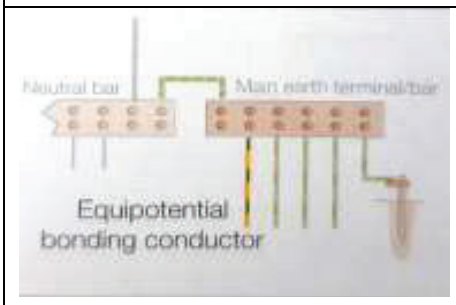
	The supply neutral acts as a protective earth and neutral conductor. It carries both the out-of balance return current from the installation under normal use and the fault current when an earth fault occurs.	Clause 5.1.3
	Protective earthing conductors, commonly green-and-yellow insulated cable are provided with each circuit to connect the associated exposed conductive parts to the main neutral and subsequently the main neutral and the mass of the earth. A protective earthing conductor is required at each socket outlet and light point. A protective earthing conductor does not always have to be a cable but may be metallic cable sheath or armouring.	Clause 5.3.2 Clause 5.3.3 Table 5.1 Clause 5.5.2
	Equipotential bonding conductors connect conductive parts that are not part of the electrical installation but which might be in contact with earth (known as extraneous conductive parts) to the earthing system of the installation. The point of this is to eliminate any potential difference that might occur between the extraneous and exposed conductive parts. A metallic water pipe and a metal pool fence are example of extraneous conductive parts.	Clause 5.6

Figure 2.2c: Components of MEN earthing system
Source: https://circuitglobe.com/electrical-earthing.html

EARTH FAULTS

Earth faults are faults that affect the operation of an electrical installation which can occur either;

- On the electricity supply system to the installation
- On an adjacent installation
- In wiring or accessories in an installation
- Within electrical apparatus.

Supply system faults are most often due to either;

- An open circuit of supply neutral

The supply neutral on the distribution side acts as protection and as a neutral conductor too and carries out-out of –balance current to the earth normalizing working conditions but having a poor connection can result in the earth fault.

- Reversed polarity of supply.

The active and neutral connection are been reversed at the point of supply which results in earth faults. Care should always be taken when making connections and quality check before testing.

Mistakes in Wiring

Carelessly installed wiring or wiring accessories can cause exposed conductive parts such as metallic enclosures to become live. This may seem petty but it is very important in avoiding earth faults.

Neutral-to-earth breakdown

Breakdown of the neutral-to-earth conductor constitutes another fault condition. In this case a residual current device (RCD) needs to be installed to reduce the likelihood of having earth faults.

EARTHING SYSTEM FOR SELECTION AND INSTALLATIONS

To achieve an adequate degree of protection, the earthing system must be installed in an efficient and electrically sound manner. Section 5 of the *Wiring Rules* describes the MEN earthing system and sets out requirements for protective earthing in that system in the logical manner.

Earthing conductor selection

Clause 5.5.1 relates earthing conductor sizes to the size of the largest active conductor, and the appropriate sizes are listed in table 5.1 of the *Wiring Rules.*

Earth electrodes and main earth

The minimum size for a main earthing conductor is 4mm² for copper. The main earthing conductor size is generally selected from Table 5.1 of the *Wiring Rules* in relation to the cross-sectional area of the active-phase conductor of the consumer's mains.

Earthing of equipment

In general, earthing of equipment is achieved by direct connection of a suitable earthing conductor, but there are some circumstances where other earthing mediums are permitted. The *Wiring Rules* under clause 5.4 require specific accessories and equipment to be earthed.

Separate MEN

A detached portion of a premises, say, another building which is called an 'outbuilding' in *Wiring Rules* be regarded as a separate MEN installation. Clause 5.5.3.1 and Section 8.4 of the *Wiring Rules* outlines these.

Unprotected Consumer's mains
The only position for interconnection of the main earthing conductor and the main neutral conductor is the main switchboard or at the substation (Clause 5.3.5). Where the Men link is at the main switchboard, some energy distributors might prefer it under seal in their link.

Earth connections
Connection methods and joints in the earth wires are restricted to those outlined in Clause 3.7.2.11.

Equipotential bonding
A very important part of earthing in an installation is the bonding of extraneous conductive parts to the earthing system to reduce the risk of a rise in potential between them. Extraneous conductive parts are not part of the electrical installation but maybe at local earth
potential (Clause 1.4.54)

Examples of earthed situations
If you have any doubt about whether the exposed conductive of a particular item of equipment should be earthed, apply the definition for an earthed situation, Clause 1.4.44.

Teaching and Learning Strategies
Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of electrical earthing system, specifically MEN system. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Introduction to Earthing system

Teaching Strategies
Students engage in brainstorming exercise to discover what earthing systems are in electrical wiring. They then are allowed to view a video on how earthing system is done. Discussions in groups to review the video shown.

Learning Strategies
Activity 1: Brainstorming activity.
Activity 2: Film viewing and review.
Activity 3: Discussions on the demonstration experience.

Resources
Electrical cables, circuit breakers and switches.

Lesson 2: MEN Earthing System

Teaching Strategies
Engage students in the discussion of MEN earthing system.

Learning Strategies
Discover the MEN earthing system, the types and the characteristics.

Activity 1: Use a model to discover the MEN system, the types and the characteristics.
Activity 2: Analyse the MEN system and present new knowledge learnt.
Activity 3: Observe how the MEN system works.

Resources
Electrical cables, circuit breakers and switches.

Lesson 3: Earth Faults

Teaching Strategies
Students are engaged in brainstorm activities to identify causes of Earth faults.
They are then allowed to discuss in their groups on findings of their work.

Learning Strategies
Conduct research with guiding questions that will lead to identify causes of Earth faults.

Activity 1: Brainstorm activity to identify the causes of Earth faults.
Activity 2: Conduct and present research findings on the causes of Earth faults.

Resources
Electrical cables, circuit breakers and switches.

Lesson 4: Earthing System for Selection and Installations

Teaching Strategies
Students are engaged in brainstorm activities on selection and installation of Earthing System.
They are then allowed to discuss in their groups on findings of their work

Learning Strategies
Conduct research with guiding questions that will lead to selection and installation of Earthing System

Activity 1: Brainstorm activity to identify selection and installation of Earthing System.
Activity 2: Conduct and present research findings on the selection and installation of Earthing System.

Resources
Electrical cables, circuit breakers and switches.

STEAM Activity Students work in groups to create an activity incorporating concepts of earthing systems.

Assessment

The main purpose of assessment is to find out if students can use the skill of synthesis to Social application of electricity, Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment

1. Conduct research into the social application of electricity to improving the quality of life and create a model displaying a solution to an identified electrical problem

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Research findings on the social application of electricity to improve quality of human life	Research findings show all the social applications of electricity to improve life.	Research findings show most the social applications of electricity to improve life.	Research findings show few the social applications of electricity to improve life.	Research findings show no social applications of electricity to improve life.
2. Identify solutions to electrical problems to improve social application of electricity	Model created show four solutions to electrical problems to improve social application of electricity.	Model created show three solutions to electrical problems to improve social application of electricity.	Model created show two solutions to electrical problems to improve social application of electricity.	Model created show one solution to electrical problems to improve social application of electricity.

UNIT 2: Electrical Technology

Content Standard 3.2 Investigate, analyse and apply the technological processes, concepts, principles and practices related to Electrical Technology and its social contribution with regard to economic growth, entrepreneurship, sustainability and as a tool for change, improving quality of life responsive to individual, community and industrial needs.

Benchmark 12.3.2.3 Employ correct handling and maintenance techniques in performing tasks using hand and power tools.

Topic 3: Hand and power tools

Learning Objectives
By the end of this topic, the students will be able to;

- Identify the hand and power tools.
- Identify the correct handling techniques of tools.
- Practice the correct handling techniques of tools.

Essential Questions:
1. What are the correct techniques in handling hand and power tools?
2. Why is it important for users to understand the safe handling of hand and power tools?
3. What are the consequences of not properly handling hand and power tools?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Hand and power tools	Investigate, explore and discover the names, and correct handling of hand and power tools.	Appreciate, and value correctness of using tools and safety.	Considerate and responsible and safety conscious.

Content Background

Electrical work can't be done without the right tools. As basic tools have been improved over the years and new specialised tools are developed, the list of tool choices for electricians becomes even longer. Even so, there's a short list of “must have” tools that every electrician needs-indeed, cannot do without-regardless of the type of electrical work he or she does.

1. Wire strippers
2. Insulated pliers
3. Insulated screwdrivers
4. Electrical tape
5. Hacksaws
6. Cable cutters
7. Spanners
8. Voltage tester
9. Safety knife
10. Hex keys
11. Claw Hammer
12. Chisel
13. Torch

Figure 2.3a: Electricians Tools
Source: https://au.rs-online.com/web/content/discovery/ideas-and-advice/electricians-tool-kit-guide

Hand Tools

Today's basics are better than older models, providing more comfort and safety than their predecessors. Manufacturers have made tools more 'ergonomically correct,' and improved designs to help cut down on hand and wrist injuries often caused by repetitive movement. Also, because the tools just feel more comfortable. While today's designs may provide more safety and comfort, they're still the basic hand tools electricians have been using for years."

- Pliers
- Side-Cutting Pliers
- Needle-Nose Stripping Tool
- Channel Locks
- Screwdrivers
- Claw Hammer
- Pipe Reamer
- Tape Measure

Power Tools

Whether corded or cordless, today's power tools pack more power in smaller, lightweight models. Ergonomic consideration makes today's tools easier and safer to use. "Cordless power tools," Rees said, "are enjoying greater acceptance because tool designs and recent improvements in battery and charger technology make them more convenient and versatile, making workers more productive."

- Power drills/hammer
- Heat guns
- Soldering irons
- Electric saws

Hand Tool Safety

Hand tools are non-powered. They include anything from axes to wrenches. The greatest hazards posed by hand tools result from misuse and improper maintenance. Appropriate personal protective equipment such as safety goggles, gloves, etc., should be worn due to hazards that may be encountered while using portable power tools and hand tools. Around flammable substances, sparks produced by iron and steel hand tools can be a dangerous ignition source. Where this hazard exists, spark-resistant tools made from brass, plastic, aluminium, or wood will provide for safety.

Power Tools Precautions

Power tools can be hazardous when improperly used. There are several types of power tools, based on the power source they use: electric, pneumatic, liquid fuel, hydraulic, and powder-actuated.

- Never carry a tool by the cord or hose.
- Never yank the cord or the hose to disconnect it from the receptacle.
- Keep cords and hoses away from heat, oil, and sharp edges.
- Disconnect tools when not in use, before servicing, and when changing accessories such as blades, bits and cutters.
- All observers should be kept at a safe distance away from the work area.
- Secure work with clamps or a vise, freeing both hands to operate the tool.
- Avoid accidental starting. The worker should not hold a finger on the switch button while carrying a plugged-in tool.
- Tools should be maintained with care. They should be kept sharp and clean for the best performance. Follow instructions in the user's manual for lubricating and changing accessories.
- Be sure to keep good footing and maintain good balance.

Almost every worker uses some type of tool during the day to accomplish tasks. Whether it’s a screwdriver or jack hammer, your role as a supervisor is to ensure, that the tools used for each job, are the right tool for that job. This includes making sure tools are used safely and are in good working condition.

Power Tool Safety

Tools may be powered by electricity, compressed air, hydraulics, belts or chain drives. Power used by tools to do work can possess a tremendous amount of energy that must be controlled by the worker using the tool. Hazards from tool power sources affect not only the person using it, but also to those working close by.

Maintenance of hand and power tools

Check Damages and Repair
Look at handles, tool edges, power cords, hoses & connections, switches, triggers, casings and attachments. Check hand tools for cracks dings and chips. Don't use damaged tools. Generally, hand tools cannot be repaired and should be thrown away. Power tools should not be jury rigged to work. Have repairs made only by someone who knows the tool repair craft

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Teaching and Learning Strategies
Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to practice safety and correctness in handling electrical tools. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Hand Tools

Teaching Strategies
Students engage in brainstorming exercise to discover electrical hand tools and their safe use. They then are allowed to design guiding questions that will enable them to conduct research on discussions in groups on the research findings.

Learning Strategies
Activity 1: Brainstorming activity on guiding questions for research on the basic hand tools, their
uses, the factors when selecting tools and the maintenance procedures for tool.
Activity 2: Conduct research on the basic hand tools, their uses, the factors when selecting tools \
and the maintenance procedures for tool.
Activity 3: Discussions and presentation of research findings.

Resources
Teacher Notes

Lesson 2: Power Tools

Teaching Strategies
Engage students in the discussion to compare the power sources used for power tools, power tools safety and how to operate portable power tools.
Discuss the operation of stationary wood working power tools.

Learning Strategies
Discover power sources used for power tools, their use and safety and the operation of stationary woodworking power tools.

Activity 1: Study a chart or handouts on the power sources used for power tools, their use and safety and the operation of stationary woodworking power tools and make comparisons.
Activity 2: Practice operating a power tool.
Activity 3: Discuss the operation of stationary woodworking power tools.

Resources
Teacher Notes

Lesson 3: Maintenance for Hand and Power Tools

Teaching Strategies
Discuss tool hazards and tool use responsibilities.
Engage the students to practice safe and proper work habits to master relevant safety tests, comply with safety guidelines as described in various manuals, instructions, and regulations. Identify and classify hazardous materials according to Occupational Safety and Health Administration (OSHA) regulations and industry standards.
Engage students in maintenance of power tools.

Learning Strategies
Guided discovery and discussion of tool hazards and responsibilities.

Activity 1: Discover tool hazards and responsibilities and discuss safety guidelines.
Activity 2: Practice safe and proper work habits to master relevant safety tests in compliance to safety guidelines.
Activity 3: Set up safety posters for the use of electrical tools and their proper maintenance.

Resources
Teacher Notes

STEAM Activity Students work in groups to create an activity incorporating concepts of safety guideline when using manual and power tools.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to apply safety in using manual and power electrical tools. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment

1. Identify the safe use of manual and power electrical tools.
2. Outline maintenance and management of electrical tools.
3. Analyse abuse and misuse of electrical tools and the effects.

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Identify the safe use of manual and power electrical tools.	Excellently identify the safe use of manual and power electrical tools with examples.	Correctly identify the safe use of manual and power electrical tools.	Partially Identify the safe use of manual and power electrical tools.	Cannot identify the safe use of manual and power electrical tools.
2. Outline maintenance and management of electrical tools.	Excellently outline maintenance and management of electrical tools with examples.	Correctly outline maintenance and management of electrical tools.	Partially outline maintenance and management of electrical tools.	Cannot outline maintenance and management of electrical tools.
3. Analyse abuse and misuse of electrical tools and the effects.	Excellently analyse abuse and misuse of electrical tools and the effects with examples.	Correctly analyse abuse and misuse of electrical tools and the effects.	Partially analyse abuse and misuse of electrical tools and the effects.	Cannot analyse abuse and misuse of electrical tools and the effects.

UNIT 2: Electrical Technology

Content Standard 3.2 Investigate, analyse and apply the technological processes, concepts, principles and practices related to Electrical Technology and its social contribution with regard to economic growth, entrepreneurship, sustainability and as a tool for change, improving quality of life responsive to individual, community and industrial needs.

Benchmark 12.3.2.4 Analyse the process of installing a circuit breaker and a meter box and install the different types of switching circuits for switch points to control light points.

Topic 4:Circuit Installations

Learning Objectives
By the end of this topic, the students will be able to;

- Explain single phase and three phase.
- Distinguish single phase from three phase and identify significant components and functions in
  installations.

Essential Questions:
1. What are circuit installations?
2. What is a single phase and three phase circuits?
3. What is the difference between single phase and three phase circuits?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Single phase and three phase	Distinguish single phase from three phase	Appreciate and value significant components and functions in installations.	Considerate and responsible

Content Background

Installation of circuit breaker and meter box

Circuit breakers are devices designed to regulate the flow of electricity throughout your home. Breakers cut the flow of electricity in the event of an overloaded current and eliminate the risk of fires, burned wiring, and ruined appliances. Circuit breakers are housed in a main switch board. Most main Switch Board are found in basements, utility rooms and laundry rooms. Call a professional and certified electrician to help you find your main switch board if you're unsure where it's located.

Installing a New Breaker

Once you've identified the faulty breaker, it's time to install a replacement. Here's a step-by step guide:

i. Power down. Shut off your branch circuit breakers one at a time. Next, turn off the power to your breaker box by flipping the power main. Your power main should be large switch above or below your breaker panel. Call a professional if you're unsure how to locate your power main.
ii. Remove the panel cover. Unscrew the panel cover to gain access to the breakers.
iii. Loosen the terminal screws. Turn the screws until the terminal and wires are loose. Pull the wires out of the breaker terminals.
iv. Remove the breaker. Press the breaker handle toward the outside of the breaker panel until it comes loose.

v. Install your new breaker. Line up your new breaker with the clips on the side of the bus bar. Press the breaker down firmly until it snaps in place. Reconnect the wires to the terminal screws and replace your panel cover.
vi. Power up. Turn on the branch circuit breakers and your power main.

When to call a professional assistance
Installing a new breaker is a simple DIY job. But certain circumstances can present a real danger to you and your home. Always call a professional or certified electrical tradesman if you're unsure about replacing your breaker or notice dangerous signs like moisture, burns or corrosion around your breaker box.

Basic Steps for installing a new circuit breaker.

The main reason for installing a new circuit breaker in an existing home is to take some of the load off of another circuit breaker. If there is one circuit breaker that is connected to too many electrical devices then it may be wise to install another circuit breaker and split the burden.
i. Shut off the power at the main panel. It is extremely important to make sure the circuit breaker panels or sub-panels do not have any live wires. Homeowners who are not experienced with electricity should not attempt to work with electrical wiring. When the power is shut off, unscrew the breaker panel. The large black wires that feed the main breaker will still be live so you need to test the incoming wires with an electrical tester to make sure there is no electrical current in the wires that you will be touching. This will help you make sure it is safe to begin installation.
ii. Install a new cable clamp. In order to do this, you will need to locate the knockout around the panel and use a screw driver to hammer one of the knockouts so that you can screw the cable clamp in. Next, run the new wire to the circuit panel and cut the wire off the jack to the circuit clamp.
iii. Connect the ground wire into the ground bar. The ground wire is the wire without insulation. The tightening should be done carefully in order to prevent the wire from breaking.

iv. Place the neutral wire into the neutral bus. Cut off the insulation around the end of the wire and slide the bare wire into the neutral bus, tightening it gently.
v. Install the actual circuit breaker device. To do this you loosen the screw on the bottom of the breaker and place the last wire under the screw; this wire will be black. When the black wire is in place, tighten the screw and hold the wire in place. Use the three prongs on the backside of the circuit breaker to hold it in position. Align the breaker in the space and push the prongs in. Make sure the breaker is secure.
vi. Remove the knockouts from the panel cover and place it over the circuit panel in order to secure and protect all of the circuit breakers. Circuit breaker installation is typically done by a professional specialising in electrical procedures.

Circuit Breaker Installation: Electrical Wiring rules and Electrical Codes
New electrical wires or circuit breakers and other electrical equipment in the home need to meet the Standards used by PNG Power. This electrical code is a nationwide set of requirements. Electrical work has to be up-to-code in order to pass an inspection. Most electrical work, like upgrading a circuit breaker panel or running new electrical wire in the house, requires a permit and city inspection. If you attempt to do major electrical changes in your home and do not get a permit, you could be subject to fines and other repercussions. The AS/NZS Standards or code was developed to protect consumers and homeowners from dishonest contractors and wiring mistakes that could result in fire risk, electrocution or fatal accidents. The electrical code is updated periodically and any new work is required to meet the new code specifications.

STEPS OF INSTALLING A METER BOX
The electric meter measures the amount of electricity that is used by your home or business, which tracks it by a rate of kilowatts per hour as is the electric companies billing unit of measurement. Installing a new electric meter box is not the most difficult electrical element to replace, but it needs to be done with extreme diligence since the risk of electrocution is always a possibility.

Step 1 – Turn Off all of the Electrical Appliances
To make sure that none of your electrical appliances can short out or get damaged you should go around your house or business and ensure that anything that is electrical is turned off and unplugged. Also, turn off all lights and make sure that there is nothing that is extremely perishable in the refrigerator or freezer since your power will be shut off for a certain amount of time.

Step 2 – Call your Electric Company
You need to call your electricity provider and ask them to shut off all power to your home or business. Do not attempt to install a new electric meter box without ensuring that there is no electricity running to your household or business. Not following this step is very dangerous. Also, you will be cutting a security tag off of the meter so the electric company will need to know that they need to issue you a new one.

Step 3 – Disconnect the High-Voltage Feed and Ground Wire
Use the wrench to unscrew the covering to the high-voltage feed and the covering to the ground wire. Since your electricity is shut off you shouldn't have a problem with this step.

Step 4 – Cut the Security Tag and Remove the Old Meter
Use the wire cutters to cut off the security tag, which will allow you to remove the meter. Pull the meter toward you and remove it from the socket. From here you will see the connection terminals and the ground wire that are all held in place by a clamp-like holder, which is pieced together by a screw. These terminals are in sets of three — one set called the line side and is connected to the service pole and the other is the load side which is connected to your home or business.

Step 5 – Remove Insulation
If there is a layer of insulation on the terminals then use the wire stripper to remove a section of it near the end. Once you do this you will see that the two outside wires on each set are black (these are hot wires) and the middle wires will be white or have white tape around it (this is the neutral wire). If you need to use the screwdriver to unscrew the clamp so that you can get to the insulation then screw them back into place.

Step 6: Connect Wires to the New Electric Meter
Connect the wires to the corresponding places on your new electrical meter by slipping them into the appropriate spot and screwing it down with the screwdriver. The line side wires should connect to the upper terminals on the new meter, while the bottom terminals are for the load side wires.

Step 7 – Reconnect the High-Voltage Feed and Ground Wire
Place the new meter into the socket and reconnect the high-voltage feed and ground wire. Before turning your power back on, it is highly recommended that you get an electrician or related professional to look over your installation. This is to ensure that everything has been done properly and that it will not cause any damage to your property or any harm to yourself or family.

Installations of switching circuits

One-Way switching circuit
This circuit uses a switch to control a light point.

Two-Way Switching Circuit
This circuit uses two switch points to control a light point

Multi-way Switching
In building wiring, multiway switching is interconnection of two or more light switches to control lighting from more than one location. This allows lighting in a hallway or stairwell to be controlled from either end. Three-way and four-way switches make it possible to control a light from multiple locations, such as the top and bottom of a stairway, or either end of a long hallway. These switches are externally similar to single-pole switches, but have extra

connections which allow two circuits to be controlled. Toggling the switch disconnects one circuit and connects the other.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to understand safety and the danger in electrical wirings. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Installation of Circuit Breakers and Meter Box

Teaching Strategies

Students engage in brainstorming exercise to discover the installation procedures of circuit breakers and meter box.
They then are allowed to design guiding questions that will enable them to conduct research on the installation of circuit breakers.
Discussions in groups on the research findings.

Learning Strategies

Activity 1: Brainstorming activity to discover the installation procedures of circuit breakers and meter box.
Activity 2: Conduct research to discover the installation procedures of circuit breakers and meter box.
Activity 3: Discussions and presentation of research findings.

Resources

Teacher Notes

Lesson 2: Installation of Switching Circuits

Teaching Strategies

Engage students in presentation of installations.
Engage students in the discussion on installation of circuit breaker and meter box.
Engage students in the discussions and setting out the steps in correctly and safely install switching circuits.

Learning Strategies

Discover the safe steps in installing switching circuits.

Activity 1: Discuss and analyse installation of circuit breakers and meter box.
Activity 2: Discuss and analyse safe installation of switching circuits.
Activity 3: Develop step by step poster on the installation of switching circuits safely.

Resources
Teacher Notes

Lesson 3: Installations of Other Circuits
Discover the safe steps in installing other circuits.

Teaching Strategies
Guided Discovery of installing other circuits

Learning Strategies
Discuss what other circuits are and define them.

Activity 1: Using prior knowledge from previous lessons define other circuits.
Activity 2: Discuss what the other circuits are and how they operate.
Activity 3: Practice installs other circuits.

Resources
Teacher Notes

STEAM Activity Students work in groups to create a circuit board for a simple electrical appliance.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to installations. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Define circuits
2. Install circuit breakers using the correct procedures
3. Apply safety practices during installations

Performance Assessment Scoring
Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. define circuits	Accurately define circuits	Correctly define circuits	Poorly define circuits	Cannot define circuits
2. install circuit breakers using the correct procedures	Accurately install circuit breakers using the correct procedures	Correctly install circuit breakers using the correct procedures	Poorly install circuit breakers using the correct procedures	Cannot install circuit breakers using the correct procedures
3. apply safety practices during installations	Competently apply safety practices during installations	Correctly apply safety practices during installations	Poorly apply safety practices during installations	Cannot apply safety practices during installations

UNIT 2: Electrical Technology

Content Standard 3.2 Investigate, analyse and apply the technological processes, concepts, principles and practices related to Electrical Technology and its social contribution with regard to economic growth, entrepreneurship, sustainability and as a tool for change, improving quality of life responsive to individual, community and industrial needs.

Benchmark 12.3.2.5 Safely conduct dead and live tests on circuits and apply electrical energy to assess and evaluate circuits.

Topic 5: Circuit Testing and Verification

Learning Objectives
By the end of this topic, the students will be able to;

- Objectively define circuit testing and verification.
- Investigate circuit testing and verification.

Essential Questions:
1. What is circuit testing and verification?
2. How are testing and verification carried out?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Circuit diagrams, floor plans	Investigate, explore and discover circuit testing and verification.	Appreciate, value, safety for the consumer, homeowner, properties and others.	Considerate and responsible to understand the importance of engaging certified electrical tradesman in any electrical work.

Content Background

Testing Principle and Safety
As with many activities involved in electrical work, control measures to limit the risk of death or injury, testing principles must be followed when testing electrical circuits and equipment. Before testing electrical circuits, it is imperative that hazards be identified, the risks are assessed and safe work methods are developed that could eliminate or reduce or control the risk, particularly inadvertent contact with energized parts. Approved testing devices are used and persons conducting the test are competent to do so. Proper PPE must be worn before testing is carried out. The equipment needed for testing should be made available before conducting test and most importantly safe testing techniques should be employed to do testing. Apart from evaluating how well an electrical installation, circuit or equipment is operating; the purpose of electrical testing is to locate faults. This is whether conducting

verification tests on new or existing installations or responding to a reported electrical breakdown or fault. Underlying the ability to test electrical circuits and find faults is a sound understanding of;

- Ohm's Law
- The characteristics of series and parallel circuits
- The characteristics of electrical control devices and appliances
- How wiring for various types of circuits is arranged.

All Electrical testing methods employ the same basic principle, of connecting an electrical energy source to a circuit to be tested and using electrical indicators or measuring instruments to observe how the circuit behaves. This includes De-energised testing and energised testings.

Testing Devices

The most common electrical testing devices for electricians comprise those that give a visual/ audible indication of the effect being tested and those that measure the actual voltage, current or resistance of a circuit. Testing devices comes in analogue and digital. Analogue meters are read and a bit of calculations are done to arrive at the circuit quantities such as voltage, current or resistance.
Testing devices include;

1. Ammeters – for measuring current
2. Insulation testers (ohmmeters)
3. Voltmeters

Testing devices are used with the id of their accessories such as test leads, probes and clips, current lamps, temperature and electronic testing accessories.

Verification and Compliance

Any new installation or addition or major repair to an existing installation must be tested and checked to ensure that it is safe and complies with regulations. This must be done before the new work is connected to the supply. Testing and checking the installation is the responsibility of the electrical contractor or electrician carrying out the installation work, who must notify PNG Power in writing that the installation is safe, complies with regulations and is ready for connection to the supply. Basic compliance testing comprehensive guide in AS/NZS3017:2007 Electrical Installations – verification guidelines. The following are tested and verified;

- Earthing systems
- Insulation resistance
- Correct polarity
- Correctness of wiring circuits and connections
- Testing the operation of residual current devices (RCDs)
- Verification of the testing process, devices and accessories
- Appliance testing

Fault Finding and Diagnosis

Fault finding goes more deeper in the process in not only identifying or locating faults but a methodical process is followed to understand the nature of faults, consider the possible causes and decide the actions to be taken in locating and solving faults.

Fault symptoms and possible causes

Symptoms	Possible cause	Investigate further for
Fuse blown or circuit breaker tripped	Overload Short circuit between actives, active to protective earth or neutral	Too much connected load on a circuit Damage to wiring by others doing non electrical work Faulty connections at the switchboard, accessories or current-using devices. Damaged or deteriorated wiring (usually in older installations
Current –using devices does not operate with circuit energized.	Human Error Faulty current-using devices Control devices not operating Open-circuited supply	A switch operated incorrectly Internal open circuit Mechanical fault Faulty control devices (field switches sensors and the like) Faulty control switches Open circuited control circuit wiring Faulty connection at accessories or current using devices. Open circuited power wiring
Switch is not operating correctly	Short or open circuit	Faulty connection at accessories Faulty control wiring
RCD (known to consumers as safety switch) constantly trips	Leakage current too high	Faulty current-using device Too many current-using devices on the circuit.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of circuit testing and verification. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Testing Principle and Safety

Teaching Strategies

Students engage in brainstorming exercise to discover electrical testing principles and safety.

They then are allowed to design guiding questions that will enable them to conduct research on electrical testing principles and safety.
Discussions in groups on the research findings on electrical testing principles and safety.

Learning Strategies
Activity 1: Discuss and brainstorm the principles of testing and safety.
Activity 2: Conduct research on the principles of testing and safety.
Activity 3: Presentation and discussions of research findings using a chart or if possible a ppt presentation.

Resources
Teacher Notes

Lesson 2: Testing Devices

Teaching Strategies
Engage students in discussion as analysing testing devices on an electrical appliance.
Engage students in the discussion of how a testing device works in the maintenance of an electrical appliance.

Learning Strategies
Students engage in collecting all information on how a testing device works.
Analyse how a testing device works on in the maintenance of an electrical appliance.

Activity 1: Collection of information on testing devices and how they work.
Activity 2: Analyse how a testing device works in the maintenance of an electrical appliance.
Activity 3: Use testing device on an electrical appliance for maintenance.

Resources
Teacher Notes

Lesson 3: Verification and Compliance

Teaching Strategies
Guided Discovery of verification and compliance regulations for installation in the electrical industry or PNGPOWER/National Energy Authority.

Learning Strategies
Conduct research and do presentation.

Activity 1: Brainstorm guiding questions on the regulations of verification and compliance
Activity 2: Conduct research on the verification and compliance regulation in PNG and abroad.
Activity 3: Do presentations and compare the verification and compliance regulations in PNG and abroad and draw conclusions of compatibility in electrical installations.

Resources
Teacher Notes

Lesson 4: Fault Finding and Diagnosis

Teaching Strategies
Teachers introduce students to a system of fault finding and how to diagnose faults. Develop a system for finding the faults and how to diagnose a problem based on how an electrical appliance operates. (by its user manual)

Learning Strategies
Conduct a research with guiding questions that will lead to discovering what the finding faults and diagnosing a problem is.

Activity 1: Discussions on devising guiding questions for research on finding faults and diagnosing a problem correctly in an electrical appliance.
Activity 2: Conduct the research.
Activity 3: Use the research findings to develop a system to find faults and correctly diagnose the problem in an electrical appliance.

Resources
Teacher Notes

STEAM Activity Students work in groups to create an activity incorporating concepts of circuit testing and verification.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to circuit testing Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Types of circuits
2. Compliance and installation standards
3. Verification standards

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Identify types of circuits	Accurately identify the different types of circuits	Correctly identify the different types of circuits	Partially identify the different types of circuits	Cannot identify the different types of circuits
2. Comply with compliance and installation standards	Accurately comply with compliance and installation standards	Correctly comply with compliance and installation standards	Partially comply with compliance and installation standards	Cannot comply with compliance and installation standards
3. Explain verification standards	Accurately explain of verification standards	Correctly explain of verification standards	Partially explain of verification standards	Cannot explain of verification standards

UNIT 2: Electrical Technology

Content Standard 3.2 Investigate, analyse and apply the technological processes, concepts, principles and practices related to Electrical Technology and its social contribution with regard to economic growth, entrepreneurship, sustainability and as a tool for change, improving quality of life responsive to individual, community and industrial needs.

Benchmark 12.3.2.6 Apply knowledge and skills in troubleshooting, repairing and maintenance of electrical products, appliances and components of electrical systems.

Topic 6: Maintenance

Learning Objectives
By the end of this topic, the students will be able to;

- Explain the installation process
- List and explain the electrical accessories, materials and tools used in the installation process.

Essential Questions:
1. What is the installation process?
2. How are electrical appliances maintained?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Electrical Installation, Electrical materials, accessories and tools.	Explore, analyse	Considerate and cautious when understanding electrical troubleshooting.	Value, and responsible

Content Background

Electrical Troubleshooting, Diagnosis, and Repair Steps
An electrician has to perform a certain method to find out what is causing the problem in your electrical system, and identifying the problem is key to getting it fixed. Here are some of the steps that are commonly followed by electricians when they have to troubleshoot the problem.

Information Gathering
The first step to electrical troubleshooting is gathering as much information as possible about the fault or the appliance that is malfunctioning. First and foremost, the electrician checks if there is an owner's manual or technical documentation for the system, fixture, or appliance. This would have all the information that they may need to troubleshoot the problem, along with possible steps that they can follow.

Moreover, this documentation will also contain the wiring diagram for the electrical fixture, and it helps electricians match it against the actual wiring so that they can find what may be causing the problem. Apart from this, the information gathering process also involves focusing on the proper operation of the fixture, i.e. how it should normally work. Moreover, you should also provide them any information about prior repairs or maintenance work that may have been done on the fixture.

Understanding the Fault

The next step involves how the electrical fixture is malfunctioning, and this can be done by understanding how the fixture or appliance actually works. Once you know its proper function, you can find out which part of the fixture isn't working properly or causing a disruption in its normal function. Basically, you need to determine what the proper operation is, and which function of the operation isn't working the way it should.

Once you have gathered this information, the next step is to determine the possible causes for this malfunction. Any electrical fixture consists of various components and parts that work together and ensure smooth operation. Once the malfunction is detected and its root cause is isolated, this makes it very easy for the electrician to proceed to the next steps.

Evaluating Parameters

Moving on, detecting the malfunction is followed by determining the parameters that the electrician needs to examine in order to zero in on the fault. Electrical fixtures have various parts that send a signal to the main circuit board, and this ensures its proper function. So, the electrician has to identify which of these signals they have to examine.

One thing that electricians do is to measure the input and output signals of the electrical fixture that they have to troubleshoot. For this, they have to know the correct input and output signal values, which enables them to find out which component isn't sending the full signal as it should. Once the input signals are sent, the output value is measured, and the electrician identifies any delays or interruptions in the process.

In a nutshell, the electrician determines the measurable parameters and their expected values for proper operation. Then, they have to find out the right equipment to measure the input and output signals. Once these values are measured, they will be able to know better about which component may be at fault.

Identifying the Problem

To identify the root of the problem, the electrician separates the electrical components from one another and examines them according to the parameters determined in the previous section. Next, the electrician checks each component according to the signal it sends or receives from the circuit. By isolating these components, they will be able to identify which component is causing the malfunction.

If electricians don't have access to technical data or the preferred input and output signal values, they can measure the current or signals of two similar electrical components or fixtures, and if they match, the component seems to be working fine. However, if there is an anomaly, then you can identify the malfunctioning component much easier.

Repairing the Component
Once the above steps are completed, the electrician should be able to isolate or remove the malfunctioning or broken component from the electrical fixture, or they should have sufficient diagnostic data to be able to determine what needs to be done to fix the problem properly. Once the component is repaired or a new one has been bought, the electrician will install it into the fixture.
After this step is completed, the electrician can repeat the troubleshooting steps to determine whether the newly repaired or replaced component works perfectly and has restored the machine to its original and proper function.

Verifying the Repair
Once the repair process has been completed, the electricians have to troubleshoot the electrical fixture once again to determine that their repairs have proven to be useful. The entire troubleshooting, diagnosis, and repair process involve a lot of troubleshooting and testing, which takes up a lot of time. However, this is highly important, as it will ensure that there aren't any other problems that may pop up later in your electrical fixtures.
Repeated testing and verification also ensures that the same component won't malfunction in the future, as it can set you back a lot of money if you have to hire an electrician in Vancouver to carry out the repairs repeatedly.

Analysing the Root Cause
By this step, you have completed the electrical troubleshooting, diagnosis, and repair process successfully and the electrical fixture should be working properly by now. The last step requires the electrician to single out the root cause of the failure, i.e. whether the machine failed prematurely, or there was a certain component that requires periodic maintenance or replacement.
Sometimes, certain components have to be replaced, and if their replacement date is overdue, the machine may start to malfunction. Therefore, the electrician will be able to single out the root cause, and it helps you to understand any future problems that may arise. These are the most common steps involved in the electrical troubleshooting, diagnosis, and repair process.

Importance of regular maintenance

The electrical wiring of your home is largely out of sight, and this is one of the reasons why its maintenance is often set aside. Over time, the wires suffer wear and tear and it impacts on the equipment and appliances that operate on the circuit. Eventually, you will have to deal with electrical problems more frequently that you used to. The best thing to do to avoid such complications is to hire a licensed electrician for regular electrical maintenance. Once you find a good electrician, it will be easier to perform an annual inspection of your property's power system.

Here are some of the benefits of regular inspection to your property's electrical works.

1. Reduced Energy Cost
When appliances are working properly, they use less energy, which in turn will save you some money. Out-dated electrical systems and faulty appliances may have to use more power to continue working, which can drive up your electric bill. By letting an electrician perform maintenance works regularly, your electrical system and items at home are kept in their best working condition. Plus, your electrician can recommend ways to further save energy with the use of today's technological advancements.

2. Protection of Appliances
Whether you're using a mini fridge or a four-door fridge at home, you've spent good amount of money to buy it, so of course you would want to make good use out of it. Not having regular maintenance by a licensed electrician services is like waiting for an appliance to die before its lifetime. Each piece of equipment you have at home comes with a manual that states their recommended maintenance works and how often it should be done. Discuss this with your electrician in Singapore so he can schedule his visits accordingly.

3. Fire Safety
Electrical incidents and wirings usually spark home fires. Out-dated electrical systems, wirings and fixtures are usually the root cause of these accidents. Having an annual check-up of your power system will ensure that the power source, electrical lines, wirings and outlets are up to date and are functioning properly.

4. Safety of Occupants
Periodic inspections done by reputable electrician services companies always include inspections for possibility of electrical shocks, power overloading, out-dated or faulty wiring and fire hazards. The safety of your family and anyone occupying the property is definitely at risk when you choose to skip regular maintenance of your home's electrical works.

5. Continuous Productivity
If you are looking to maintain the comfort of your home or the productivity of your business, a major electrical problem can cause a major problem. Electricity runs your appliances, including the most important ones like the air conditioning system, refrigerator and your desktop computer. If the damage has worsened, it may take a few days to get the power working again. This means less productivity, especially for those working from home, and discomfort in times when you should already be relaxing after a long tiring day.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of electrical maintenance. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Repairing and Troubleshooting

Teaching Strategies

Students engage in brainstorming exercise to discover what is repairing and trouble shooting in maintenance.

They then are allowed to design guiding questions that will enable them to conduct research on Discussions in groups on the research findings.

Learning Strategies

Activity 1: Brainstorming activity on repairing and trouble shooting in maintenance.
Activity 2: Conduct research on repairing and trouble shooting.
Activity 3: Discussions and presentation of research findings of research conducted.

Resources

Teacher Notes

Lesson 2: Importance of Regular Maintenance

Teaching Strategies

Engage students in presentation of regular maintenance and its importance.

Engage students in the discussion of the presentation on the importance of regular maintenance.

Learning Strategies

Discover the importance of regular maintenance in electrical settings.

Activity 1: Collect information on the maintenance in electrical settings.
Activity 2: Analyse and discuss the importance of maintenance in electrical settings.
Activity 3: Set up a strategy manual for strict maintenance in electrical settings and how they are important**.**

Resources
Teacher Notes

STEAM Activity Students work in groups to create dragonfly torchlight.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to the maintenance of electrical appliances. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Trouble shooting of electrical appliance
2. Diagnose faults with good explanation
3. Work plan to work on maintenance of a faulty appliance.

Performance Assessment Scoring
Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Trouble shooting of electrical appliance	Accurate trouble shooting of electrical appliance	Correct trouble shooting of electrical appliance	Just able to do trouble shooting of electrical appliance	Cannot do trouble shooting of electrical appliance
2. Diagnose faults with good explanation	Accurately diagnose faults with good explanation	Correctly diagnose faults with good explanation	2. diagnose faults with good explanation	Cannot diagnose faults with good explanation
3. Create a work plan to work on maintenance of a faulty appliance.	Accurately create a Work plan to work on maintenance of a faulty appliance.	Correctly create a work plan to work on maintenance of a faulty appliance.	Just able to create a work plan to work on maintenance of a faulty appliance.	Cannot create a work plan to work on maintenance of a faulty appliance.

Unit 3: Plumbing Technology

Unit	Topic	Lesson Titles
3.Plumbing Technology	**Topic 1:** Plumbing Project Management	1. Plumbing Project Management 2. Project Management Principle and Process 3. Types of Management Process 4. The Role of Project Manager
	Topic 2: Introduction to OHS On-Site	1. OHS On- Site 2. Types of Hazards on site 3. Type of Personal Protective Equipment used On-Site 4. The Role of OHS officer On-Site 5. Methods of controlling Hazard on site and workplace
	Topic 3: Introduction to Plumbing Trade Math	1. Applied Math in Plumbing 2. Method of Calculating Water Distribution System, DWV system 3. Methods of Preparing Plumbing Material List 4. The Role of the Estimator
	Topic 4: Installation of plumbing fitting and accessories-water distribution system, DWV system	1. Method of Analysing Plumbing Fitting and Accessories to Specific Task 2. Methods of Installation and Connection of Water Distribution System 3. Methods of installation and connection, Drain, Waste, Vent System to Existing Plumbing System

UNIT 3: Plumbing Technology

Content Standard 3.3 Investigate and analyse the concepts and underlying theories in plumbing materials tools and equipment.

Benchmark 12.3.3.1 Explore and apply plumbing project management principles and process.

Topic 1: Plumbing Project Management

Learning Objectives
By the end of this topic, the students will be able to;

- Define plumbing project management
- Analyse and describe the Project management principle and process

Essential Questions:
1. What is plumbing project management?
2. What are the Project management principle and process?
3. What are the types of management process?
4. What is the role of project Manager?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Plumbing project management	Apply principles and processes of plumbing project management	Tolerant and considerate with project management knowledge to apply on a project.	Appreciate the importance of plumbing project management

Content Background

Plumbing project management is the process of directing and giving instruction to peoples or managing resources to use techniques to achieve the aims and objectives of company/project. The administering or managing the project in a certain plumbing project is to manage and control resources effectively, efficiently to minimise cost and maximise the earning to be successful in completion of the project. They are so many roles and responsibilities for a project manager to do in plumbing profession or trade. The common roles and responsibilities are bidding process, negotiations of project cost, ensure that the project is worth and estimated costs are to a minimum to complete the project successfully on the time frame given.

Plumbing project management
Project management is the process of planning, organising, and managing resources to bring about the successful completion of specific project goals and objectives. It is the application of knowledge, skills, tools and techniques to project activities to meet project requirements. The most important thing for any project manager is to have a clear understanding of the project's goals and objectives, as well as the specific steps needed to achieve them.

Project management principle and process

a. Project management is an investment.

b. People problems cannot be solved by software. Make sure everyone's viewpoints are heard and that everyone agrees to respect the course of action, even if as individuals, they would have made a different decision.

c. Value for what is to be done. If there is value it must be done.

d. Choose the right management to and use it.

e. Communication is paramount. Use the best communication tool that everyone on the team hears the project manager.

As discussed on the underlying principles at play in the world of project management, as the project manager, one will need to make a lot of choices: which tools to use, how to communicate with your team and your clients, and how best to design your work processes—among other things! Making the right decisions about which processes and tools to be used use is going to be your most important job as a project manager.

These four aspects (time, budget, scope, and quality) make up what's known as the balance quadrant. The balance quadrant demonstrates the interrelationship between the four aspects and how a change to one aspect will unbalance the quadrant. For instance, an increase in the project's scope will have an impact on the time, the cost, and the quality of the project.2 In practice, any project decision you or your clients make will have an impact on these four aspects—will it make the project more expensive, take longer, be of lower or higher quality, or affect its scope?

Essentially, project management is a set of skills and tools that will help you get the project right in every way.

Understanding the Project Life Cycle

The generic project life cycle is fairly simple—first you start the project (called Initiating), then you go on to actually do the project (through the Planning, Executing, and Controlling phases, which form a loop), and finally you finish with everyone happy, a strategy for the future in place, and a check in your hand (Closing). This process is illustrated in Figure 1.2

Figure 3.1a. The project life cycle
Source: https://www.method123.com/project-lifecycle.php

The Role of a Project Manager

Plumbing project managers are responsible for overseeing the installation of plumbing systems in residential and commercial buildings. They're often tasked with managing a team of plumbers, pipefitters, and other tradespeople who work together to install new water supply lines, sewer connections, or other types of plumbing fixtures.

Plumbing project managers must be able to effectively communicate with all members of their team. This includes giving clear instructions about what needs to be done and answering questions from individual workers about how they should go about completing their assigned tasks.

Plumbing Project Manager Job Duties

A plumbing project manager typically has a wide range of responsibilities, which can include:

- Managing the installation of equipment such as water heaters, furnaces, boilers, and radiators
- Managing and overseeing contractors who are hired to complete projects
- Scheduling the work team to ensure that deadlines are met
- Ensuring that all permits are obtained from local authorities prior to beginning work on any project
- Making sure that all plumbing work complies with local building codes and regulations
- Reviewing blueprints and building plans to determine construction requirements
- Managing and overseeing the bidding process for new construction projects
- Managing relationships with contractors, vendors, and subcontractors
- Coordinating with architects and designers to ensure that design plans meet code requirements

Plumbing Project Manager Skills

Plumbing project managers need the following skills;

Communication: As a project manager, you need to communicate with many different people throughout the day. You need to be able to communicate with clients, other project managers and team members. You also need to be able to communicate with suppliers and contractors. Effective communication is an important skill for a plumbing project manager.

Organisation: A plumbing project manager needs to be organised to ensure they meet deadlines and stay within budget. They often have many responsibilities, including managing a team of plumbers, overseeing the project's finances and ensuring the project meets all building regulations. Being able to manage your time effectively and keep track of important documents and information can help you be more productive and efficient.

Time management: As a plumbing project manager, you may oversee several projects at once. Having strong time management skills can help you prioritize tasks and meet deadlines. Time management skills are used to ensure that there is enough resources to complete each project within the projected time of completion of each project.

Plumbing Project Manager Trends

Here are three trends influencing how plumbing project managers work. Plumbing project managers will need to stay up-to-date on these developments to keep their skills relevant and maintain a competitive advantage in the workplace.

1. The Need for More Technical Skills

The plumbing industry is changing rapidly, and the need for more technical skills is becoming increasingly important. As projects become more complex, plumbers will need to be able to manage them effectively and ensure that they are done correctly.

Project managers can utilize this trend by developing their own technical skills and hiring plumbers who have the same. This will allow them to better manage projects and ensure that they are completed on time and within budget.

2. More Collaboration Between Plumbing Professionals

The plumbing industry is changing as professionals are beginning to collaborate more often in order to get jobs done faster and more efficiently.

As a project manager, you can take advantage of this trend by networking with other professionals and forming partnerships that can help you get work done faster. You can also look for opportunities to collaborate on projects with other professionals, which can lead to long-term relationships and more work down the road.

3. A Greater Focus on Energy Efficiency

Energy efficiency has become an increasingly important topic in recent years, as people become more aware of the impact that their actions have on the environment.

As a result, plumbing professionals are now focusing on ways to make homes and businesses more energy efficient. This includes installing new pipes and fixtures that use less water and energy, as well as designing heating and cooling systems that use less electricity.

Advancement Prospects

A plumbing project manager is responsible for the coordination and completion of projects within the plumbing industry. They set deadlines, assign tasks, and monitor and summarize progress of project.

The most common advancement for a plumbing project manager is to a general construction project manager role. In this role, they would be responsible for the coordination and completion of construction projects. Other advancement opportunities include a construction executive role or a construction operations manager role.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to learn Plumbing Project Management. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Plumbing Project Management

Teaching Strategies

Students engage in brainstorming exercise to define plumbing project management.
They then are allowed to design guiding questions that will enable them to conduct research on definition of plumbing project management.
Discussions in groups on the research findings on definition of plumbing project management.

Learning Strategies

Activity 1: Brainstorming activity definition of plumbing project management.
Activity 2: Conduct research on different terminologies used in plumbing project management.
Activity 3: Discussions and presentation of research findings on different terminologies used in plumbing project management.

Resources

Building Design & construction process

Lesson 2: Project Management Principle and Process

Teaching Strategies

Students engage in brainstorming exercise the project management principle and process.
They then are allowed to design guiding questions that will enable them to conduct research on project management principle and process.
Discussions in groups on the research findings on the project management principle and process.

Learning Strategies

Activity 1: Brainstorming activity the project management principle and process.
Activity 2: Conduct research on project management principle and process.
Activity 3: Discussions and presentation of research findings on the project management principle and process.

Resources

Building Design & construction process

Lesson 3: Types of Management Process

Teaching Strategies

Students engage in brainstorming exercise the types of management process.
They then are allowed to design guiding questions that will enable them to conduct research on types of management process.
Discussions in groups on the research findings on the types of management process.

Learning Strategies

Activity 1: Brainstorming activity the types of management process.
Activity 2: Conduct research on different types of management process.
Activity 3: Discussions and presentation of research findings on the types of management process

Resources
Building Design & construction process

Lesson 4: The Role of Project Manager

Teaching Strategies
Students engage in brainstorming exercise the role of project manager.
They then are allowed to design guiding questions that will enable them to conduct research on the role of project manager.
Discussions in groups on the research findings of the role of project manager.

Learning Strategies
Activity 1: Brainstorming activity the role of project manager.
Activity 2: Conduct research on different the role of project manager.
Activity 3: Discussions and presentation of research findings of the role of project manager.

Resources
Building Design & construction process

STEAM Activity Students work in groups to form a management team and employee. Act it as a role play based on plumbing management process and procedures.

Assessment

The main purpose of assessment is to find out if students can use the skill of synthesis to plumbing project management. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Define plumbing project management.
2. Analyse and describe the project management principle and process.
3. State and describe the types of management process.
4. State and define the role of project manager.

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1.Define plumbing project management	Excellently define plumbing project management	Correctly define plumbing project management	Partially define plumbing project management	Poorly define plumbing project management
2. Analyse and describe the project management principle and process	Excellently analyse and describe the project management principle and process	Correctly analyse and describe the project management principle and process	analyse and describe the project management principle and process	Poorly analyse and Poorly describe the project management principle and process
3. State and describe the types of management process	Excellently state and describe the types of management process	Correctly state and describe the types of management process	Partially state and describe the types of management process	Poorly state and describe the types of management process
4. State and define the role of project manager	Excellently state and define the role of project manager	Correctly state and define the role of project manager	Partially state and define the role of project manager	Poorly state and define the role of project manager

UNIT 3: Plumbing Technology

Content Standard 3.3 Investigate and analyse the concepts and underlying theories in plumbing materials tools and equipment.

Benchmark 12.3.3.2 Describe and apply OHS- On-Site.

Topic 2: Occupational Health and Safety On-Site

Learning Objectives
By the end of this topic, the students will be able to;

- Analyse and describe the OHS for plumbing and methods of controlling hazards on-site and at the workplace.

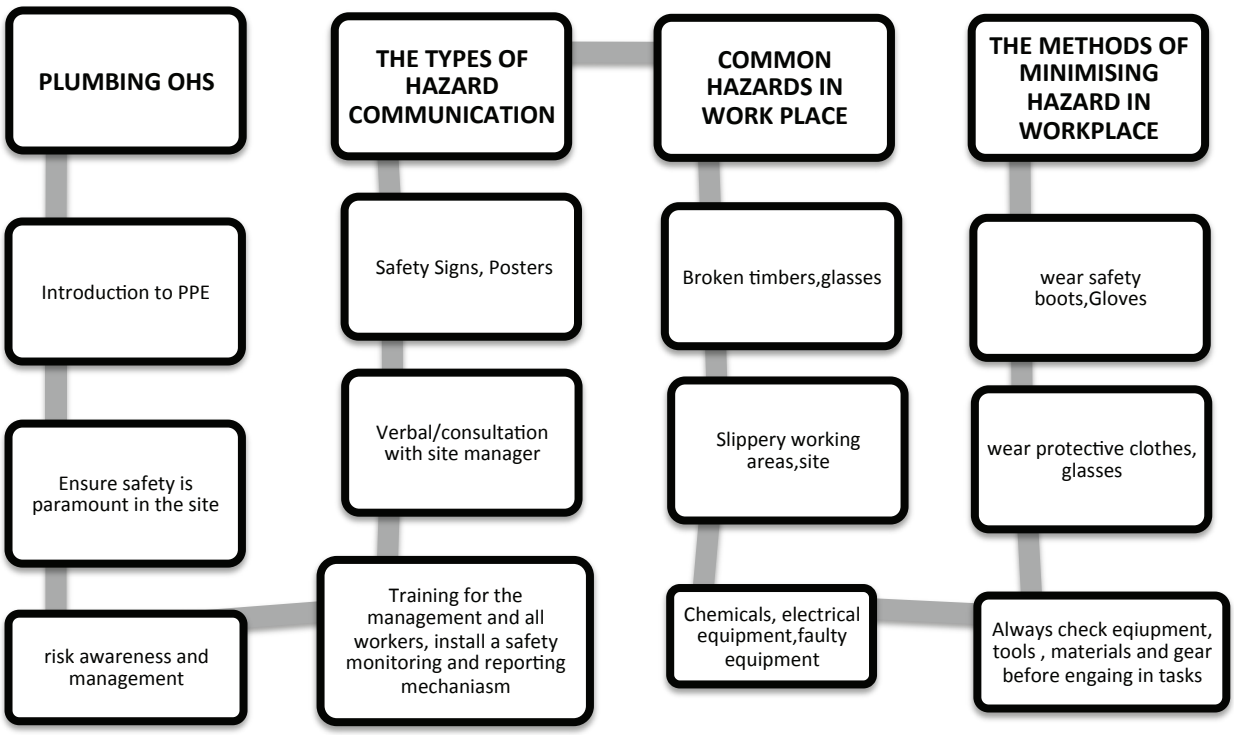
Essential Questions:
1. What is OHS on- site?
2. What are the types of hazards on-site?
3. What are the types of personal protective equipment used on-site?
4. What is the role of OHS officer on-site?
5. How are plumbing processes handled safely on-site?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Occupational Health and Safety on-site	Describe and demonstrate	Open-minded and Safety cautious when studying OHS in plumbing.	Safe practice

Content Background

OHS on site- Is the fundamental of OHS that are applied on site/project site during construction. The OHS is specifically concerns on the project/on site to safeguard the trades' person from accidents, injuries, harmful/poisonous chemicals etc.
Types of hazards on site, types of PPE to be used on site, Roles of OHS officer on site, methods of controlling Hard on site/project.



Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to learn the Introduction to OHS on-site. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: OHS On-Site

Teaching Strategies

Students engage in brainstorming exercise on the definition of OHS on-site.

They then are allowed to design guiding questions that will enable them to conduct research on the definition of OHS on-site.

Discussions in groups on the research findings the definition of OHS on-site.

Learning Strategies

Activity 1: Brainstorming activity on the definition of OHS on-site.

Activity 2: Conduct research on different definition/terminologies of OHS on-site.

Activity 3: Discussions and presentation of research findings on the definition of OHS on-site.

Resources

Building Design & construction process

Lesson 2: The types of Hazards On-Site

Teaching Strategies
Students engage in brainstorming exercise on the types of hazards on-site.
They then are allowed to design guiding questions that will enable them to conduct research on the types of Hazards on-site.
Discussions in groups on the research findings the types of hazards on-site.

Learning Strategies
Activity 1: Brainstorming activity on the types of hazard on-site.
Activity 2: Conduct research on different the types of hazard on-site.
Activity 3: Discussions and presentation of research findings on the types of hazards on-site.

Resources
Building Design & construction process

Lesson 3: The type of Personal Protective Equipment used On-Site

Teaching Strategies
Students engage in brainstorming exercise on the type of personal protective equipment used on-site.
They then are allowed to design guiding questions that will enable them to conduct research on the type of personal protective equipment used on-site.
Discussions in groups on the research findings on the type of personal protective equipment used on-site.

Learning Strategies
Activity 1: Brainstorming activity on the type of personal protective equipment used on-site.
Activity 2: Conduct research on different the type of personal protective equipment used on-site.

Activity 3: Discussions and presentation of research findings on the type of personal protective equipment used on-site.

Resources
Building Design & construction process

Lesson 4: The Roles of OHS Officer On-Site

Teaching Strategies
Students engage in brainstorming exercise on the roles of OHS officer on-site.
They then are allowed to design guiding questions that will enable them to conduct research on the roles of OHS officer on-site.
Discussions in groups on the research findings the roles of OHS officer on-site.

Learning Strategies

Activity 1: Brainstorming activity on the roles of OHS officer on-site.

Activity 2: Conduct research on different the roles of OHS officer on site.

Activity 3: Discussions and presentation of research findings on the roles of OHS officer on-site.

Resources

Building Design & construction process

Lesson 5: The Methods of Controlling Hazard On-Site and the Workplace

Teaching Strategies

Students engage in brainstorming exercise on the methods of controlling hazard on-site and the workplace.

They then are allowed to design guiding questions that will enable them to conduct research on the methods of controlling hazard on-site and the workplace.

Discussions in groups on the research findings on the methods of controlling hazard on-site and the workplace.

Learning Strategies

Activity 1: Brainstorming activity on the methods of controlling hazard on-site and the workplace.

Activity 2: Conduct research on different methods of controlling Hazard on-site and the workplace.

Activity 3 Discussions and presentation of research findings on the methods of controlling Hazard on-site and the workplace.

Resources

Building Design & construction process

STEAM Activity Students work in groups to create safety mask and clothes, gloves on-site

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Assessment

The main purpose of assessment is to find out if students can use the skill of synthesis to Introduction to OHS on-site. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment

1. Define OHS on-site
2. State and analyse the types of hazards on site
3. State and describe the type of Personal Protective Equipment used on site
4. Analyse and describe the roles of OHS officer on site
5. Analyse and describe the methods of controlling hazard on site and workplace

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Define OHS On-Site	Define OHS on- site accurately and with examples	Define OHS on- site accurately.	Define OHS on-site partially.	Define OHS on-site very poorly.
2. State and analyse the types of hazards on- site	State and analyse the types of hazards on-site accurately and with examples	State and analyse the types of hazards on-site accurately.	State and analyse the types of hazards on- site partially.	State and analyse the types of hazards on- site very poorly.
3. State and describe the type of Personal Protective Equipment used on-site	State and describe the type of Personal Protective Equipment used on- site accurately and with examples	State and describe the type of Personal Protective Equipment used on- site accurately.	State and describe the type of Personal Protective Equipment used on- site partially.	State and describe the type of Personal Protective Equipment used on- site very poorly.
4. Analyse and describe the roles of OHS officer on-site	Analyse and describe the roles of OHS officer on- site accurately and with examples	Analyse and describe the roles of OHS officer on- site accurately.	Analyse and describe the roles of OHS officer on-site partially.	Analyse and describe the roles of OHS officer on-site very poorly.
5. Analyse and describe the methods of controlling hazard on- site and workplace	Analyse and describe the methods of controlling hazard on- site and workplace accurately and with examples	Analyse and describe the methods of controlling hazard on- site and workplace accurately.	Analyse and describe the methods of controlling hazard on- site and workplace partially.	Analyse and describe the methods of controlling hazard on- site and workplace very poorly.

UNIT 3. Plumbing Technology

Content Standard 3.3 Investigate and analyse the concepts and underlying theories in plumbing materials tools and equipment.

Benchmark 12.3.3.3 Describe and apply trade maths in Plumbing to estimate material cost.

Topic 3: Introduction to Plumbing Trade Math

Learning Objectives
By the end of this topic, the students will be able to;

- Define applied math in plumbing.
- Demonstrate the method of calculating water distribution system, DWV System, and plumbing materials.

Essential Questions:
1. What is applied trade math in Plumbing?
2. What are the method of calculating water distribution system, DWV system?
3. What are the methods of preparing plumbing material list?
4. What is the role of the estimator?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Trade Math in plumbing	Apply Trade Math in plumbing	Appreciate and apply Trade Math in plumbing.	Value the importance of trade Math calculations

Content Background
Trade maths in plumbing is used to calculate the total cost of plumbing materials/project cost. This includes the total cost of certain project cost to bid for, total cost of materials used to work on the project of new residential buildings or homes. The methods of calculating water distribution system, DWV system, preparing plumbing material list and the roles of the estimator in plumbing.

Math unfortunately is part of being a plumber or any other skilled trade for that matter. Various aspect of plumbing have their own formulas for calculation of loads and capacities.

- Volume of various Objects – Cylinder, sphere, rectangular, frustum
- Converting decimals to fractions
- Pipe size capacity ratio
- Area of objects
- Simple pipe offsets
- Rolling pipe offsets
- Jumper Offset
- Head pressure

- Thermal expansion
- Specific gravity
- Pressure
- Roof drain hydraulic load calculations
- Conversion tool download – Freeware

Finding The Volume Of A Rectangular Tank

- V = volume
- L = length
- H = height
- W = width

Formula

V = L x W x H

- To find the volume in Liters:
  - Measure the tank in centimeters and divide the result by 1000. (Example: 13cm x 11cm x 28cm = 4004cm³ 4004cm³ /1000 = 4.004 L)
  - Measure the tank in meters and multiply by 1000.
- To find the volume in US gallons:
  - Measure the tank in inches and divide by 231.
  - Measure the tank in feet and multiply by 7.48.

Finding The Volume Of A Cylindrical Tank

- V = volume
- D = diameter
- L = length

Formula

V = D x D x 0.7854 x L or **V = ∏R2L**

- To find the volume in Liters:
  - Measure the tank in centimeters and divide the result by 1000. (Example: 10cm x 10cm x 0.7854 x 30cm = 2356.2cm³) (2356.2cm³ / 1000 = 2.36 L)
  - Measure the tank in meters and multiply by 1000.
- To find the volume in US gallons:
  - Measure the tank in inches and divide by 231.
  - Measure the tank in feet and multiply by 7.48.

Finding The Volume Of An Elliptical Tank

- V = volume
- L = length
- W = width
- H = height

Formula

V = H x W x 0.7854 x L

- To find the volume in Liters:
  - Measure the tank in centimeters and divide the result by 1000. (EX: 20cm x 10cm x 0.7854 x 30cm = 4712.4cm³) (4712.4cm³ / 1000 = 4.71 L)
  - Measure the tank in meters and multiply by 1000.
- To find the volume in US gallons:
  - Measure the tank in inches and divide by 231.
  - Measure the tank in feet and multiply by 7.48.

Finding The Volume Of A Spherical Tank

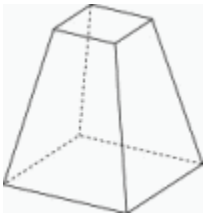
- V = volume
- D3 = diameter cubed

Formula

- To find the volume in Liters:
  - Measure the tank in centimeters and divide the result by 1000.
    (EX: 20cm x 20cm x 20cm x 0.5236 = 4188.8cm³) (4188.8cm³ / 1000 = 4.19 L)
  - Measure the tank in meters and multiply by 1000.
- To find the volume in US gallons:
  - Measure the tank in inches and divide by 231.
  - Measure the tank in feet and multiply by 7.48.

Finding The Volume Of A Frustum Tank

A frustum can be multi-sided or conical, the formula below will work for both.



- V = volume
- H = height between bases
- B1 = area of upper base
- B2 = area of lower base

Formula

$$V = \frac{1}{3}h(B_1 + B_2 + \sqrt{B_1 B_2})$$

- To Find The Volume In Liters:
  - Measure the tank in centimeters and divide the result by 1000.
  - Measure the tank in meters and multiply by 1000.
- To find the volume in US gallons:
  - Measure the tank in inches and divide by 231.
  - Measure the tank in feet and multiply by 7.48.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to understand the application of trade math in plumbing. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Define Applied Math in Plumbing

Teaching Strategies
Students engage in brainstorming exercise on the definition of applied math in plumbing.
They then are allowed to design guiding questions that will enable them to conduct research on definition of applied math in plumbing.
Discuss in groups the research findings the definition of applied math in plumbing.

Learning Strategies
Activity 1: Brainstorming activity on the definition of applied math in plumbing.
Activity 2: Conduct research on the different types of corrugated stainless-steel tubing.
Activity 3: Discussions and presentation of research findings on the definition of applied math in plumbing.

Resources
Building Design & construction process

Lesson 2: Method of Calculating Water Distribution System, DWV System

Teaching Strategies
Students engage in brainstorming exercise on the method of calculating water distribution system, (DWV) system.
They then are allowed to design guiding questions that will enable them to conduct research on the method of calculating water distribution system, (DWV system).
Discussions in groups on the research findings on the method of calculating water distribution system, (DWV system).

Learning Strategies
Activity 1: Brainstorming activity on the method of calculating water distribution system, DWV System.
Activity 2: Conduct research on different the method of calculating water distribution system, DWV System.
Activity 3: Discussions and presentation of research findings on the method of calculating water distribution system, DWV system.

Resources

Building Design & construction process

Lesson 3: Methods of Preparing Plumbing Material List

Teaching Strategies
Students engage in brainstorming exercise on the methods of preparing plumbing material list.

They then are allowed to design guiding questions that will enable them to conduct research on the methods of preparing plumbing material list.

Learning Strategies

Activity 1: Brainstorming activity on the methods of preparing plumbing material list.

Activity 2: Conduct research on different methods of preparing plumbing material list.

Activity 3: Discussions and presentation of research findings on the methods of preparing plumbing material list.

Resources

Building Design & construction process

Lesson 4: The Role of the Estimator

Teaching Strategies

Students engage in brainstorming exercise on the role of the estimator.

They then are allowed to design guiding questions that will enable them to conduct research on the role of the estimator.

Discussions in groups on the research findings the role of the estimator.

Learning Strategies

Activity 1: Brainstorming activity on the role of the estimator.

Activity 2: Conduct research on different roles of the estimator.

Activity 3: Discussions and presentation of research findings on the role of the estimator.

Resources

Building Design & construction process

STEAM Activity Students work in groups to create a pipping system using bamboo sticks and their fittings and estimate the total cost of the model.

Assessment

The main purpose of assessment is to find out if students can use the skill of synthesis on the Plumbing Trade math. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment

1. Define Applied math in Plumbing
2 State and demonstrate the method of calculating water distribution system, DWV system
3. Analyse and describe the methods of preparing plumbing material list
4. State and describe the role of the estimator

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Define Applied math in Plumbing	Define applied math in plumbing accurately and with examples	Define applied math in plumbing correctly	Define applied math in plumbing partially	Define applied math in plumbing very poorly
2. State and demonstrate the method of calculating water distribution system, DWV system	State and demonstrate the method of calculating water distribution system, DWV system accurately and with examples	State and demonstrate the method of calculating water distribution system, DWV system correctly	State and demonstrate the method of calculating water distribution system, DWV system partially	State and demonstrate the method of calculating water distribution system, DWV system very poorly
3. Analyse and describe the methods of preparing plumbing material list	Analyse and describe the methods of preparing plumbing material list accurately and with examples	Analyse and describe the methods of preparing plumbing material list correctly	Analyse and describe the methods of preparing plumbing material list partially	Analyse and describe the methods of preparing plumbing material list very poorly
4. State and describe the role of the estimator	State and describe the role of the estimator accurately and with examples	State and describe the role of the estimator correctly	State and describe the role of the estimator partially	State and describe the role of the estimator very poorly

UNIT 3: Plumbing Technology

Content Standard 3.3 Investigate and analyse the concepts and underlying theories in plumbing materials tools and equipment.

Benchmark 12.3.3.4 Adapt Installation of plumbing fittings and accessories, Water Distribution system, Drain, waste, vent system

Topic 4: Installation Plumbing Fitting and Accessories-Water Distribution System, DWV system

Learning Objectives
By the end of this topic, the students will be able to;

- State and demonstrate the method of analysing plumbing fitting and accessories to specific task.
- Analyse and demonstrate the methods of installation and connection, Drain, Waste, Vent system to existing plumbing system.

Essential Questions:
1. What are the method of analysing plumbing fitting and accessories to specific task?
2 What are the methods of installation and connection of water distribution system?
3 What are the methods of installation and connection, Drain, Waste, Vent System to existing plumbing system?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Installation plumbing fittings	Apply installation of plumbing fittings	Appreciative of understanding of installation fittings and fixtures.	Appreciate the importance

Content Background

Installation plumbing fitting and accessories for water distribution system, DWV system basically refers to the practical part of the plumbing Installation system. This deals with water distribution system, DWV system to the new and residential building. They are so many plumbing materials that are used for installation/piping system in any building/homes. For example, copper wire, poly pipes, p.v.c pipes, these will determine on the plan being drafted by the architect/Draftsman.

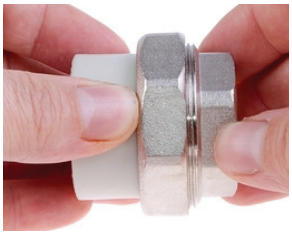
ADAPTER

Adaptors are used anytime two different types of pipes need to be connected to one another. Due to the fact that pipes can be either male or females, an adaptor can be used to adjust adjoining pipes accordingly. Used for both PVC and copper piping, adaptors can have threaded or non-threaded ends that can then be welded, soldered or glued to the pipe.

BARB

Used to connect hoses to pipes, barbs usually have one male end and one that is a ridged and tapered cone. Depending on whether they are designed to carry cold or hot water, barbs are made from plastic or brass accordingly.

COUPLING



Facilitating the connection of two pipes that share a similar diameter, couplings are often used to repair a pipe that has broken or is leaking. They come in a standard, compression or slip variety that serve slightly different purposes. Compression fitting are connected between two pipes via rubber seals or gaskets on both sides which prevents leaking. Slip couplings, on the other hand, includes two pipes and be adjusted to repair a specific length of damaged pipe.

CROSS

These plumbing accessories are able to connect four pipes, cross fittings come with three inlets and an outlet or three outlets and an inlet. Due to the higher amount of stress they need to endure, cross pipes are typically built from stronger material.

ELBOW

Type of fitting resembles an important arm joint. Elbows come in several kinds of degrees and help the flow of water change direction. Although elbow fittings can be made of different materials, most are female.

MECHANICAL SLEEVE

These nifty plumbing accessories make fitting easy to install by connecting two pipes through the use of a screw or other device. Usually made of rubber that is then inserted inside a metal jacket, or stainless-steel clamp, the clamp is then tightened and compresses the rubber inside to make a tight seal.

NIPPLE

A super short fitting, these plumbing accessories can be made of copper, brass or steel or chlorinated polyvinyl chloride (CPVC). Serving to connect two fittings, they come in varying lengths.

REDUCER

These specialized fittings are designed to reduce flow and come in concentric or eccentric varieties. A concentric reducer is intended to join two pipes on the same axis, while an eccentric reducer is used to join pipes of different diameters.

TEE

Shaped like its namesake letter, a tee has both an inlet and outlet. Due to the fact that they have three instead of four openings, they are considered sturdier than the cross fitting. Sometimes used as a diverter, they are marked with directional indications and need to be installed correctly for the system to operate.

UNION

Similar to couplings, unions are easier to remove and are therefore very convenient for maintenance or a planned future replacement. These plumbing accessories contain three parts, nut, male end, and female end. The nut is used to join the male and female ends.

VALVE

Working to control the flow of fluids, valves come in a variety of different types, including throttling, non-return and isolation. Non-return valves only allow the liquid to flow in one direction and are often found in drains. Isolation valves, alternatively, have the capacity to block off a part of the overall system so that a different part can be serviced or maintained.
When work is not being done, these kinds of valves are always left open or closed. As a result of the fact that they aren't moving regularly, it is wise to check in from time to time to ensure functionality. Finally, throttling valves control the pressure and amount of a fluid, which may cause a lot of stress as a result. For this reason, they tend to wear out quickly.

WYE

Resembling the structure of the letter 'Y,' these specific fittings are able to connect three pipes and allow them to branch out into freshwater lines or drains. Their function is largely similar to that of tee fittings, but thanks to the fact that they tend to hand smoother angling, there is less friction generated in the flow of water.

Figure:3.4a Plumbing fittings
Source: https://ncert.nic.in/textbook/pdf/iepg105.pdf

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to learn on Installation plumbing fitting and accessories-water distribution system, DWV system. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Methods of Analysing Plumbing Fitting and Accessories to Specific Task

Teaching Strategies

Students engage in brainstorming exercise on the method of analysing plumbing fitting and accessories to specific task.

They then are allowed to design guiding questions that will enable them to conduct research on the method of analysing plumbing fitting and accessories to specific task.

Discussions in groups on the research findings the methods of analysing plumbing fitting and accessories to specific task.

Learning Strategies

Activity 1: Brainstorming activity on the methods of analysing plumbing fitting and accessories to specific task.

Activity 2: Conduct research on different methods of analysing plumbing fitting and accessories to specific task.

Activity 3: Discussions and presentation of research findings on methods of analysing plumbing fitting and accessories to specific task.

Resources

Building Design & construction process

Lesson 2: Methods of Installation and Connection of Water Distribution System

Teaching Strategies

Students engage in brainstorming exercise on methods of installation and connection of water distribution system.

They then are allowed to design guiding questions that will enable them to conduct research on the methods of installation and connection of water distribution system.

Discussions in groups on the research findings the methods of installation and connection of water distribution system.

Learning Strategies

Activity 1: Brainstorming activity on the methods of installation and connection of water distribution system.

Activity 2: Conduct research on different methods of installation and connection of water distribution system.

Activity 3: Discussions and presentation of research findings on the methods of installation and connection of water distribution system.

Resources
Building Design & construction process

Lesson 3: Methods of Installation and Connection, Drain, Waste, Vent System to existing plumbing system

Teaching Strategies
Students engage in brainstorming exercise on methods of installation and connection, Drain, Waste, Vent System to existing plumbing system.
They then are allowed to design guiding questions that will enable them to conduct research on the methods of installation and connection, Drain, Waste, Vent System to existing plumbing system.

Discussions in groups on the research findings the methods of installation and connection, Drain, Waste, Vent System to existing plumbing system.

Learning Strategies
Activity 1: Brainstorming activity on the methods of installation and connection, Drain, Waste, Vent System to existing plumbing system.
Activity 2: Conduct research on different the methods of installation and connection, Drain, Waste, Vent System to existing plumbing system.
Activity 3: Discussions and presentation of research findings on the methods of installation and connection, drain, waste, vent system to existing plumbing system.

Resources
Building Design & construction process

STEAM Activity Students work in groups to construct a pipping system using bamboo sticks with fittings to the existing pipes model.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis for Installation plumbing fitting and accessories-water distribution system, DWV system. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. State and demonstrate the method of analysing plumbing fitting and accessories to specific task.
2. Analyse and demonstrate the methods of installation and connection of water distribution system.
3. Analyse and demonstrate the methods of installation and connection, Drain, Waste, Vent System to existing plumbing system.

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. State and demonstrate the method of analysing plumbing fitting and accessories to specific task	Highly competent to state and demonstrate the method of analysing plumbing fitting and accessories to specific task	Competent to state and demonstrate the method of analysing plumbing fitting and accessories to specific task	Partly able to state and demonstrate the method of analysing plumbing fitting and accessories to specific task	Cannot state and demonstrate the method of analysing plumbing fitting and accessories to specific task
2. Analyse and demonstrate the methods of installation and connection of water distribution system	Highly competent to analyse and demonstrate the methods of installation and connection of water distribution system	Competent to analyse and demonstrate the methods of installation and connection of water distribution system	Partly able to analyse and demonstrate the methods of installation and connection of water distribution system	Cannot Analyse and demonstrate the methods of installation and connection of water distribution system
3. Analyse and demonstrate the methods of installation and connection, Drain, waste, vent to existing plumbing system	Highly competent to analyse and demonstrate the methods of installation and connection, Drain, Waste, Vent to existing plumbing system	Competent to analyse and demonstrate the methods of installation and connection, Drain, Waste, Vent to existing plumbing system	Partly able to analyse and demonstrate the methods of installation and connection, Drain, Waste, Vent to existing plumbing system	Cannot analyse and demonstrate the methods of installation and connection, Drain, Waste, Vent to existing plumbing system

Unit 4: Welding Technology

Unit	Topic	Lesson Titles
4:WeldingTechnology	**Topic 1.** Safety	1. Material Handling 2. Safe Handling Procedures for Tools and Equipment.
	Topic 2. Life cycle of designed products	1. Carbon steel production process 2. Economic costs of designed products 3. Social and environmental impacts of the designing process 4. Recycling
	Topic 3. Identification of metals and materials	1. Metal Identification Process 2. Machining Procedures 3. Forms of Welding
	Topic 4. Computers Applications in Welding	1. Use of Computers in the welding industry 2. Use computer applications to design projects 3. Use computer applications to simulate projects in 3D CAD.
	Topic 5. Inspection standards	1. Welding and machining quality 2. Inspections Standards and Procedures
	Topic 6. Welding Project Evaluations	1. Validation of welding and machining projects. 2. MFW Industry standards

UNIT 4: Welding Technology

Content Standard 3.4 Investigate and analyse safety procedures, print reading, measurement and layout, identify properties of metals, the welding techniques, cutting processes according to welding codes, inspections, testing principles and apply fundamentals of fabrication.

Benchmark 12.3.4.1 Observe health and safety practices when handling materials, tools and equipment.

Topic 1: Safety

Learning Objectives

By the end of this topic, the students will be able to;

- Observe OHS when handling materials, tools and equipment.

Essential Questions:

1. What is material handling in welding?
2. What are the safe working practices and techniques in handling tools and equipment in welding?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Safe practices for materials, tools and equipment handling	Observe	Cautious with the safety practices when handling plumbing tools and equipment.	Awareness and appreciate

Content Background

Material Handling

Material Handling is the process of moving goods and materials short distances within a building, factory, facility, or warehouse. Material handling includes a wide range of different types of materials, ranging from tiny boxes to large and heavy components for manufacturing. To conduct this process of material handling, there is a wide range of material handling equipment. The types of equipment range from:

- manual
- semi-automated
- and automated equipment

Material handling refers to the entire process of processing, storage, as well as the control of the goods. It is used to help create “time & place utility” through handling, storage and the control of the material (Michael G. Kay, Material Handling Equipment, 2012).

“Material handling is the movement, protection, storage and control of materials and products throughout manufacturing, warehousing, distribution, consumption, and disposal. As a process, material handling incorporates a wide range of manual, semi-automated and automated equipment and systems that support logistics and make the supply chain work. ” (Michael G. Kay, Material Handling Equipment, 2012).

The role of material handling plays a significant role and has become a topic of discussion, in particular amongst manufacturing companies. Every type of product that has been manufactured or produced has been involved in a material handling sequence of some sort. Whether that be transported via forklift, or along a conveyor line. Many large manufacturing companies invest so much every year to ensure that their material handling processes and flows are up to date and efficient.

Figure:4.1a Material handling
Source: https://www.leanmaterialhandling.com/what-is-material-handling/

This is where the idea of lean manufacturing and six sigma have originated, as processes and ideas to eliminate inefficiencies within manufacturing processes.

Creating an efficient material handling system for a large factory, facility or warehouse isn’t an easy task to accomplish. The dynamic environment that all industries exist today makes it very difficult to plan long term. Especially with the development of the internet and the personalisation of many products it has become more and more difficult for manufacturers to keep up with the level of customization now offered to consumers.

Material handling systems are planned out to help develop best practices and methods within a facility for long-term efficient flows. There are generally ten material handling principles which have been taken and used by a majority of facilities globally. These principles have been made and have greatly helped facility managers with the productivity, customer service, and profitability of their factories.

There are ten principles of material handling. They are:

1) Planning Principle
2) Standardisation Principle
3) Work Principle
4) Ergonomic Principle
5) Unit Load Principle
6) Space utilization Principle
7) System Principle
8) Automation Principle
9) Environmental Principle
10) Life Cycle Cost Principle

These principles help with the planning and processes of all material handling and are just as relevant whether the equipment is manual, semi-automated or fully automated.

While material handling of a product does not add any direct value to the customer, how efficient or inefficient a process is, can directly affect the consumers' outlook on the company, product and possibly the industry.

Safe handling procedures for tools and equipment.

Basic Safety Rules for Hand Tools

- ALWAYS WEAR EYE PROTECTION.
- Wear the RIGHT SAFETY EQUIPMENT for the job.
- Use tools that are the RIGHT SIZE & RIGHT TYPE for your job.
- Follow the correct procedure for using EVERY tool.
- Keep your cutting tools SHARP and in good condition.
- DON'T work with OILY or GREASY hands.
- Handle SHARP-EDGED and POINTED TOOLS with care.
- Always carry pointed tools by your side with the points and heavy ends DOWN.
- SECURE all small work & short work with a vise or clamp.
- NEVER carry tools in your pockets.
- DON'T use tools which are LOOSE or CRACKED.
- KEEP your punches & chisels in good condition. Mushroomed heads can chip & cause injuries.
- DON'T use a file without a HANDLE.
- DON'T pry or hammer with a FILE. It may shatter.
- DON'T use screwdrivers as chisels or pry bars.
- DON'T try to increase your leverage by using a "cheater" with a wrench. Wrenches are designed at the right strength for their size and length.
- AFTER USING A TOOL — clean it and return it to its proper storage place.
- If anything breaks or malfunctions — report it to your supervisor AT ONCE.
- Use the RIGHT TYPE of tool for the job.
- NEVER place tools and materials where they hang on the edge of a bench.
- Don't use tools for things they weren't meant for.

- Store tools and materials vertically, with the points and heavy end down.
- Cut away from yourself when you use chisels and other edged tools.
- DON'T FORCE screws; make sure that the correct screw for the job is being used.

Hand tools and power tools present a host of potential hazards such as flying objects, electrical shock, falling objects, punctures and lacerations. Tips for safely working with hand and power tools.

1) INSPECT YOUR TOOLS. Never issue or use a damaged or defective hand or power tool. Always make sure they are in good working order before and after each use.
2) PICK THE RIGHT TOOL. Make sure you are using the correct tool for the task at hand. This also means using the right sized bits, blades and accessories on your power tools.
3) WEAR YOUR PPE. Issue personal protective equipment to your employees and make sure they wear them properly. This comprises of items like safety goggles, hard hats, etc.
4) DON'T ALTER YOUR TOOLS. Never remove guards or disable safety devices on power tools. Don't paint or cover up your tools as this could prevent you from noticing chips or cracks.
5) HANDLE WITH CARE. Tools are not toys. Never throw or toss a tool in the direction of or directly to a co-worker. Never use electrical cords to lower or lift a tool to get it to a workspace.
6) KEEP YOUR DISTANCE. When working with hand and power tools be sure you have enough room to safely operate without coming into contact with other objects or co-workers.
7) PICK UP AFTER YOURSELF. Don't leave idle hand tools lying around the job site. They can lead to tripping or be accidentally knocking on someone's head.
8) UNPLUG AND DISCONNECT. Don't leave electric power tools plugged in when not in use, when making adjustments such as replacing blades and bits, or loading fasteners.
9) KEEP YOUR WORKSPACE CLEAN.A cluttered floor can lead to accidental trips or falls which can be extremely dangerous when working with hand and power tools.
10) GET TRAINED UP. Make sure you and your employees are thoroughly trained on the proper use of hand and power tools required for the task at hand.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of safety in welding practices. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Material Handling

Teaching Strategies
Key: What is material handling?

Students are engaged in brainstorm exercises to observe the importance of OHS in handling materials.
They are then allowed to discuss questions that will enable them to conduct research on importance of observing OHS in handling materials.

Learning Strategies
Conduct research with guiding questions that will explain importance of observing OHS in handling materials.

Activity 1: List the correct procedures of observing OHS in handling materials.
Activity 2: Present the research findings in groups.

Resources
Text on safety in material, tools and equipment handling.

Lesson 2: Safe Handling Procedures for Tools and Equipment.

Teaching Strategies
Key: What are the safe working practices and techniques in handling tools and equipment?

Engage students in the discussion safe handling procedures for tools and equipment.
Engage students in presentation of a research on safe handling procedures for tools and equipment.

Learning Strategies
Activity 1: Discuss the safe handling procedures for tools and equipment.
Activity 2: Do research on safe handling procedures for tools and equipment.
Activity 3: Do a group presentation on safe handling procedures for tools and equipment.

Resources
Text on safe handling procedures for tools and equipment.

STEAM Activity Students work in groups to create a welded flower using nuts and bolts.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to observe OHS when handling materials, tools and equipment. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment

1. Observe OHS when handling materials, tools and equipment.

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Interpret OHS practices into handling tools, materials and equipment.	Accurately Interpret OHS practices into handling tools, materials and equipment.	Correctly Interpret OHS practices into handling tools, materials and equipment.	Poorly interpret OHS practices into handling tools, materials and equipment.	Cannot interpret OHS practices into handling tools, materials and equipment.
2. Presentation of OHS practices into handling tools, materials and equipment	Accurate Presentation of OHS practices into handling tools, materials and equipment	Correct Presentation of OHS practices into handling tools, materials and equipment	Poor Presentation of OHS practices into handling tools, materials and equipment	Cannot Presentation of OHS practices into handling tools, materials and equipment

UNIT 4: Welding Technology

Content Standard 3.4 Investigate and analyse safety procedures, print reading, measurement and layout, identify properties of metals, the welding techniques, cutting processes according to welding codes, inspections, testing principles and apply fundamentals of fabrication.

Benchmark 12.3.4.2 Describe the design for the life cycle, taking into account economic costs, social and environmental impacts of the product, from the extraction of raw materials to eventual reuse or recycling of component materials.

Topic 2: Life Cycle of Designed Products

Learning Objectives

By the end of this topic, the students will be able to;

- Describe processes involved in extracting raw materials all the way to recycling of the used product.

Essential Questions:

1. What is the life cycle of the design products?
2. What are processes involved in extracting raw material up to recycling of the design product after use?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Extraction of raw materials to recycling of used products.	Describe and explain	Caring and tolerant with the cycle of designed products.	Awareness, appreciation and value

Content Background

Carbon Steel Production Process

The manufacturing processes, properties, and applications of steel.

Over 1.5 billion tons of steel are produced every year to make products as diverse as sewing needles and structural beams for skyscrapers. Carbon steel is a type of steel where the main alloying element is carbon, and the properties depend on the percentage of carbon present. Carbon steel is comprised of iron and carbon, and is the most common category of steel. The carbon content of the product is in the 0–2% range and gives the metal carbon-like properties due to the influence of the carbon on the microstructure. Carbon steel can also contain small amounts of manganese, silicon, and copper. Mild steel is a commercial term for low carbon steel, where the carbon content is in the 0.04–0.3% range. It is a general classification that is not covered by a standard specification. Carbon steel is essentially iron with varying levels of carbon as the main alloying element. Carbon steel is

one of the most widely used manufacturing materials due to its formability, weldability, strength, and ability to be heat treated to precisely modify its mechanical properties. Apart from carbon, an extra amount of manganese is also included in most alloys. Sulfur and phosphorus are also present however these are typically undesired and seen as impurities.

Figure 4.2a: Carbon steel manufacturing
Source: https://www.worthproject.eu/the-impact-of-design-on-the-economy/

Mild steel has exceptional ductility and are used for pipelines that transport oil, gas, or water.

Carbon steel manufacturing
Carbon steel and mild steel are manufactured in three stages:

1) ***Primary steelmaking***
2) ***Secondary steelmaking***
3) ***Casting***

These are followed by various finishing techniques that have a direct effect on the final product characteristics.

Steel is produced in a blast furnace, and then the molten steel is tapped from the furnace into ladles or steel baths for further processing.

1. Primary steelmaking
Steel can either be made from 100% recycled material or from a combination of recycled material and virgin steel. Virgin steel is produced in a blast furnace from iron ore, coke (produced from coal), and lime. The raw materials are added to the top of the furnace, which operates at 3000°F. As the iron ore melts and mixes with the burning coke, carbon is released into the molten product. Impurities are absorbed by lime into a slag on the surface, which can be skimmed from the liquid steel. The product at this stage contains about 4% carbon and still has some impurities present. Molten virgin steel is transferred to the basic oxygen furnace (BOF), which already contains recycled scrap metal. Pure oxygen is blown through the liquid steel to oxidize the excess carbon, forming a finished product with up to 1.5% carbon content.

Recycled scrap steel can be reprocessed without the addition of virgin steel in an electric arc furnace. High-power electric arcs melt the metal at temperatures up to 3000°F. As the scrap steel melts, further batches of scrap can be added to the furnace up to its capacity. Once a flat bath of molten steel is achieved, oxygen is blown through in the same manner as the BOF. In both cases, molten steel is tapped from the furnace into ladles or steel baths for further processing, while the surface slag containing impurities is removed.

2. Secondary steelmaking

Market demands for higher-quality steel products and consistent properties have fuelled the development of secondary steelmaking processes.

Electric arc furnace

Steel composition is altered in an electric arc furnace by adding or removing individual components or by manipulating the temperature.

Stirring

Electromagnetic fields are used to induce turbulent currents in the ladle. This method easily separates non-metallic inclusions, which float to the surface, while ensuring a homogeneous mixture and composition of the steel.

Ladle furnace

The ladle acts as a secondary electrode furnace enabling precise temperature control and the measured injection of alloy components.

Ladle injection

Inert gas is injected into the bottom of the steel bath. As the gas heats up and rises through the molten steel, a stirring effect is achieved.

Degassing

Removes hydrogen, oxygen, and nitrogen, while also reducing the sulphur content of the product. Various techniques used to degas molten steel including vacuums, inert gas injection, and temperature control.

Composition adjustment (sealed argon bubbling with oxygen blowing – CAS-OB)

Stirring is achieved by injecting argon gas into the sealed steel bath. A snorkel arrangement prevents the slag from being disturbed while hydrogen content is reduced and oxide inclusions are floated to the surface. Oxygen is fed to the bath through a lance and aluminium is added through the snorkel giving an increased level of temperature control and accurate final composition.

Deoxidizing steel

A critical aspect of secondary steelmaking is the removal of oxygen. The presence of oxygen in molten steel as it begins to solidify results in a reaction with carbon to release

carbon monoxide gas. Controlling deoxidation can be used to alter the characteristics of the finished product and therefore the suitability of the steel to be used for different applications.

Rimming steels
Rimming steels are non-deoxidized or partially deoxidized steels. High levels of carbon monoxide are produced during solidification resulting in good surface quality but with the presence of many blow holes.

Capped steels
Capped steels follow the same pattern as rimming initially, but after about a minute, the mold is capped to suppress the formation of carbon monoxide.

Semi-killed steels
Semi-killed steels have been partially deoxidized prior to pouring into the mold and usually have carbon content in the range of 0.15–0.3%.

Killed steels
Killed steels have been fully deoxidized such that there is no formation of carbon monoxide at all during solidification. The finished product has a homogeneous structure and no blowholes. Aluminium is added into the ladle or mold as a primary deoxidizer to “kill” the formation of carbon monoxide; however, there are applications where the addition of aluminium to the finished product is undesirable. Alternatives to aluminium are ferroalloys of manganese and silicon or calcium silicide.

3. Casting
Traditional casting methods involve the lifting of the ladle by crane so that molten steel can be teemed into individual molds mounted on rail cars. Ingot molds are tapered slightly to facilitate removal of the ingots after solidification. Ingots are transferred to soaking pits where they are reheated for hot rolling.

Casting machines enable continuous casting of molten steel into shapes more suitable for downstream processing. Ladles are lifted to an elevated platform where they discharge the molten steel into a tundish, which feeds the casting machine. Molten steel is fed from the tundish into a water-cooled mold with a movable bottom plate. As the steel skin solidifies, the plate is slowly lowered allowing more molten steel to enter the mold. Steel is formed into slabs, blooms, or billets in a continuous casting machine. The solidified product is pulled by rollers before being straightened and cut at the end of the machine. This process can continue for days or weeks without interruption.

Carbon steel finishing
After the manufacturing process of carbon steel is complete, it is finished using rolling, heat treatment, surface treatment, or downstream secondary processing. Steel is formed into slabs, blooms, or billets in a continuous casting machine.

Product rolling
Solid cast ingots must be rolled into more useful shapes and sizes like those produced by continuous casting. Steel is compressed and pulled by rotating rolls. The rolls rotate at a faster pace than the steel as it enters the machine, therefore thrusting the steel forward and compressing it. Carbon steel is hot rolled into steel strips.

Hot forming
Steel is heated above the recrystallization temperature to break up the as-cast microstructure. This yields a more uniform grain size and even distribution of carbon within the steel.

Cold forming increases the strength of carbon steel while improving the finish and allowing tighter tolerances.

Cold forming
Cold forming is carried out below the recrystallization temperature. This process increases the strength through strain hardening by up to 20%, while improving the finish and allowing tighter tolerances. Steel emerges from the rolling process as semi-finished products in the form of blooms, billets, or slabs, depending on the final dimensions. A bloom is a very thick rectangular slab, a billet has a similar thickness but a narrower width, and a slab is a thinner and wider product.

Semi-finished products are further processed to intermediate products in a rolling mill to make them ready for manufacturing and final processing by downstream companies.

Economic cost of design products

THE IMPACT OF DESIGN ON THE ECONOMY

The most amazing thing about design is how it can be interpreted in so many various ways and is therefore impossible to define precisely. However, one thing is for certain, that design is always produced with a purpose, whether it be to bring people pleasure by admiring a product, or it is made with an intended end user to consume. Whether it be something produced by a market giant or a small start-up brand, the impact that these outputs can have on the overall economy can be astronomical.

What we strive for is a balance between products that are original, innovative and sustainable but also have a high potential to succeed once available on the market. We understand the importance of merging good business management with creativity and design in order to establish a business that is liable and sustainable in every aspect but also genuine and original.

What these innovative design concepts create once manufactured and available on the market is not just revenue for the companies that produce them, but they also benefit a massive network of factors. A successful product allows the businesses who created it to grow which provides job opportunities for people, suppliers of materials benefit from the

growth in sales and if the products are designed with a high regard for sustainability, it is also reduces the long-term impact on the environment.

Social and environmental impacts of the designing process

Social and environmental issues or conflicts are significantly affecting the delivery of projects. Social conflicts and potential environmental threats, when they arise, are typically manifested at the early stages of project development and often continue, frequently escalating, as the project progresses. These conflicts impact on capital costs in the project phase, and operating costs and productivity in the production phase.

Another major constraint for projects, particularly in the current financial environment, is the sensitivity to financing. Given that under normal circumstances roughly only one project in 40 becomes an operation, companies aim to minimise upfront costs as much as possible. This is acutely true due to the current lack of capital.

Environmental Considerations

Current design methods prioritise economic considerations over environmental ones. In some cases, economic considerations also serve environmental goals.

Environmental considerations are marginalised in the design process to the extent that Environmental Impact Statements have been introduced around the world in recent years in an effort to ensure that the environment is considered by those designing significant engineering projects. Yet whilst environmental impact statements may deal with the gross impacts of developments on the environment, the environmental considerations that should be considered at the design stage of every product and project of whatever size, such as the choice of materials, layout and processes and the implications that follow from these, remain neglected.

This treatment of environmental impact, if applied to economic impacts, would be similar to designing each part of a project without concern for how much the materials were to cost and then at the end doing an economic impact statement to see if the cost of the overall structure was going to have too much impact on the economy. Not only would you end up with a needlessly expensive project even if the economy could stand it but any attempts at that stage to cut down on costs would interfere with the integrity of the design and it would not be the most efficient way of going about things.

Engineers use safety factors to cover uncertainties about how their products will be used and behave in the real world. A safety factor, sometimes referred to as a "factor of ignorance", allows for a margin of error or the bad luck combination of poor materials and overstressing.16 Safety factors bring into focus the conflict between safety and cost considerations. A large safety factor will require the use of more materials and parts and may make an item less competitive with one that is less conservatively designed.

Safety factors in engineering design, however much they might be whittled down, are a reluctant concession to the overriding need for safety yet there is no similar concession to the need for sustainability. Safety factors do not incorporate environmental considerations

and engineers do not build environmental safety factors into their designs to ensure environmental protection (environmental protection factors") even though the uncertainties surrounding the impact of their designs on the environment are even greater than the uncertainties surrounding the performance and capabilities of their products in use.

Recycling

Metals can be recycled repeatedly without altering their properties. According to the American Iron and Steel Institute (AISI), steel is the most recycled material on the planet. The other highly recycled metals include aluminum, copper, silver, brass, and gold.

Why Do We Recycle Metals?

Metals are valuable materials that can be recycled again and again without degrading their properties. Scrap metal has value, which motivates people to collect it for sale to recycling operations.

In addition to a financial incentive, there is also an environmental imperative. The recycling of metals enables us to preserve natural resources while requiring less energy to process than the manufacture of new products using virgin raw materials. Recycling emits less carbon dioxide and other harmful gasses. More importantly, it saves money and allows manufacturing businesses to reduce their production cost. Recycling also creates jobs.

Quick Metal Recycling Facts

Although almost every kind of metal can be recycled again and again without degradation of properties, currently, only 30 percent of metal is recycled. Below are some additional facts:

- Nearly 40 percent of worldwide steel production is made using recycled steel.
- Around 42 percent of crude steel in the United States is made of recycled materials.
- In the United States alone, around 100 million steel and tin cans are used every day.
- Steel and iron are the most recycled materials in the world due in part to the opportunity to recover large structures as well as the ease of reprocessing. The use of magnets in the sorting process enables recyclers to easily separate them from the mixed waste stream.
- Every year, around 400 million tons of metal are recycled worldwide.
- Currently, the single most recycled consumer product in the U.S. is the aluminium can.
- Throwing away single aluminium can waste energy equivalent to the same can filled with gasoline.

Types of Metals Recycled

Metals can be classified as ferrous, or non-ferrous. Ferrous metals are combinations of iron with carbon. Some common ferrous metals include carbon steel, alloy steel, wrought iron, and cast iron.

On the other hand, non-ferrous metals include aluminium, copper, lead, zinc, and tin. Precious metals are non-ferrous. The most common precious metals include gold, platinum, silver, iridium, and palladium.

Recycling carbon steel

Metal recycling is one of the success stories of sustainable living and minimizing the impact of human activities on the environment. Steel is the most recycled material on the planet, more than all other materials combined.

Sources for recycled steel include scrap from steel mills, secondary manufacturers, and steel products at the end of their product life cycle. There is often not enough recycled steel to meet the manufacturing demand so there is almost always a combination of virgin and recycled steel in the production of finished products.

Recycling steel is also economical as it brings down the cost of finished products. For this reason, the steel industry has been actively involved in promoting and establishing recycling networks to make it easy for end-of life products to be recycled.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of carbon steel production. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Carbon Steel Production Process

Teaching Strategies

Students engage in brainstorming exercise to discover the process of carbon steel production.
They then are allowed to design guiding questions that will enable them to conduct research on carbon steel production process.
Discussions in groups on the research findings.

Learning Strategies

Activity 1: Brainstorming activity to discover the process of carbon steel production.
Activity 2: Conduct research on the process of carbon steel production.
Activity 3: Presentation and discussions of research findings.

Resources

Text on carbon steel production process.

Lesson 2: Economic Costs of Designed Products

Teaching Strategies
Engage students in discussion and presentation of economic costs of designed products.
Engage students in producing a chart on the various impacts in the production of designed products.

Learning Strategies
Activity 1: Discuss and present discussions on economic costs of designed products.
Activity 2: Research and organise presentation various impacts in the production of designed products.
Activity 3: Group presentation

Resources
Text on carbon steel production process.

Lesson 3: Social and Environmental Impacts of the Designing Process

Teaching Strategies
Guided Discovery of social and environmental impacts of the designing process.
Provide reading texts and guided points and questions to guide students.

Learning Strategies
Activity 1: Students read texts on social and environmental impacts of the designing process
Activity 2: Follow guided questions and points to discover the social and environmental impacts of the designing process.
Activity 3: Present works.

Resources
Notes on carbon steel production

Lesson 4: Recycling

Teaching Strategies
Teachers introduce students to the recycling process.

Learning Strategies
Conduct research using guiding questions that will lead to discovering what the recycling terms are.
Activity 1: Brainstorming activity on recycling process and terms.
Activity 2: Conduct research on the recycling process.
Activity 3: Discussions and presentation of research findings.

Resources
Text on carbon steel production process.

STEAM Activity Students work in groups to create a welded key ring or key tag.

Assessment

The main purpose of assessment is to find out if students can use the skill of synthesis to describe processes involved in extracting raw materials all the way to recycling of the used product. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Describe processes involved in extracting raw materials all the way to recycling of the used product.

Performance Assessment Scoring
Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Identifying processes	Clarity in identifying processes	Very good in Identifying processes	Poor in identifying processes	Very poor in identifying processes
2. Describing processes	Clarity in describing processes	Very good in Describing processes	Poor in describing processes	Very poor in describing processes
3.Designing cycles in the process	Clarity in designing cycles in the process	Very good in designing cycles in the process	Poor in designing cycles in the process	Very poor in designing cycles in the process

UNIT 4 Welding Technology

Content Standard 3.4 Investigate and analyse safety procedures, print reading, measurement and layout, identify properties of metals, the welding techniques, cutting processes according to welding codes, inspections, testing principles and apply fundamentals of fabrication.

Benchmark 12.3.4.3 Practice identification and selection of suitable metal material for machining or welding with precision measurement.

Topic 3: Identification of Metals and Materials

Learning Objectives

By the end of this topic, the students will be able to;

- Identify and select correct metals for machining and welding.

Essential Questions:

1. How do we select metals for machining and welding?
2. Why is it important to correctly choose the metal needed in machining and welding?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Identification and selection of Metals for machining, welding processes, forms of welding.	Practice, Identify and select	Appreciative and considerate of the procedures of identification of metals and materials.	Awareness & appreciation

Content Background

Metal Identification process

When you are selecting a metal to use in fabrication, to perform a mechanical repair, or even to determine if the metal is weldable, you must be able to identify its basic type. A number of field identification methods can be used to identify a piece of metal. Some common methods are surface appearance, spark test, chip test, magnet test, and occasionally a hardness test.

Surface Appearance

Sometimes you can identify a metal simply by its surface appearance.

Table 1-1 — Surface Appearance of Some Common Metals

Metal	Color		Color and Structure
	Unfinished, unbroken surface	Freshly filed surface	Newly fractured surface
Aluminum	Light gray	White	White: finely crystalline
Brass and Bronze	Reddish-yellow, yellow-green, or brown	Reddish-yellow to yellowish-white	Red to yellow
Copper	Reddish-brown to green	Bright copper color	Bright red
Iron, Cast-gray	Dull gray	Light silvery gray	Dark gray: crystalline
Iron, Cast-white	Dull gray	Silvery white	Silvery white: crystalline
Iron, Malleable	Dull gray	Light silvery gray	Dark gray: finely crystalline
Iron, Wrought	Light gray	Light silvery gray	Bright gray
Lead	White to gray	White	Light gray: crystalline
Monel metals	Dark gray	Light gray	Light gray
Nickel	Dark gray	Bright silvery white	Off-white
Steel, Cast and Steel, Low-carbon	Dark gray	Bright silvery gray	Bright gray
Steel, High-carbon	Dark gray	Bright silvery gray	Light gray
Steel, Stainless	Dark gray	Bright silvery gray	Medium gray

In addition to the color of the metal, distinctive marks left from manufacturing also help in determining the identity of the metal.

- Cast iron and malleable iron usually show evidence of the sand mold.
- Low-carbon steel often shows forging marks.
- High-carbon steel shows either forging or rolling marks.

Spark Test

You perform the spark test by holding a sample of the unidentified material against an abrasive wheel and visually inspecting the spark stream. This test is fast, economical, convenient, easily accomplished, and requires no special equipment.

As you become a more experienced Steelworker, you will be able to identify the sample metals with considerable accuracy. You can use this test to identify scrap-salvaged metal, which is particularly important when you are selecting material for cast iron or cast steel heat treatment. When you hold a piece of iron or steel (ferrous metals) in contact with a high-speed abrasive wheel, small particles of the metal are torn loose so rapidly that they become red-hot. These small particles of metal fly away from the wheel, and glow as they follow a trajectory path called the carrier line, which is easily followed with the eye, especially when observed against a dark background.

The sparks (or lack of sparks) given off can help you identify the metal. Features you should look for include:

- length of the spark stream
- form of the sparks
- color(s) of the sparks

Chip Test

Another simple field test you can use to identify an unknown piece of metal is the chip test. You perform the chip test by removing a small amount of material from the test piece with a sharp, cold chisel. The material you remove can vary from small, broken fragments to a continuous strip. The chip may have smooth, sharp edges, may be coarse-grained or fine-grained, or may have saw-like edges.

The size of the chip is important in identifying the metal, as well as the ease with which you can accomplish the chipping.

Table 1-2 — Metal Identification by Chip Test

Metal	Chip Characteristics
Aluminum and Aluminum Alloys	Smooth with saw tooth edges. A chip can be cut as a continuous strip.
Brass and Bronze	Smooth with saw tooth edges. These metals are easily cut, but chips are more brittle than chips of copper. Continuous strip is not easily cut.
Copper	Smooth with saw tooth edges where cut. Metal is easily cut as a continuous strip.
Iron, Cast-white	Small brittle fragments. Chipped surfaces are not smooth.
Iron, Cast-gray	About 1/8 inch in length. Metal is not easily chipped; therefore, chips break off and prevent smooth cut.
Iron, Malleable	Vary from 1/4 to 3/8 inch in length (larger than chips from cast iron). Metal is tough and hard to chip.
Iron, Wrought	Smooth edges. Metal is easily cut or chipped, and a chip can be made as a continuous strip.
Lead	Any shape may be obtained because the metal is so soft that it can be cut with a knife.
Monel	Smooth edges. Continuous strips can be cut. Metal chips easily.
Nickel	Smooth edges. Continuous strips can be cut. Metal chips easily.
Steel, Cast and Steel, Low-carbon	Smooth edges. Metal is easily cut or chipped, and a chip can be taken off as a continuous strip.
Steel, High-carbon	Show a fine-grain structure. Edges of chips are lighter in color than chips of low-carbon steel. Metal is hard, but can be chipped in a continuous strip.

Magnetic Test

A magnet test is another method you can use to aid in a metal's general identification. Remember: ferrous metals are iron-based alloys and normally magnetic; nonferrous metals are nonmagnetic. This test is not 100 percent accurate because some stainless steels are nonmagnetic, but it can aid in the first differentiation of most metals. When dealing with stainless steel, there is no substitute for experience.

Hardness Test

Hardness is the property of a material to resist permanent indentation. One simple way to check for hardness in a piece of metal is to file a small portion of it. If it is soft enough to be machined with regular tooling, the file will cut it. If it is too hard to machine, the file will not cut it. This method will indicate whether the material being tested is softer or harder than the file, but it will not tell exactly how soft or hard it is.

The file can also be used to determine the harder of two pieces of metal; the file will cut the softer metal faster and easier. The file method should be used only in situations when the exact hardness is not required. This test has the added advantage of needing very little in the way of time, equipment, and experience.

Machining procedures

Principle Elements of Metal Machining:

1) Cutting Speed:

The cutting speed can be defined as the relative surface speed between the tool and the job. It is a relative term since either the tool or the job or both may be moving during cutting. It is expressed in m/min.

2) Feed:

It may be defined as the relatively small the cutting tool relative to the work piece in a direction which is usually perpendicular to the cutting speed direction. It is expressed in mm/rev or mm/stroke.

It is more complex element as compare to the cutting speed. It is expressed differently for various operations.

3) Depth of cut:

The depth of cut is the thickness of the layer of the metal remove in one cut or pass measured in a direction perpendicular to the machine surface. The depth of cut is always perpendicular to the direction feed motion.

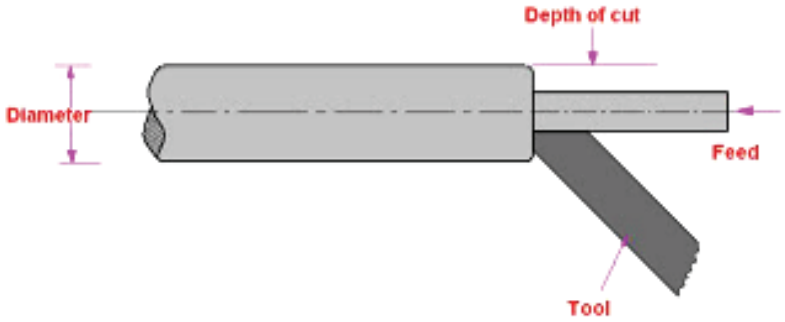


Figure4.3a: Metal machining
Source:https://3.bp.blogspot.com/_2_P6uqc8P3w/TOTHah080JI/AAAAAAAAAJM/EsuRheQZHPY?s1600/metal+machininig+elementsJPG

Forms of welding

1.Soldering

Soldering is similar to welding in that both the base metal and the filler metals are heated to melting and then solidify to form a joint; however, soldering temperatures are typically 840 deg. F or less. Soldering typically involves smaller components to be joined and "softer" metals such as lead/tin or silver. Manual soldering processes use a hand-held iron to heat the components to be joined and the filler metals. Often the filler metal is in the form of a flux-cored wire with additional flux added to assist with wetting (i.e. flow). Where possible, a lead-free solder should be used to avoid potential exposure to lead. For more information on the hazards associated with lead,

2. Arc Welding/Cutting

In arc welding, the intense heat needed to melt metal is produced by an electric arc. The arc is formed between the actual work piece and an electrode (stick or wire) that is manually or mechanically guided along the joint. The electrode can either be a rod, with the purpose of simply carrying the current between the tip and the work, or it may be a specially prepared rod or wire that not only conducts current, but also melts and supplies filler metal to the joint. Power sources for arc welding can be either alternating (AC) or direct (DC) current. The work cable connects to the work piece and the electrode cable creates an arc across the gap when the energized circuit and the electrode tip touches the workpiece and is withdrawn (yet still in close contact). The arc produces a temperature of about 6,500 deg. F at the tip. This heat melts both the base metal and the electrode, producing a pool of molten metal.

Metals at high temperatures can react chemically with elements in the air (oxygen and nitrogen). Oxides and nitrides form, which destroy the strength of the weld. A protective shield of gas, vapor, or slag is used to cover the arc and molten pool to prevent or minimize contact or molten metal with air.

3. Gas Welding/Cutting

Gas welding, or oxy/fuel welding as it is commonly referred to, is slower and easier to control than arc welding. This method unites metals by heating - the heat source being a flame produced by the combustion of a fuel gas, such as acetylene, methylacetylene (MAPP gas), or hydrogen. Temperatures can reach up to 6,000 deg. F. This process sometimes includes the use of pressure and a filler material.

Gases commonly used are oxygen and either acetylene, hydrogen, propane, or propylene. These gases are commonly supplied in compressed gas cylinders, which can pose additional handling and transport hazards.

4. Brazing

Brazing is a process similar to welding in that a liquid filler metal is heated and flows between two or more metal surfaces to be joined. It is very flexible in that any number of metals may be joined. However, brazing occurs at lower temperatures than welding, typically around 840 deg. F. A braze metal is heated to a liquefied state and is spread over the surface to be joined, rather than both the base metal and filler metal being heated to a molten state as in welding. Parts to be joined must be very clean, often using mechanical methods such as sanding, grinding, abrasive blasting, or the use of chemical solvents. There are several types of brazing based upon the source of heat. Brazing is commonly used to seal or join pipes and the associated hazards are similar to those of welding.

5. Shielded Metal Arc Welding

Shielded Metal Arc Welding (SMAW) is commonly known as "stick" welding. A flux-covered electrode is used to form a gas shield around the molten weld pool. The flux coating quickly forms a protective "slag" during welding, which produces a gas shield that decreases exposure to oxygen. The electrode is consumed as it moves down the length of the weld joint and the "slag" must cool and later be chipped away.

6. Gas Metal Arc Welding

Gas Metal Arc Welding (GMAW) is commonly known as "MIG" welding. A continuous-feed electrode (i.e. wire) from a spool is used to supply filler metal directly from the torch tip to the weld. As arcing occurs, the electrode instantly melts and a shielding gas, such as argon, carbon dioxide, or helium, is supplied through the torch tip.

7. Gas Tungsten Arc Welding

Gas Tungsten Arc Welding (GTAW) is commonly known as "TIG" welding. An electric arc between a tungsten electrode and the base metal is created. A separate filler rod is fed into the molten base metal, if needed. A shielding gas (i.e. commonly argon, helium, or carbon dioxide) also flows around the arc to minimize atmospheric interactions. Water is often used to cool the torch and cables.

8. Plasma Arc Welding

Plasma Arc Welding (PAW) is similar to TIG welding in which an arc, shielded by an inert gas, creates the necessary heat to melt the metals involved. The electrode is not consumed in PAW; however, the primary means of transferring heat to the work piece is by a hot ionized gas (i.e. "plasma"). Temperatures can reach up to 30,000 deg. F, which is substantially hotter than those produced by an arc only. Commonly, PAW is a fully automatic process. Filler metal may be used, and plasma and shielding gases include argon, argon/helium, and argon/hydrogen.

Welding and Cutting Processes

Welding involves joining two or more pieces of metal together to form a single piece. Molten metal is generated through an intense heat source, such as oxygen and fuel gas or an electrical arc. Common welding processes using an electrical arc include Shielded Metal Arc Welding, Gas Metal Arc Welding, and Gas Tungsten Arc Welding.

Unlike welding processes which join two pieces of metal, cutting processes involve separating or severing a piece of metal through intense heat generated to melt the metal. Cutting processes include oxygen and fuel gas and electrical arc gouging.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of welding technology. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Metal Identification Process

Teaching Strategies
Students engage in brainstorming exercise to discover the Metal Identification Process
They then are allowed to design guiding questions that will enable them to conduct research on
Metal Identification Process.
Discussions in groups on the research findings.

Learning Strategies
Activity 1 Brainstorming activity on the metal identification process.
Activity 2 Conduct research on the metal identification process.
Activity 3 Discussions and presentation of research findings.

Resources
Text on metal identification process

Lesson 2: Machining Procedures

Teaching Strategies
Engage students in discussion on the presentation of machining procedures.
Make use of resources to discover the machining procedures.

Learning Strategies
Activity 1: Discuss and present discussions on machining procedures.
Activity 2: Research and organise a presentation on machining procedures using pictures for clarity.
Activity 3: Group presentation.

Resources
Text on the machining process

Lesson 3: Forms of Welding

Teaching Strategies
Guided discovery of the Forms of Welding
Provide reading texts and guided points and questions to guide students.

Learning Strategies
Activity 1: Students read texts on the Forms of Welding.
Activity 2: Follow guided questions and points to discover on the Forms of Welding.
Activity 3: Present works.

Resources
Notes on the forms of welding.

STEAM Activity Students work in groups to create a welded candle holder

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Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to practice identification and selection of suitable metal material for machining or welding with precision measurement. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Identify and select correct metals for machining and welding

Performance Assessment Scoring
Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. 1. identifying and selecting correct metals for a project	Highly competent in identifying and selecting correct metals for a project	Competent efforts in identifying and selecting correct metals for a project	Satisfactory efforts identifying and selecting correct metals for a project	Difficulty in identifying and selecting correct metals for a project
Selection of materials by their properties	Accurate demonstration of properties of metals when selecting for fabrication	Correct demonstration of properties of metals when selecting for fabrication	Partial demonstration of properties of metals when selecting for fabrication	Poor demonstration of properties of metals when selecting for fabrication

UNIT4: Welding Technology

Content Standard 3.4 Investigate and analyse safety procedures, print reading, measurement and layout, identify properties of metals, the welding techniques, cutting processes according to welding codes, inspections, testing principles and apply fundamentals of fabrication.

Benchmark 12.3.4.4 Use computer applications for planning, preparing and processing of materials.

Topic 4: Computer Applications in Welding

Learning Objectives
By the end of this topic, the students will be able to;

- Use computer applications to plan, prepare and process materials.

Essential Questions:
1. How are computers used in the welding industry?
2. Why is it important for a welder to be computer literate?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Computer applications (CAD programs)	Use and apply	Open-minded and appreciative of computer applications in welding.	Appreciate, passion, awareness

Content Background

The use of computers in the welding industry

Welding industry is a dynamic industry that has evolved considerably with recent developments in technology. These technological developments have continually improved the quality, accuracy and versatility of welding processes. The welding process today, is a high-tech skill, which uses powerful lasers, electron beams and sometimes explosives for conjoining metals.

Computers have become an indispensable part of welding processes. Computer proficiency is required for execution of all these welding operations. If studies are to be believed, people from fields of lasers, computer programming, robotics, materials engineering and systems integration will find plenty of career opportunities in welding.

With the increasing demand for high-skilled and technically sound workers arising, more and more people are entering welding to shape up their careers around the fields of their interest. Computers have played a pivotal role in welding fields in some of the following ways:

Computer modelling

Computer technology has helped enhance productivity and quality of welding. Efficient conciliation of technology and economy has helped in defining better fabrication conditions. This has led to development of better modelling approaches that have augmented productivity and quality. The modelling processes include establishing the needs for the project, complexity of welding procedure specifications and requirements for welding documentation. Some ways in which computers have made life easy for most welders include:

Selection: The welding engineer, with the help of experts, documentation from steel works and catalogues from electrode manufacturers, earlier made the selection of welding consumable. The material of welding and even its techniques had to be selected similarly. These can now easily be selected using computer technology and complex simulations.

This helped in indicating the smallest variations of a design parameter with a very high resolution. You can keep a check on welding safety by this method. It is however, still important to use the correct safety equipment for better safety.

Resolving complex problems: Finding solutions for complex and imprecise problems was a herculean task before the advent of artificial intelligence and operational analysis tools. The simulated annealing solution is one such resolving strategy that can help find exact solutions to such complex problems. There is hence, the best possible and most optimum solution for every such complex problem by using computerized mathematical methods.

Evaluation: The engineering evaluation of the computed results is again calculated using computers. This helps in attaining the exact and most accurate results, to determine the precise expectations and perspectives of modelling tools for better fabrication quality.

Computer technology also plays a major role in welding engineering for equipment control, manufacturing support and production monitoring. These further become instrumental for information handling, quality control, and education and training. The application of more and more developed software and innovative control systems will help information control and product value, while simultaneously reducing manufacturing and production costs.

Types of computer programs used in the welding industry.

Designed to integrate with one-another, the following welding software packages allow you to cover your requirements simply and effectively.

Welding Qualifier – This welding management software is designed to help engineers and managers track welding procedures and welder qualifications while also ensuring compliance with the latest code rules and QA procedures. Saving you time and money in tracking your qualifications, Welding Qualifier allows you to make sure your records and documentation are up-to-date and ready to meet your welding needs.

Welding Coordinator – This fabrication management software covers design, engineering, production and QC issues, allowing you to monitor your site-wide welding activities and giving you traceability of your welding information. Welding Coordinator has full progress and performance reporting facilities as well as mobile data entry functions.

Welding Estimator – This easy-to-use cost estimation tool allows you to find the most cost-effective process for your welding requirements. Create and compare costing reports to make sure you get the best value for money for your job while meeting project timescales.

Computer-aided design (CAD) is the generic term describing the use of software and computer tools that create 2-D and 3-D technical drawings. CAD software in general is used to create and manipulate geometric shapes into specific designs. AutoCAD is the name of a proprietary software of the same use created in 1982 by Autodesk, Inc. AutoCAD software is used in all phases of design for manufacturing, infrastructure, and building construction, as well as in the media and entertainment world to create 3-D visual effects.

3D CAD, or three-dimensional computer-aided design**,** is technology for design and technical documentation, which replaces manual drafting with an automated process. Used by architects, engineers, and other professionals, 3D CAD software precisely represents and visualizes objects using a collection of points in three dimensions on the computer.

Autodesk has a broad portfolio of **3D CAD software** programs to help people explore and share ideas, visualise concepts, and simulate how designs will perform before they are made.

Teaching and Learning Strategies
Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of CAD in welding. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: The Use of Computers in the Welding Industry

Teaching Strategies
Students engage in brainstorming exercise to discover the use of computers in the welding industry.
They then are allowed to design guiding questions that will enable them to conduct research.
Discussions in groups on the research findings.
Present their research.

Learning Strategies
Activity 1: Brainstorming activity on the use of computers in the welding industry.
Activity 2: Conduct research on welding computer applications and or software in the industry.
Activity 3: Discussions and presentation of research findings.

Resources
Notes on the use of computers in the welding industry.

Lesson 2: Types of Computer Applications used in the Welding Industry.

Teaching Strategies
Engage students in presentation of types of computer applications used in the welding industry.
Engage students in the discussion.

Learning Strategies
Discover computer types
Activity 1: Brainstorming activity on how computer welding applications are used in the industry.
Activity 2: Conduct research on how they are used, the characteristics and the benefits.
Activity 3: Discussions and presentation of research findings.

Resources
Teacher Notes

Lesson 3: Use of Computer Applications to simulate projects in 3D CAD.

Teaching Strategies
Engage students in presentation of types of computer applications to simulate projects in welding.
Engage students in the discussion of CAD in welding.

Learning Strategies
Discover computer types
Activity 1: Brainstorming activity on how computer applications to simulate welding projects.
Activity 2: Conduct research on how CAD in simulation of welding projects.
Activity 3: Discussions and presentation of research findings.

Resources
Teacher Notes

STEAM Activity Students work in groups to create a welded Christmas tree with a metal base utilising CAD or FreeCAD.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to use computer applications to plan, prepare and process materials. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
Use computer applications to plan, prepare and process materials.
1. Types of metals
2. Metal uses and properties

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1.Discover and express correctly the metals and their alloys, at least 4 metals and their alloys	Correct names of four metals and their alloys.	Correct names of three metals and their alloys.	Correct names of two metals and their alloys.	Correct names of one metal and its alloys.
2. Investigate and explain their properties and their uses of at least 4 metals.	Investigate and explain their properties and their uses of at least 4 metals.	Investigate and explain their properties and their uses of at least 3 metals.	Investigate and explain their properties and their uses of at least 2 metals.	Investigate and explain their properties and uses of at least 1 metal.

UNIT 4 Welding Technology

Content Standard 3.4 Investigate and analyse safety procedures, print reading, measurement and layout, identify properties of metals, the welding techniques, cutting processes according to welding codes, inspections, testing principles and apply fundamentals of fabrication.

Benchmark 12.3.4.5 Assess procedures and standards for inspection of welding and machining quality.

Topic 5: Inspection Standards

Learning Objectives
By the end of this topic, the students will be able to;

- Assess the standards and procedures for welding Inspections.
- Identify importance of inspecting welding and machining

Essential Questions:
1. What are the standards and procedures for Inspections?
2. Why is inspection important for welding and machining?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Inspection standards and procedures	Assess	Appreciative and open-minded to understanding standards and inspection sin welding.	Appreciate and value

Content Background

Welding and machining quality

Welding Quality

Checking the quality of welding is extremely important, so comprehensive and stringent quality management is required. This page introduces various welding quality requirements.

Quality of Welding
The following are typical requirements for the quality of weld products.

- The product is finished accurately in accordance with the design dimensions.
- The product offers the required functionality and strength (or safety).
- The appearance of the weld satisfies the required level.

The basic conditions of welding quality to achieve products of such high quality includes the following:

- No cracks or holes found in the bead.
- The bead has uniform waves, width and height.
- The finished product satisfies the design dimensions and has almost no distortion.
- The welding meets the required strength.
- Full penetration welds that fuse and join the entire interface between the base materials or a weld-joints including partial penetration welds should be used appropriately to ensure the necessary rigidity.

Machining Quality

This study investigates the effects of machining parameters as they relate to the quality characteristics of machined features. Two most important quality characteristics are set as the dimensional accuracy and the surface roughness. Before any newly acquired machine tool is put to use for production, it is important to test the machine in a systematic way to find out how different parameter settings affect machining quality.

Inspections standards and procedures

Figure 4.5a: Welding standards
Source: https://www.sciencedirect.com/science/article/pii/S2288430014500188

Welding Inspection Prior to Welding Work
Stage 1 - Welding Inspection Procedure / Checklist

- Welding symbols and weld sizes clearly specified in drawing and related documents.
- Weld joint designs and dimensions clearly specified in drawings and related documents.
- Weld maps identify the welding procedure specification (WPS) to be used for specific weld joints.
- Dimensions detailed and potential for distortion addressed.
- Welding consumables specified.
- Proper handling of consumables, if any, identified.
- Base material requirements specified (such as the use of impact tested materials where notch ductility is a requirement in low temperature service).
- Mechanical properties and required testing identified.
- Weather protection and wind break requirements defined.
- Preheat requirements and acceptable preheat methods defined.
- Post-weld heat treatment (PWHT) requirements and acceptable PWHT method defined.
- Inspection hold-points and NDE requirements defined.
- Additional requirements, such as production weld coupons, clearly specified.
- Pressure testing requirements, if any, clearly specified

- Competency of welding organisation to perform welding activities in accordance with codes, standards, and specifications specified
- Roles and responsibilities of engineers, welding organisation, and welding inspectors defined and appropriate for the work.
- Independence of the inspection organization from the production organisation is clear and demonstrated.
- WPS(s) are properly qualified and meet applicable codes, standards and specifications for the work.
- Procedure qualification records (PQR) are properly performed and support the WPS(s).
- Welder performance qualifications (WPQ) meet requirements for the WPS.
- NDE examiners are properly certified for the NDE technique.
- NDE procedures are current and accurate.
- Calibration of NDE equipment is current.
- Welding machine calibration is current
- Instruments such as ammeters, voltmeters, contact pyrometers, have current calibrations.
- Storage ovens for welding consumables operate with automatic heat control and visible temperature indication.
- Heat treatment procedure is available and appropriate
- Pressure testing procedures are available and detail test requirements.
- PWHT equipment calibration is current.
- Pressure testing equipment and gauges calibrated and meet appropriate test requirements.
- Material test certifications are available and items properly marked (including back-up ring if used).
- Electrode marking, bare wire flag tags, identification on spools of wire, etc. as-specified.
- Filler material markings are traceable to a filler material certification.
- Base metal markings are traceable to a material certification.
- Recording of filler and base metal traceability information is performed.
- Base metal stampings are low stress and not detrimental to the component.
- Paint striping color code is correct for the material of construction.
- PMI records supplement the material traceability and confirm the material of construction.
- Weld preparation surfaces are free of contaminants and base metal defects such as laminations and cracks.
- Preheat, if required, applied for thermal cutting c. Hydrogen bake-out heat treatment, if required, performed to procedure.
- Weld joint is free from oxide and sulfide scales, hydrocarbon residue, and any excessive build-up of weld-through primers.
- Weld joint type, bevel angle, root face and root opening are correct.
- Alignment and mismatch are correct and acceptable.
- Dimensions of base materials, filler metal, and weld joint are correct.
- Piping socket welds have proper gap.
- Preheat equipment and technique are acceptable.
- Preheat coverage and temperature are correct.
- Reheat, if required, applied to thermal cutting operations.
- Preheat, if required, applied to remove moisture
- Filler metal type and size are correct per procedure.
- Filler metals are being properly handled and stored.
- Filler metals are clean and free of contaminants.
- Coating on coated electrodes is neither damaged nor wet.
- Flux is appropriate for the welding process and being properly handled.
- Inert gases, if required are appropriate for shielding and purging.

- Gas composition is correct and meets any purity requirements.
- Shielding gas and purging manifold systems are periodically bled to prevent back filling with air.

Stage 2 - Welding Inspection During Welding

- Welder is responsible for quality craftsmanship of weldments
- Welder meets qualification requirements
- Welder understands welding procedure and requirements for the work.
- Special training and mock-up weldments performed if required.
- Welder understands the inspection hold-points.
- Essential variables are being met during welding.
- Filler material, fluxes, and inert gas composition/flow rate.
- Purge technique, flow rate, O2 analysis, etc.
- Rod warmers energized or where rod warmers are not employed, the welder complies with maximum exposure times out of the electrode oven.
- Preheating during tack welding and tack welds removed (if required).
- Welding technique, weld progression, bead overlap, etc.
- Equipment settings such as amps, volts, and wire feed.
- Preheat and inter-pass temperatures.
- Travel speed (key element in heat input).
- Heat input (where appropriate).
- Mock-up weldment, if required, meets requirements with welder and welding engineer.
- Welder displays confidence and adheres to good welding practices.
- Tack welds to be incorporated in the weld are of acceptable quality.
- Weld root has adequate penetration and quality.
- Cleaning between weld passes and of any back-gouged surfaces is acceptable.
- Additional NDE performed between weld passes and on back-gouged surfaces shows acceptable results.
- In-process rework and defect removal are accomplished.
- In-process ferrite measurement, if required, is performed and recorded.
- Final weld reinforcement and fillet weld size meets work specifications and drawings.

Stage 3 - Welding Inspection Upon Completion Of Welding

Figure 4.5b : Welding standards
Source: https://www.inspection-for-industry.com/welding-inspection.html

- Size, length and location of all welds conform to the drawings / specifications / Code.
- No welds added without approval.
- Dimensional and visual checks of the weld don't identify welding discontinuities, excessive distortion and poor workmanship.
- Temporary attachments and attachment welds removed and blended with base metal.
- Discontinuities reviewed against acceptance criteria for defect classification.
- PMI of the weld, if required and examiner's findings indicate they comply with the specification.
- Welder stamping/marking of welds confirmed.
- Perform field hardness check.
- Verify NDE is performed at selected locations and review examiner's findings.
- Specified locations examined.
- Specified frequency of examination.
- NDE performed after final PWHT.
- Work of each welder included in random examination techniques.
- RT film quality, IQI placement, IQI visibility, etc. complies with standards.
- Inspector is in agreement with examiners interpretations and findings.
- Documentation for all NDE correctly executed
- Verify post-weld heat treatment is performed to the procedure and produces acceptable results.
- Paint marking and other detrimental contamination removed.
- Temporary attachments removed.
- Machined surfaces protected from oxidation.
- Equipment internals, such as valve internals, removed to prevent damage.
- Equipment supported to prevent distortion.
- Thermocouples fastened properly.
- Thermocouples adequately monitor the different temperature zones and thickest/thinnest parts in the fabrication.
- Temperature monitoring system calibrated.
- Local heating bandwidth is adequate.
- Insulation applied to the component where required for local heating.
- Temperature and hold time are correct.
- Heating rate and cooling rate is correct.
- Distortion is acceptable after completion of the thermal cycle.
- Hardness indicates an acceptable heat treatment
- Verify pressure test is performed to the procedure
- Pressure meets test specification.
- Test duration is as-specified.
- Metal temperature of component meets minimum and maximum requirements.
- Pressure drop or decay is acceptable per procedure.
- Visual examination does not reveal defects.
- Perform a final audit of the inspection dossier to identify inaccuracies and incomplete information.
- All verifications in the quality plan were properly executed.
- Inspection reports are complete, accepted and signed by responsible parties.
- Inspection reports, NDE examiners interpretations and findings are accurate.

Teaching and Learning Strategies
Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of welding standards and inspections. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Welding and Machining Quality

Teaching Strategies
Students engage in brainstorming exercise to discover welding and machining quality
They then are allowed to design guiding questions that will enable them to conduct research.
Discussions in groups on the research findings.

Learning Strategies
Activity 1: Brainstorming activity welding and machining quality.
Activity 2: Conduct research.
Activity 3: Discussions and presentation of research findings.

Resources
Texts on welding and machining quality

Lesson 2: Inspections Standards and Procedures

Teaching Strategies
Engage students in the discussion presentation of Inspections standards and procedures.

Learning Strategies
Activity 1: Use notes and question as guides.
Activity 2: Do class exercises.

Resources
Texts on welding and machining

STEAM Activity Students work in groups to create an activity incorporating machining safety standards,

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to Assess procedures and standards for inspection of welding and machining quality.
Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment

1. Assess the standards and procedures for Inspections.
2. Identify importance of inspecting welding and machining
1. Types of welding techniques
2. How to apply them.
3. Careers in welding

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	**Advanced**	**Meet Standard**	**Progressing**	**Not Yet**
1. Identify standards and procedures for Inspections.	Accurately identify standards and procedures for Inspections.	Correctly **i**dentify standards and procedures for Inspections.	Partially identify standards and procedures for Inspections.	Cannot identify standards and procedures for Inspections.
2. Identify importance of inspecting welding and machining.	Accurately identify importance of inspecting welding and machining.	Correctly identify importance of inspecting welding and machining.	Partially identify importance of inspecting welding and machining.	Cannot identify importance of inspecting welding and machining.
1. Discover and express correctly the different types of welding techniques at least 4 types.	Correct names of four welding techniques and their applications.	Correct names of three welding techniques and their applications.	Correct names of two welding techniques and their applications.	Correct names of one welding technique and its applications.
2. Investigate and describe 4 career pathways in welding.	Investigate and describe 4 career pathways in welding.	Investigate and describe 3 career pathways in welding.	Investigate and describe 2 career pathways in welding.	Investigate and describe 1 career pathway in welding.

UNIT 4 Welding Technology

Content Standard 3.4 Investigate and analyse safety procedures, print reading, measurement and layout, identify properties of metals, the welding techniques, cutting processes according to welding codes, inspections, testing principles and apply fundamentals of fabrication.

Benchmark 12.3.4.6 Evaluate welding and machining project creation in accordance to industry standards.

Topic 6: Welding Projects Evaluation

Learning Objectives
By the end of this topic, the students will be able to;

- Evaluate and assess welding and machining projects according to industry standards.

Essential Questions:
1. How are the projects evaluated to meet industry standards?
2. Why is it important to assess and evaluate welding projects or tasks based on industry standards?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Welding and machining projects	Evaluate	Collaboration and teamwork in understanding materials standards and inspections in welding.	Creativity, value and appreciate

Content Background

Validation of welding and machining projects or tasks
Checklist – Before Welding

- ✓ Review drawings and specifications to determine if any special considerations, such as preheat is necessary.
- ✓ Ensure purchased material (base material and consumables) are those which have been specified.
- ✓ Check material test reports and chemical compositions against requirements.
- ✓ Check condition and storage of welding consumables. Low-hydrogen electrodes need special storage to prevent moisture pick up.
- ✓ Check that material fit-up is adequate
- ✓ Check the cleanliness of the joint. Excessive levels of rust, oil, dirt, paint and other contaminants are detrimental to weld quality.

- ✓ Check that proper welding procedures specification and welder qualifications are in place and up to date.
- ✓ If preheat is necessary, ensure it is done and measured correctly.

Checklist – During Welding

- ✓ Check that all parameters stated in the Welding Procedure Specification are being followed. These parameters include items such as wire feed speed, voltage, electrical stick out, welding technique, welding progression, travel and push angles, shielding gas, adequate preheat and inter-pass temperature (if required), etc.
- ✓ Check individual weld passes. If there is a multi-pass weld make sure each pass is adequate before placing the next weld. Problems can arise when welding over passes that have excessive convexity, trapped slag at the toes and other inconsistencies.
- ✓ If necessary, check that proper inter-pass temperature is being maintained. Inter-pass temperature is usually shown as a minimum, but some cases will also have a maximum inter-pass temperature.
- ✓ Check for visual cues that can indicate problems. This is the responsibility of the welder. Surface contaminants, low-melting elements and other things can cause a variety of problems. A welder can see if he is not getting adequate penetration, something that can't be seen after welding unless ultrasonic, radiographic or tests are performed.

Checklist – After Welding

- ✓ Check weld appearance to ensure no inconsistencies or discontinuities are present.
- ✓ Check for adequate weld size.
- ✓ Check for adequate weld length, especially when intermittent welds are used.
- ✓ Select parts to be tested according to specifications.
- ✓ Check that post weld heat treatment is done properly, if necessary

Metal Fabrication and Welding Industry Standards

Metal fabrication is the building of metal structures by cutting, bending, and assembling processes. It is a value-added process that involves the creation of machines, parts, and structures from various raw materials. An abundance of codes and standards are available for use by nearly all manufacturers and fabricators. Some are mandated by state law, and some are selective. Some states mandate by law that any producer of pressure vessels or piping must be an "authorized" code-compliant company. The end product determines the codes and standards to be followed. To state that a product is constructed or repaired to a certain code, you must follow all "mandatory" instructions of that particular code. The word *shall* in a code or standard indicates a mandatory rule. The word *should* indicate a no mandatory recommendation that requires you to make your "best engineering judgment."

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of welding technology. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Validation of Welding and Machining Projects or Tasks

Teaching Strategies
Students engage in brainstorming exercise to discover validation of welding and machining projects or tasks.
They then are allowed to design guiding questions that will enable them to conduct research.
Discuss in groups on the research findings.

Learning Strategies
Activity 1: Brainstorming activity to discover the validation of welding and machining projects.
Activity 2: Conduct research on welding and machining projects.
Activity 3: Discussions and presentation of research findings welding and machining projects.

Resources
Texts on validation of welding and machining projects or tasks

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Lesson 2: MFW Industry Standards

Teaching Strategies
Students engage in brainstorming exercise to discover MFW standards in welding and machining projects or tasks.
They then are allowed to design guiding questions that will enable them to conduct research on MFW standards in welding and machining projects or tasks.
Discuss in groups on the research findings on MFW standards in welding and machining projects or tasks.

Learning Strategies
Activity 1: Brainstorming activity to discover the MFW standards in welding and machining projects or tasks.
Activity 2: Conduct research on MFW standards in welding and machining projects or tasks.
Activity 3: Discussions and presentation of research findings on MFW standards in welding and machining projects or tasks.

Resources
Texts on validation of welding and machining projects or tasks.

STEAM Activity Students work in groups to create a sculptured, welded metal craft.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to evaluate welding and machining project creation in accordance to industry standards. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Evaluate and assess welding and machining projects according to industry standards.

Performance Assessment Scoring
Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Identify methods of evaluation of welding and machining projects according to industry standards.	Accurately identify methods of evaluation of welding and machining projects according to industry standards.	Correctly identify methods of evaluation of welding and machining projects according to industry standards.	Partially identify methods of evaluation of welding and machining projects according to industry standards.	Cannot identify methods of evaluation of welding and machining projects according to industry standards.
2. Conduct an assessment on welding and machining projects according to industry standards.	Accurately conduct an assessment on welding and machining projects according to industry standards.	Correctly conduct an assessment on welding and machining projects according to industry standards.	Partially conduct an assessment on welding and machining projects according to industry standards.	Cannot conduct an assessment on welding and machining projects according to industry standards.

Unit 5: Engineering Technology

Unit	Topic	Lesson Titles
5.Engineering Technology	**Topic 1**: The Nature of Engineering in Various Fields and its Significance in Society	1. The Nature of Engineering in Various Fields 2. Significance of Engineering Field to Society 3. The Roles and Responsibilities of Engineering Fields 4. Methods of Controlling Pollution in Engineering Fields
	Topic 2: Applications of Engineering Design	1. Methods of Engineering Designs Structures in Various Field 2. Types of Design Specification and Symbols used in Engineering 3. The Common Significant Design Specifications Used and Applied in Engineering
	Topic 3: Properties of Engineering Material, Equipment uses and Application	1. Types of Engineering Material and their Properties 2. Types of Engineering Equipment 3. Methods of Using Material and Equipment in Engineering 4. Process Equipment Used in Various Engineering
	Topic 4: Introduction to Engineering Analytical and solving Techniques	1. Engineering Skills and Techniques 2. Types of Skills and Techniques used in Engineering Field 3. Methods of Decision Making in Graphs 4. Types of Graphs used in Engineering Assumption
	Topic 5: Impacts of Technological Change in Engineering	1. Environmental effect and pollution caused by engineering field 2. Types of pollutions caused by engineering field 3. Methods of minimising Pollutions 4. Types of engineering report writing and presentation

UNIT 5. Engineering Technology

Content Standard 3.5 Investigate and analyse the historical and societal influences in Engineering by understanding the engineering principles, practices, the design process, the management, problem-solving and communication skills appropriate to any engineering field.

Benchmark 12.3.5.1 Describe and analyse the nature of engineering in specific field and its importance to society

Topic 1: The Nature of Engineering in Various Fields and its Significance in Society

Learning Objectives
By the end of this topic, the students will be able to;

- Analyse and describe the nature of engineering and its significance to society.

Essential Questions:
1. What is the nature of engineering in various fields?
2. What is the significance of engineering field in society?
3. What are the common roles and responsibilities of engineering field?
4. What are the methods of controlling pollution in engineering fields?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Nature of engineering in various fields	Describe and apply	Open-minded and critical in the nature of engineering in society.	Importance

Content Background

The Nature of engineering in various fields and its significant in society

The nature of engineers is to design and develop new solutions that meet people's needs on a daily basis by using scientific principles and technological tools. In other words, the role of engineers tends to extend to research and development of new products, with a focus on the maintenance of engineering equipment, the use of materials and the methods used in engineering.

The human race has come a long way. From discovering the fire to now building human counterparts in the form of robots - human beings are leaving no stones unturned to make the living easier and sustainable. Today, the application of engineering spans the spectrum from deep sea exploration to space travel and beyond. In the modern era, it would be extremely difficult to find an avenue where engineering hasn’t left its footprint. From construction to aeronautics, medicine to environment, and even the chair you are sitting in, engineering is everywhere. Engineers play an important part in all of these.

Engineering is considered as one of the most important disciplines of study in the current world. And its importance is felt around by almost everybody across the world. Without the adoption of Engineering practices, no country will evolve and be able to heighten its economy.

An Engineer is a person who develops ways through his/her scientific knowledge, mathematics, experiments, intuition and judgement to use materials or forces of nature economically for a sustainable future of mankind. And their applications are observed anywhere and everywhere. With their innovative, imaginative minds, Engineers give a lot to the betterment of society.

Influence of Engineering across Various Sectors

1. Construction

Engineering has contributed immensely towards the development of infrastructure that is crucial to the sustenance of our civilization. Proper knowledge of civil engineering has not only enabled us to build bridges, dams, tunnels, expressways but also figure out a way to effectively handle traffic congestions, disasters, and other unfavorable circumstances.

2. Medicine

When we talk about the progress in medical science, the image of a biologist or a highly-qualified doctor comes to our mind. But, you will be surprised to know that engineering and medical science goes hand in hand with each other to improve the quality of healthcare. From MRI machines to X-rays and pacemakers to Glucose Level Monitors - engineering has contributed more to medical science.

3. Energy

Have you ever wondered about the technology that powers small household appliances to humongous machines in factories? Of course, it's the electric current that is conducted by high-tension wires from power stations. But, how are the grids designed? Or, how do you ensure that high-voltage current doesn't damage your gadgets? Electrical engineering is helping us generate a massive amount of energy by designing and developing power grids, transformers, commutations, etc. Over the last decade, power generation through sustainable means such as solar and wind energy have been made possible due to the advancements in electrical and other engineering and technology.

4. Environment

Development and deployment of systems that provide drinking water, that is safe for human consumption is one of the major contributions of environmental engineering. Moreover, there is also the need for a mechanism that can reduce pollution and clean up contaminated water bodies, land, and sustain our crops and livestock. Thankfully, the pioneers in environmental engineering are tackling these issues by coming up with new and innovative solutions to minimise pollution making industrial processes that are environment-friendly.

Apart from these areas, Engineering has a wide range of applications in automotive, food processing, manufacturing, electronics, avionics, biotechnology, and software industries.

How engineering is solving complex problems

The basic tenet of engineering has always been about solving complex issues and making lives simple, safe, happy and productive. Through the pages of history, it can be seen how engineering has solved complex problems. Be it transportation, manufacturing, or even winning wars, engineering has always played a pivotal role in all ventures.

Today, engineering is helping society create devices, machines, and software that can solve some of the most complex problems. For example, robotics and embedded engineers have already developed robots that can detect and disarm explosive charges. Robots have already been developed to help in the case of fires and disasters to evacuate trapped victims. These systems are being put through rigorous testing, undergoing continuous improvement before they can be deployed on a large scale.

Climate change is a looming disaster; it could be quite disastrous for the human race if left unchecked. Fortunately, engineers and scientists are working together to develop green technologies, low-cost nuclear reactors, and means to harness solar power. These innovations will focus on curbing the amount of pollution humans spill into our ecosystem.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of engineering technology. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: The Nature of Engineering in Various Fields

Teaching Strategies

Engage students in brainstorming exercise to define the nature of engineering in various fields.
Engage students to discuss and define the nature of engineering in various fields.

Learning Strategies

Discover the nature of engineering in various fields.

Activity 1: Brainstorming activity on different terminologies used to define the nature of engineering in various fields.
Activity 2: Conduct research on the nature of engineering in various fields.
Activity 3: Discussions and presentation of research findings on the nature of engineering in various fields.

Resources
Front Matter Structural Engineering Handbook Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

Lesson 2: Significance of Engineering Fields to Society

Teaching Strategies
Engage students in brainstorming exercise to state the significant of engineering field to society.
Engage students to discuss to state the significant of engineering field to society.

Learning Strategies
Discover and state the significant of engineering field to society.

Activity 1: Brainstorming activity to state the significant of engineering field to society.
Activity 2: Conduct research on the significant of engineering field to society.
Activity 3: Discussions and presentation of research findings on the significant of engineering field to society.

Resource
Front Matter Structural Engineering Handbook Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

Lesson 3: The Roles and Responsibilities of Engineering Fields

Teaching Strategies
Engage students in brainstorming exercise on the roles and responsibilities of engineering fields.
Engage students to discuss the roles and responsibilities of engineering fields.

Learning Strategies
Discover the roles and responsibilities of engineering fields.

Activity 1: Brainstorming activity on the roles and responsibilities of engineering fields.
Activity 2: Conduct research on the roles and responsibilities of engineering fields.
Activity 3: Discussions and presentation of research findings on the roles and responsibilities of engineering fields.

Resources
Front Matter Structural Engineering Handbook Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

Lesson 4: Methods of Controlling Pollution in Engineering Fields

Teaching Strategies
Engage students in brainstorming exercise on the methods of controlling pollution in engineering fields.
Engage students to discuss on different methods of controlling pollution in engineering fields.

Learning Strategies
Discover the methods of controlling pollution in engineering fields.

Activity 1: Brainstorming activity on different methods of controlling pollution in engineering fields.
Activity 2: Conduct research on different methods of controlling pollution in engineering fields.
Activity 3: Discussions and presentation of research findings on different methods of controlling pollution in engineering fields.

Resources
Front Matter Structural Engineering Handbook Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

STEAM Activity Students work in groups to create an activity incorporating concepts of impacts of engineering to society.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to describe and analyse the nature of engineering in specific field and its importance to society. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Analyse and describe the nature of engineering in various fields.
2. Analyse and apply the most significant of engineering field in the society.
3. List and describe the common roles and responsibilities of engineering field.
4. Analyse and apply the methods of controlling pollution in engineering fields.

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1.Analyse and describe the nature of engineering in various fields	Analyse and describe the nature of engineering in various fields excellently.	Analyse and describe the nature of engineering in various fields very well.	Analyse and describe the nature of engineering in various fields partially.	Analyse and describe the nature of engineering in various fields very poorly.
2. Analyse and apply the significance of engineering field in the society	Analyse and apply the significance of engineering field in the society excellently.	Analyse and apply the significance of engineering field in the society very well.	Analyse and apply the significance of engineering field in the society partially.	Analyse and apply the significance of engineering field in the society very poorly.
3.List and describe the common roles and responsibilities of engineering field	List and describe all the common roles and responsibilities of engineering field	List and describe some of the common roles and responsibilities of engineering field	List and describe a few of the common roles and responsibilities of engineering field	List and describe the none common roles and responsibilities of engineering field
4.Analyse and apply the methods of controlling pollution in engineering fields	Excellent analysis and description of the methods of controlling pollution in engineering fields	Correctly analyse and describe the methods of controlling pollution in engineering fields	Partially analyse and describe the methods of controlling pollution in engineering fields	Cannot analyse and describe the methods of controlling pollution in engineering fields.

UNIT 5. Engineering Technology

Content Standard 3.5 Investigate and analyse the historical and societal influences in Engineering by understanding the engineering principles, practices, the design process, the management, problem-solving and communication skills appropriate to any engineering field.

Benchmark 12.3.5.2 Demonstrate ability to scale drawing designs and employ architectural drafting skills to create design structures

Topic 2: Applications of Engineering Design

Learning Objectives
By the end of this topic, the students will be able to;

- Analyse and apply the methods of engineering design structures in various field.
- Analyse and describe the common significant design specifications and symbols used and applied in engineering.

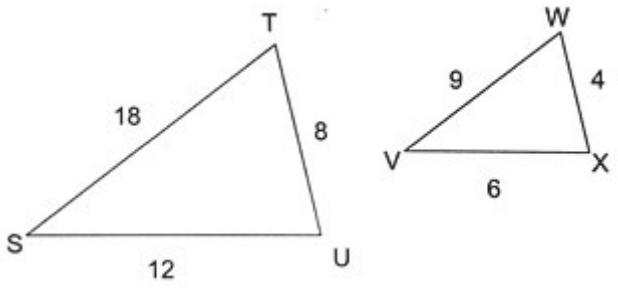
Essential Questions:
1. What are the types of methods of engineering designs structures in various fields?
2. What are the types of designs specification and symbols used in engineering?
3. What are the common significant design specifications used and applied in engineering?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Applications of engineering designs	Apply the methods of engineering design structures	Appreciative of engineering designs in new developments.	Relate the importance of engineering designs.

Content Background

Scale Drawings
An important practical application of mathematics is **scale drawing**. In order to create or accurately use a scale drawing, it is important to first understand proportional relationships. A **proportion** is a set of ratios that compares two or more sets of **measurements**. Proportions can be used to create the scale needed for creating a scale drawing. The **scale** represents the rate of enlargement or reduction from the original object. A scale drawing is an enlarged or reduced drawing that is proportional to the original object. This means that all of the ratios between the corresponding sides of the original figure and the drawing are equal. Scale drawings are used by architects, clothing designers, and map makers among others. These types of drawings allow for planning for large design and construction projects. They can be used to compare different ideas for projects and in order to estimate the number of materials needed and costs to complete the project. Scale drawings can also be used to create images that can help with understanding small objects like tiny insects and microscopic cells. Some scale drawings can be quite complex. It helps to start with simpler examples like **similar shapes**. As it is used here, similarity means more than just that the shapes are alike. In math, similarity means that the corresponding sides of the shape are proportional. In other words, all sides increase or decrease at the same rate. An example makes this definition clearer.



A pair of similar triangles

Figure: 5.2a Scale Drawing
Source: https://maths is fun.com

Here are the ratios of corresponding sides of these similar triangles:189 84 126
Notice that each fraction in this set of ratios, or proportion, can be simplified to 12. This means the scale for these similar triangles is 1/2. It can also be written as 1:2 or 1 to 2.

How To Solve Scale Drawings?
The scale of the proportional relationship can be used when deciding how to solve scale drawings. The basic steps to follow are:

1. Write a proportion.
2. Enter the known information into the proportion and use a variable to represent the unknown value.
3. Solve for the unknown value, using **inverse operations** to isolate the variable.

Architectural Drafting
An architecture draftsman, also known as an architectural drafter, creates technical plans, blueprints, and drawings of architects' original designs using computer software systems. They usually do this work with the help of their extensive training and understanding of computer-aided design (CAD) tools. Architectural drafters work with architects and engineers to confirm the materials required for the project as well as the design specifications. Once these technical drawings and plans have been finalised, they are forwarded to construction or project managers for implementation in the construction of the structure. Architectural drafters design the architectural and structural elements of structures for building projects. These workers may specialise in a specific sort of construction, such as residential or commercial. They might also specialise based on the materials they utilise, such as steel, wood, or reinforced concrete.

Architectural drafting abilities

1. Creativity and artistic ability are required.
2. Paying close attention to detail
3. Interpersonal and teamwork abilities
4. Mathematical and numerical abilities are required.
5. Technical and computer expertise is required.
6. Time-management and organising skills are required.

What exactly is the job of an architectural drafter?

Architectural drafters examine the plans of engineers and architects to provide technical drawings and blueprints for construction managers to use during the construction process. They may

investigate and include building codes and dimensions to provide clear guidelines for contractors and construction managers to follow. Architecture drafters also use computer-aided design to create 3-D models that help construction workers, architects, engineers, and clients comprehend their final product plans.

An architect drafter's other key roles include:

1. Incorporating precise building codes and measurements for use as a reference for carrying out the construction project, as well as entering this data into computer-aided design systems.
2. Building drawings show clients, leadership teams, and contractors the specific calculations, measurements, codes, and more construction information.
3. Printing schematics for architects, construction managers, and maintenance engineers to use during the planning and construction phases.
4. Using CAD software and drawing techniques to create charts and drawings for construction workers to use as a reference.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of engineering technology. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Methods of Engineering Designs Structures in Various Fields

Teaching Strategies

Engage students in brainstorming exercise on the methods of engineering designs structures in various fields.

Engage students to discuss on methods of engineering designs structures in various fields.

Learning Strategies

Describe the methods of engineering designs structures in various fields.

Activity 1: Brainstorming activity on the methods of engineering designs structures in various fields.
Activity 2: Conduct research on the methods of engineering designs structures in various fields.
Activity 3: Discussions and presentation of research findings on the methods of engineering designs structures in various fields.

Resources

Front Matter Structural Engineering Handbook Ed. Chen Wai-Fah
Structural Engineer’s Pocket Book by Fiona Cobb

Lesson 2: Types of Designs Specification and Symbols used in Engineering

Teaching Strategies
Engage students in brainstorming exercise on the types of designs specification and symbols used in engineering.
Engage students to discuss the types of designs specification and symbols used in engineering.

Learning Strategies
Discover the types of designs specification and symbols used in engineering.

Activity 1: Brainstorming activity on the types of designs specification and symbols used in engineering.
Activity 2: Conduct research on types of designs specification and symbols used in engineering.
Activity 3: Discussions and presentation of research findings on types of designs specification and symbols used in engineering.

Resources
Front Matter Structural Engineering Handbook Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

Lesson 3: The Common Significant Design Specifications used and Applied in Engineering

Teaching Strategies
Engage students in brainstorming exercise the common significant design specifications used and applied in engineering.
Engage students to discuss on the common significant design specifications used and applied in engineering.

Learning Strategies
Discover the common significant design specifications used and applied in engineering.

Activity 1: Brainstorming activity on the common significant design specifications used and applied in engineering.
Activity 2: Conduct research on the common significant design specifications used and applied in engineering.
Activity3: Discussions and presentation of research findings on the common significant design specifications used and applied in engineering.

Resources
Front Matter Structural Engineering Handbook Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

STEAM Activity Students work in groups to design and create a recycled suspension bridge with specifications.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to analyse engineering designs and specifications. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment

1. Analyse and apply the methods of engineering designs structures in various fields.
2. List and state the types of designs specification and symbols used in engineering.
3. Analyse and describe the common significant design specifications used and applied in engineering.

Performance Assessment Scoring
Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Analyse and apply the Methods of engineering designs structures in various fields.	Critically analyse and apply the Methods of engineering designs structures in various fields	Correctly analyse and apply the Methods of engineering designs structures in various fields	Partially analyse and apply the Methods of engineering designs structures in various fields	Cannot analyse and apply the Methods of engineering designs structures in various fields
2. List and state the types of designs specification and symbols used in engineering.	Accurately list and state the types of design specification and symbols used in engineering	Correctly list and state the types of design specification and symbols used in engineering	Partially list and state the types of design specification and symbols used in engineering	Cannot list and state the types of design specification and symbols used in engineering
3. Analyse and describe the common significant design specifications used and applied in engineering.	Critically analyse and describe the common significant design specifications used and applied in engineering	Correctly analyse and describe the common significant design specifications used and applied in engineering	Partially analyse and describe the common significant design specifications used and applied in engineering	Cannot analyse and describe the common significant design specifications used and applied in engineering

UNIT 5. Engineering Technology

Content Standard 3.5 Investigate and analyse the historical and societal influences in Engineering by understanding the engineering principles, practices, the design process, the management, problem-solving and communication skills appropriate to any engineering field.

Benchmark 12.3.5.3 Evaluate the scope of engineering and recognise current innovations and describe the relationship between properties, uses, applications of materials in engineering

Topic 3: Properties of Engineering Materials and Equipment uses and Application

Learning Objectives
By the end of this topic, the students will be able to;

- Analyse and state the properties of different types of engineering materials and how they are used in various fields.
- Analyse the relationship between the properties, uses and applications of materials in engineering innovations.

Essential Questions:
1. What are the types of engineering used in varies fields?
2. What are the properties of materials used in engineering fields?
3. What are the basic methods of using material and equipment in engineering fields?
4. How do we analyse the basic processes of equipment that are used in various engineering?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Engineering materials and equipment's	Describe and apply	Diligent and tolerant of engineering materials being used to manufacture products.	Importance

Content Background

The Engineering material properties, equipment uses and application

The Mechanical properties of engineering materials are those of the material that comes into action on applying forces. A substance (often a solid) is characterised as material if it is meant to be utilized for a certain purpose. We are surrounded by a wide variety of materials used in everything from spacecraft to structures. Engineering Materials are substances employed as raw materials for construction or organized production for an engineering application. Materials are classified according to their characteristics. They possess qualities such as magnetism, thermal conductivity, heat capacity, stiffness, hardness, and thermal conductivity, among others. Among various materials, the Mechanical properties of engineering materials tell the material's response against applied load.

The Mechanical properties of engineering materials are those that influence their mechanical strength and capacity for shaping into a desired shape." Or in other words, "Mechanical properties are physical properties that a material exhibits upon the application of forces.

Important Mechanical Properties of Engineering Materials

A material's property is an intensive attribute of some material and independent of the material's quantity. Some important Mechanical properties of engineering materials are:

- Strength
- Hardness
- Toughness
- Brittleness
- Ductility
- Malleability

Strength
A material's ability to resist deformation or breakdown in the presence of loads or external forces is known as strength. The materials we choose for our engineering goods must be sufficiently strong mechanically to function under various mechanical forces or loads.

Hardness
Hardness is one of the important properties among mechanical properties of engineering materials which enables the material to offer resistance to localized permanent deformation and scratches. Numerous applications of engineering design make use of hardness. This characteristic is crucial since it directly affects the functionality and appropriateness of the material.

Toughness
A material's ability to absorb energy and undergo plastic deformation without fracturing is known as toughness. The amount of energy in a given volume determines its numerical value. Joules/m3 is the unit of toughness. Stress-strain properties of a material can be used to calculate a material's toughness value. Materials need to be strong and ductile to be tough. Impact testing equipment is used to determine a metal's toughness.

Brittleness
A material's brittleness refers to how easily it fractures under the influence of a force or load. When brittle material is stressed, it experiences very little energy and cracks without experiencing a lot of strain. The opposite of a material's ductility is brittleness. Material brittleness is temperature-dependent. Some metals that are ductile at room temperature become brittle at low temperatures.

Ductility
A solid material's ductility is a property that describes how easily it deforms when subjected to tensile stress. The capacity of a substance to be drawn or pulled into a wire is a common way to classify ductility. This mechanical quality, which is temperature-dependent, is also a component of a material's plasticity. The ductility of a substance increases with temperature.

Malleability
A solid material's malleability refers to how quickly it can distort when subjected to compressive stress. The ability of a material to be rolled or hammered into a thin sheet is a common way to classify malleability. This mechanical quality is a component of the material's plasticity. Temperature affects a material's malleability. The malleability of the material rises as the temperature rises.

Creep, hardenability, resilience, and fatigue are additional essential mechanical properties of engineering materials in addition to the ones described above.

Key Factors Affecting Mechanical Properties

Mechanical properties of engineering materials refer to their ability to withstand applied forces and deformation without breaking or losing strength. These properties play a crucial role in determining the suitability of a material for various engineering applications. Several factors can affect the mechanical properties of engineering materials, including:

1. **Composition:** The chemical composition of a material affects its mechanical properties. The presence of impurities or alloying elements can alter the material's strength, ductility, and other properties.
2. **Microstructure:** The microstructure of a material refers to its crystal structure and the arrangement of its atoms and grains. The grain size, shape, and orientation can influence the mechanical properties of a material.
3. **Processing:** The method of processing a material, such as forging, casting, or extrusion, can affect its mechanical properties. The rate of cooling, heat treatment, and other processing parameters can also impact the material's properties.
4. **Temperature:** The mechanical properties of materials can change significantly at different temperatures. At high temperatures, materials may lose strength and become more prone to deformation and failure.
5. **Loading conditions:** The way a material is loaded, such as tension, compression, bending, or torsion, can affect its mechanical properties. The rate of loading, duration of loading, and type of loading can also impact the material's properties.

Importance of Mechanical Properties in Material Selection

Mechanical properties play a crucial role in material selection because they determine the ability of a material to withstand loads, stresses, and strains without failure or deformation. Different applications and environments require different mechanical properties, and the right choice of materials can make the difference between the success and failure of a product or structure.
Here are some examples of how different mechanical properties affect material selection:

1. **Strength:** The strength of a material is its ability to resist external loads without breaking or deforming. High-strength materials are preferred for applications that involve high loads or stresses, such as in structural components of buildings or in heavy machinery. However, high strength may also mean that the material is brittle and prone to fracture under certain conditions.
2. **Ductility:** Ductility is the ability of a material to deform under stress without breaking. Materials with high ductility are preferred for applications that require deformation without failure, such as in forming processes or in structural components that may experience bending or twisting.
3. **Toughness:** Toughness is the ability of a material to absorb energy without fracture. Materials with high toughness are preferred for applications that require resistance to impact or shock loading, such as in automotive parts or in structural components subjected to vibrations.
4. **Hardness:** Hardness is the ability of a material to resist indentation or scratching. Materials with high hardness are preferred for applications that require wear resistance, such as in cutting tools or in abrasive environments.

5. **Fatigue resistance:** Fatigue resistance is the ability of a material to withstand cyclic loading without failure. Materials with high fatigue resistance are preferred for applications that involve repetitive loading, such as in rotating machinery or in structural components subjected to vibrations.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of engineering technology. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Types of Engineering Materials and their Properties

Teaching Strategies

Engage students in brainstorming exercise on the common types of engineering materials and their properties.

Engage students to discuss on the common types of engineering materials and their properties.

Learning Strategies

Discover the common types of engineering materials and their properties.

Activity 1: Brainstorming activity on the common types of engineering materials and their properties.

Activity 2: Conduct research on the common types of engineering materials and their properties.

Activity 3: Discussions and presentation of research findings on the common types of engineering materials and their properties.

Resources

Front Matter Structural Engineering Handbook Ed. Chen Wai-Fah

Structural Engineer's Pocket Book by Fiona Cobb

Lesson 2: Types of Engineering Equipment

Teaching Strategies

Engage students in brainstorming exercise on the common types of engineering equipment.

Engage students to discuss on the common types of engineering equipment.

Learning Strategies

Discover the common types of engineering equipment.

Activity 1: Brainstorming activity on the common types of engineering equipment.

Activity 2: Conduct research on the common types of engineering equipment.

Activity 3: Discussions and presentation of research findings on the common types of engineering equipment.

Resources
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Lesson 3: Methods of using Material and Equipment in Engineering

Teaching Strategies
Engage students in brainstorming exercise the common methods of using material and equipment in engineering properties.
Engage students to discuss on the common methods of using material and equipment in engineering.

Learning Strategies
Discover the common methods of using materials and equipment in engineering.

Activity 1: Brainstorming activity on the common methods of using materials and equipment in engineering.
Activity 2: Conduct research on the common methods of using materials and equipment in engineering.
Activity 3: Discussions and presentation of research findings on the common methods of using materials and equipment in engineering.

Resources
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Lesson 4: Processes of Equipment used in Various Engineering

Teaching Strategies
Engage students in brainstorming exercise the processes of equipment used in various engineering.
Engage students to discuss on the processes of equipment used in various engineering.

Learning Strategies
Discover the processes of equipment used in various engineering.

Activity 1: Brainstorming activity on the processes of equipment used in various engineering.
Activity 2: Conduct research on the processes of equipment used in various engineering.
Activity 3: Discussions and presentation of research findings on the processes of equipment used in various engineering.

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STEAM Activity Students work in groups to create an aluminium oven using the sunlight as heat to bake food.

Assessment

The main purpose of assessment is to find out if students can use the skill of synthesis to evaluate the scope of engineering and recognize current innovations and describe the relationship between properties, uses, applications of materials in engineering Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment

1. Analyse and state the different types of engineering materials and their properties used in various fields.
2. Analyse and describe the types of engineering equipment.
3. State and apply the Methods of using material and equipment in engineering.
4. Analyse process equipment used in various engineering.

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Analyse and state the different types of engineering materials their properties used in varies field	Critically analyse and state the different types of engineering materials and their214roperty es used in various field	Correctly analyse and state the different types of engineering materials and their properties used in various field	Partially analyse and state the different types of engineering materials and their properties used in various field	Cannot analyse and state the different types of engineering materials and their properties used in various field
2. Analyse and describe the types of engineering equipment	Critically analyse and describe the types of engineering equipment	Correctly analyse and describe the types of engineering equipment	Partially analyse and describe the types of engineering equipment	Cannot analyse and describe the types of engineering equipment
3. State and apply the methods of using material and equipment in engineering	Accurately state and apply the methods of using material and equipment in engineering	Correctly state and apply the methods of using material and equipment in engineering	Partially state and apply the methods of using material and equipment in engineering	Cannot state and apply the methods of using material and equipment in engineering
4. Analyse process equipment used in various engineering	Critically analyse process of equipment used in various engineering	Correctly analyse process of equipment used in various engineering	Partially analyse process of equipment used in various engineering	Cannot analyse process of equipment used in various engineering

UNIT 5. Engineering Technology

Content Standard 3.5 Investigate and analyse the historical and societal influences in Engineering by understanding the engineering principles, practices, the design process, the management, problem-solving and communication skills appropriate to any engineering field.

Benchmark 12.3.5.4 Apply mathematical, scientific and graphical methods to solve of engineering practice.

Topic 4: The Introduction to Engineering Analytical and Solving Techniques

Learning Objectives
By the end of this topic, the students will be able to;

- Define and analyse engineering skills and techniques used in engineering field.
- Analyse and describe the types of graphs use in engineering.

Essential Questions:
1. What are the types of skills and techniques used in engineering field?
2. What are the methods of decision making in graphs form?
3. What are the types of graphs use in engineering?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Analytical and solving techniques in engineering	Apply analytical skills when studying engineering techniques	Be critical and creative in the analysis of solving techniques in engineering	Understand the importance of being analytical when looking at problems and solutions.

Content Background

The Introduction to Analytical and solving Techniques in Engineering

Analytical Skills
Analytical skills refer to an individual's ability to identify a problem, investigate to find out relevant facts, and find a logical solution. They are considered important skills in many different fields.

Types of Analytical Skills
The five types of skills that are crucial to success in many different jobs and industries are:

1. Communication
An underrated skill is the ability to communicate the analysis that has been conducted. Being able to identify problems and find solutions is useless if the conclusions and findings cannot be effectively communicated to decision-makers.

Findings from the analysis may need to be presented orally through a presentation or a meeting. The analysis may need to be presented in written form, either through a report or email. Therefore, communication skills are a critically important skill when developing overall analytical skills.

2. Creativity

Another important skill is the ability to think creatively. Many problems require "out-of-the-box" thinking in order to find the optimal solution. The obvious solution may not always be the most effective, and therefore, it is important to be able to think of creative solutions.

3. Critical Thinking

Critical thinking is exceptionally important to obtaining strong overall analytical skills. It refers to the objective analysis of a complex problem to form a judgment.

Effective critical thinkers are able to think clearly and rationally and understand the logical relations between data points and ideas. To find rational solutions, critical thinking is a very important skill to master.

4. Data Analysis

Data is very important in all disciplines, specifically, the ability to analyse large volumes of data and identify patterns and trends. Therefore, it is increasingly vital to understand the discipline of statistics and quantitative analysis. Data analysis is becoming more prominent within finance, as trends such as technical trading and quant-investing continue to grow in popularity.

Quantitative analysis requires identifying patterns in data but also being able to define the findings to decision-makers, which ties into the communication aspect of analytical skills.

5. Research

Applying analytical skills requires patience and curiosity. If a problem is solved quickly, without considering all relevant information, then it is highly unlikely that it will be the most effective solution. Therefore, coming up with an effective solution requires taking the time to learn more about the problem before attempting to solve it.

Research requires collecting information and relevant data, then compiling it before analysing it. Collecting data and thoroughly researching a topic is important for being able to apply strong analytical skills.

Importance of Analytical Skills

Analytical skills are important because they allow people to find solutions to various problems and make concrete decisions and action plans to solve those problems. As mentioned earlier, they are important skills in all disciplines, ranging from data science, project management, marketing, law, medicine, scientific research, accounting, etc.

What are engineering skills?

Engineering skills describe the knowledge, expertise and experience that an engineer possesses or needs to acquire. In addition to these technical skills (also known as hard skills), an engineer needs to have developed other personal qualities (sometimes called soft skills).

Soft skills help you interact and collaborate with co-workers and clients, in turn allowing you to complete your tasks more efficiently and effectively. Soft skills are more abstract than hard skills, which makes them difficult to quantify.

Problem-solving
In a sense, all engineering projects are a form of problem-solving. An engineer will be given a goal or problem, then they will need to use their expertise and problem-solving abilities to determine the best way of performing construction, manufacturing or repair work. That plan then needs to be put into action in the safest, most efficient way possible.

Computer skills (IT skills)
The use of computers is increasing in almost every profession and engineering is no exception. Digital technology allows engineers to plan, develop and manufacture projects more intricately than ever before. 3D modelling, for example, allows an engineer to gain a more complete understanding of what they are working on than traditional 2D diagrams, without the expense of constructing a physical model. A strong understanding of how computer technology is used in engineering is important in the modern world and university courses will incorporate this.

Technical knowledge
Technical knowledge is something that is learned both through study and experience.

Working under pressure
Even with all the planning and expertise of engineers, projects can be highly unpredictable and this can result in them taking longer than anticipated or going over budget.

Teamwork
Teamwork is essential in the majority of careers and this is particularly true in engineering. It is impossible to complete a major engineering project alone, with colleagues and external contractors playing their part in ensuring a project is completed successfully. This teamwork might be a case of delegating particular tasks to the most suitable engineer or it might be working together to devise a solution to a particular problem that you are unable to overcome alone. Any engineering project will be more successful if the members of a team can work together as a cohesive unit.

Creativity
Creativity is essential for any engineer. Every project is unique, whether because of the job's requirements or because of the site's location. An engineer needs to be able to analyse the job's location, the surrounding environment and any external factors, then devise a creative solution that fulfils the requirements of the task. Creativity is a quality that can't be taught, so it is highly valued by prospective employers.

Analytical ability
Analytics skills are crucial for engineers, allowing them to evaluate a project and site to decide whether a possible plan is safe. An engineer needs to examine their work and that of other people and determine the best course of action. If they decide that it isn't, they can work with their fellow team members to decide on a better alternative. Analytical work is an ongoing process during engineering projects and an engineer should always be willing to take the time to analyse their work and consider whether they are using the right strategy.

Communication skills
Just as teamwork is a key component of an engineering career, communication is essential for ensuring the members of a team can interact with their teammates and other people. They might need to contact a supplier to acquire necessary material for a project or speak with investors to update them on how their work is progressing.

Communication is a skill that will allow the other aspects of an engineering career to happen smoothly.

Eye for detail

Precision is vital in engineering. Errors that might seem minuscule to the untrained eye can be costly and, in some cases, endanger human lives.

Continued education
Engineering techniques and technology are constantly evolving, and it is the responsibility of an engineer to ensure that they are up to date with the latest developments.
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Leadership
Leadership skills are important for anyone working in engineering, even if they don't explicitly occupy a leadership role within a company.

Different Types of Graphs And Charts For Different Fields
There are some graph types that we are all aware of, like a bar graph, pie chart, line graph, etc. But there are a lot many graphs that are used for different purposes. Data visualization makes presentation more understandable and appealing. But it is important to use the right graph for your data.
What Is a Graph
Graphs are the organised pictorial representation of data and are created from various data points, representing the relationship between various things. A graph can tell the entire story without even needing the words.
Every shape, point, color, and stroke in a graph gives it a different meaning, helping the viewer understand and interpret the graph. And that's why choosing every element carefully is extremely vital.
Graphs Vs. Charts
Graphs and charts are two words that are often used interchangeably, but there is a difference between them. All graphs are charts, but not all charts are graphs.
The mathematical diagram depicting the relationship between different numerical data over a range of time is called a graph while chart represents datasets for helping users to understand the given information in a better way.

For Engineering and Technology

1) Binary Decision Diagrams
A binary decision means selecting one of two alternatives. Hence, this graph illustrates the way between one decision to another. The binary decision in computer sciences creates a Boolean data type where two different values are accosted within a process flow.
It can be used for all the processes where the action is based on the decision between two values. It is one of the few types of graphs in statistics.

2) Circuit Diagrams
Circuit diagrams visually represent an electrical circuit using simple images and shapes to illustrate its components and circuit connections from beginning to end. However, it doesn't inevitably represent the corresponding spatial fabrication of a circuit.
These diagrams are used to depict data related to both software and hardware. Apart from literally visualising the path of a circuit, it is also related to the Binary decision diagram very closely, as they are both used for charting the process flow of programming.

3) Function Graphs
Sometimes engineers, mathematicians, and statisticians graph the result of an equation to determine its value. The function graph is the set of all the coordinates that fulfill the equation. The equation function for X and Y variables is drawn on an X and Y axis graph and a 3D graph with a third axis is added if a third variable is involved.
There are 8 types of functions graph you might come across- linear, quadratic, rational, logarithmic, power, polynomial, exponential, and sinusoidal. Different types of function graphs are used for different functions. This is yet another most common type of graph in math as well.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of engineering. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Engineering Skills and Techniques

Teaching Strategies
Engage students in brainstorming exercise on the types of engineering skills and techniques.
Engage students to discuss the types of engineering skills and techniques.

Learning Strategies
Discover the types of engineering skills and techniques.

Activity 1: Brainstorming activity on the types of engineering skills and techniques.
Activity 2: Conduct research on types of engineering skills and techniques.
Activity 3: Discussions and presentation of research findings on types of engineering skills and techniques.

Resources
Front Matter *Structural Engineering Handbook* Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

Lesson 2: Types of Skills and Techniques Used in Engineering Field

Teaching Strategies
Engage students in brainstorming exercise on the types of skills and techniques used in engineering fields.
Engage students to discuss the types of skills and techniques used in engineering fields.

Learning Strategies
Discover the types of skills and techniques used in engineering fields.

Activity 1: Brainstorming activity on the types of skills and techniques used in engineering fields.
Activity 2: Conduct research on the types of skills and techniques used in engineering fields.
Activity 3: Discussions and presentation of research findings on the types of skills and techniques used in engineering fields.

Resources
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Lesson 3: Methods of Decision Making in Graphs Form

Teaching Strategies
Engage students in brainstorming exercise on the methods of decision making in graphs.
Engage students to discuss on the methods of decision making in graphs.

Learning Strategies
Discover the methods of methods of decision making in graphs.

Activity 1: Brainstorming activity on the methods of decision making in graphs.
Activity 2: Conduct research on the methods of decision making in graphs.
Activity 3: Discussions and presentation of research findings on the methods of decision making in graphs.

Resources
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Lesson 4: Types of Graphs used in Engineering

Teaching Strategies
Engage students in brainstorming exercise to describe the types of graphs used in engineering.
Engage students to describe the types of graphs used in engineering.

Learning Strategies
Analyse and describe the types of graphs used in engineering.

Activity 1: Brainstorming activity to analyse and describe the types of graphs used in engineering.
Activity 2: Conduct research to analyse and describe the types of graphs used in engineering.
Activity 3: Discussions and presentation of research findings on analyse and describe the types of graphs used in engineering.

Resources
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STEAM Activity Students work in groups to create a device using technology and engineering materials and techniques to solve a problem.

Assessment

The main purpose of assessment is to find out if students can use the skill of synthesis to and analyse engineering materials and processes. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment

1. Describe the types of engineering skills and techniques.
2. Discover the methods of methods of decision making in graphs.
3. Analyse and describe the types of graphs used in engineering.

Performance Assessment Scoring

Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Describe the types of engineering skills and techniques.	Accurately describe the types of engineering skills and techniques with specific examples.	Accurately describe the types of engineering skills and techniques.	Partially describe the types of engineering skills and techniques.	Cannot describe the types of engineering skills and techniques.
2. Outline the methods of decision making in graphs.	Outline the methods of decision making in graphs very well with steps on decision making.	Outline the methods of decision making in graphs very well.	Outline the methods of decision making in graphs partially.	Outline the methods of decision making in graphs poorly.
3. Analyse and describe the types of graphs used in engineering.	Analyse and describe the types of graphs used in engineering with specific examples and samples of graphs.	Analyse and describe the types of graphs used in engineering.	Describe the types of graphs used in engineering.	List the types of graphs used in engineering.

UNIT 5. Engineering Technology

Content Standard 3.5 Investigate and analyse the historical and societal influences in Engineering by understanding the engineering principles, practices, the design process, the management, problem-solving and communication skills appropriate to any engineering field.

Benchmark 12.3.5.5 Identify and evaluate the social, environmental and cultural implications of technological change in engineering.

Topic 5: Impacts of Technological Change in Engineering

Learning Objectives
By the end of this topic, the students will be able to;

- Analyse and describe technological changes in engineering.
- State and describe the social, environmental and cultural implications of technological change on engineering.
- Analyse and describe the types of engineering report writing and presentation.

Essential Questions:
1. What is technological change in engineering?
2. How did technology change engineering?
3. What are environmental implications of technological change on engineering?
4. What are the social and cultural implications of technological change on engineering?
5. What are the types of engineering report writing and presentation?

Essential Knowledge, Skills, Values and Attitudes:

Knowledge	Skills	Attitudes	Values
Social, cultural and environmental implications on engineering	Identify and evaluate the various implications on engineering.	Empowerment to present analysis of various implications of engineering.	Be critical when discussing the various implications on engineering.

Content Background

What are the technological changes?

A technological change (TC) can be defined as an increase in the outputs possible with a given level of inputs through the processes of invention, innovation, and diffusion. These new technological innovations include the widespread adoption of 3D printing, robots, and Internet of Thing (IoT) devices. Adoption of these innovations has shifted work processes, design, production, and testing in many engineering firms. Thus, the use of technology brings about various delivery methods. It has access to a massive amount of information, global interaction to enhance learning, and excellent examples through simulations and models.

What are the emerging engineering technologies?

1. Artificial Intelligence

Artificial Intelligence (AI) involves using computer systems to perform tasks, normally requiring human intelligence or physical input. It has already gained attention in recent years, being utilised in computer search engines, medical diagnosis, handwriting recognition, and much more.

2. Virtual Reality and Augmented Reality

Virtual Reality (VR) immerses a user in an environment while Augmented Reality (AR) enhances the environment. Despite being primarily used for gaming in its early stages, it is beginning to be used for training in some industries.

From training doctors for surgery to enhancing customer experience, there will be an increasing demand for knowledge in these technologies.

Furthermore, it is predicted that the engineering industry will derive great benefits from the adoption of VR.

3. Internet of Things (IoT)

The Internet of Things (IoT) is one of the biggest technology trends to emerge recently. Modern creations are increasingly being built with Wi-Fi connectivity, meaning they can be connected to the Internet and each other. The Internet of Things (IoT) is the future, enabling devices, appliances, cars, and much more to be connected using the Internet.

Industry has a lot to gain from the implementation of the IoT, enabling for better safety, efficiency and decision making. It can enable predictive maintenance, enhance medical care and improve customer service, for example.

4. 5G

3G and 4G technologies are familiar with many people.. They enable us to browse the Internet, use data services, stream music, and so much more. However, 5G services are expected to revolutionize our daily lives.

By enabling services that rely on advanced technologies, 5G has the potential to make our lives smarter, safer, and more efficient. It is expected to be used in factories, safety, traffic management, smart grid control, and much more. Aside from the increased speed, 5G's low latency will be fundamental to furthering upcoming technology trends, especially IoT.

5. Digital Twins

Digital twins are virtual models of real products, processes, or services. This technology allows the secure transmission of data between the virtual and real-world, monitoring objects' behavior and predicting various outcomes.

Digital twins benefit industrial processes by reducing asset downtime and lowering overall maintenance costs, making them extremely valuable in the future of industry. In the coming years, we will see digital twins expand to more applications, use cases and industries, combining with other technology trends to further the digital transformation.

6. Edge Computing

Edge computing is a networking philosophy that focuses on bringing computing as close to the data source as possible. It makes the approach much more powerful and efficient than the cloud itself.

The rise of edge computing is mainly accredited to the growing IoT devices connecting to the Internet. Edge computer allows generated data from these devices to be processed closer to its source, rather than sending it across storage networks.

With the growing capabilities of edge systems, edge computing will replace traditional cloud computing infrastructure.

7. Robotics, Drones, and Vehicle Automation

Advances in machine learning and automation are ushering in the new age of digital assistants. Drones, automated vehicles, and robots will be further integrated into our daily lives, seamlessly assisting in transportation, communication, and productivity.

Within industry, robotics has changed the way we work. Sensors combined with cloud-based applications enable robots to react to changes in the environment, allowing them to perform tasks previously belonging to human workers. Many factories are now fully autonomous, with minimal human interaction.

These technology trends have even made their way to more rural areas. AI-powered drones help farmers keep a wide eye on their infrastructure, such as using thermal imaging to identify potential leaks.

Back in the city, autonomous vehicles are coming all the more common. Transforming mobility and logistics, self-driving cars use technology to improve traffic safety and efficiency. This benefits both consumers and commercial operations by making transportation more accessible.

The increasing incorporation of robotics, drones, and vehicle automation will see an increasingly autonomous and digital society. Furthermore, these drastic industry

developments mean all the more employment opportunities and a career within a quickly growing sector.

The cultural, environmental and social implications of technological changes in engineering.

How does culture impact engineering?

Implementation of technology influences the values of society by **changing expectations and realities**. Over emphasising technology has created lack of trust among people. Technology can also be blamed for unemployment, cultural lag, changes in social institutions. These culturally influenced experiences **shape our understanding, identity, interest, and solutions to engineering problems**. The environments and associated cultures that make up our society – home, community, school, and workplace – contribute to the perceptions we hold as members of that society.

Human culture is constantly evolving. A main driving force of cultural change, on both local and global levels, is technology. To understand how technology affects culture in the modern day, it's important to have a working definition for both technology and culture. We will also take a look at how technology has affected culture historically, as that will form a base for understanding how this relationship works in the modern day. Technology does not only refer to things like computers, smartphones, and the internet as a whole. Any tool created from scientific knowledge that serves a particular function is called **technology**. By this definition, our view of technology can expand to ancient ideas, such as early agricultural tools, for example. This wide definition is necessary to examine the ways in which technology has historically impacted culture, in addition to the influences it has on it currently.

What exactly do we mean when we refer to culture? To put it broadly, culture sums up the shared knowledge and social practices of any given group of people. Culture is learned, meaning that no one is born with an inherent understanding of the social norms of their society. Culture is also constantly changing due to a number of influences. Technology affects culture extensively and could be argued as one of the primary agents of cultural change.

Culture and social values

In today's society, culture and social values are influenced by technology. Culture is a set of shared beliefs, values, and norms that influence the way we behave. Social values are an individual's personal standards for judging good or bad behavior. For example: if you don't like the idea of someone being rude to you while they're walking down the street (i.e: talking loudly on their phone), then that would be an example of your personal value system at work. Technology has changed how we interact with each other, but it has also changed how we interact with our environment and consumerism. These changes have caused some people to become more connected while others stay isolated from society as a whole. Technology is affecting our lives both negatively and positively. It is very important to

acknowledge that technology can have both negative and positive impacts on our lives. It is a double-edged sword that can be used positively or negatively based on its use and application.

Engineering affects virtually every aspect of our society and engages a substantial set of the population in carrying out engineers' plans and designs. But what is the nature of that activity? What is the role of engineering in responding to society's needs as well as in shaping them? How well does engineering carry out that role?

These questions are being asked with increasing urgency by a society that has benefited from great advances in technology, and at the same time, seen dislocations and experienced fears associated with technology—a society that has become increasingly dependent on technology, but also increasingly ambivalent about it. Often the questions about technology are confused with questions about engineering in the mind of the public despite a growing literature on the relation of technology to the rest of society.

Teaching and Learning Strategies

Teachers are encouraged to introduce students to simulations to better understand the concepts taught. Therefore, students will learn effectively and master the knowledge prescribed in each topic. Whilst introducing the topic, guided discovery and research will enable students to get a picture of engineering technology. The knowledge prescribed must be taught. It is not only about teaching what students should know but also to interpret that knowledge for students in a way that makes it relevant to them, and enables them to begin to acquire skills of analysis and problem solving, which will support teaching and learning. Students must be given opportunities to apply their knowledge, to be creative and to solve problems.

Lesson 1: Technological Changes

Teaching Strategies

Students engage in brainstorming exercise to discover the technological changes and the cultural, social and environmental implications on engineering.
They then are allowed to design guiding questions that will enable them to conduct research on the implications of technological changes in engineering.
Discussions in groups on the research findings and presentations.

Learning Strategies

Activity 1: Brainstorming activity to discover the technological changes and the cultural, social and environmental implications on engineering.
Activity 2: Conduct research on the implications of technological changes in engineering.
Activity 3: Discussions and presentation of research findings on the implications of technological changes in engineering.

Resources
Front Matter *Structural Engineering Handbook* Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

Lesson 2: Implications of Technological Changes on Engineering

Teaching Strategies
Engage students in presentation of the cultural, social and environmental implications on Engineering.
Engage students to discuss on how society and their ways of living have been impacted by technological changes in engineering.

Learning Strategies
Discover technological changes and the implications on society.

Activity 1: Use the presentations to generate discussions on technological changes, implications and engineering.
Activity 2: Create a virtual society portraying what life is like amidst all the technological changes.
Activity 3: Evaluate the positives and the negatives of technology, society, culture, the environment and engineering.

Resources
Front Matter *Structural Engineering Handbook* Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

Lesson 3: Methods of Minimising Pollutions

Teaching Strategies
Students engage in brainstorming exercise to discover methods of minimising pollutions as effects of technological changes.
They then are allowed to design guiding questions that will enable them to conduct research on methods of minimising pollutions.
Discussions in groups on the research findings and do presentations.

Learning Strategies
Activity 1: Brainstorming activity on methods of minimising pollutions as effects of technological changes.
Activity 2: Conduct research on methods of minimising pollutions.
Activity 3: Discussions and presentation of research findings.

Resources
Front Matter *Structural Engineering Handbook* Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

Lesson 4: Types of Engineering Report Writing and Presentation

Teaching Strategies
Students engage in brainstorming exercise to discover types of engineering report writing and presentation.
They then are allowed to design guiding questions that will enable them to conduct research on types of engineering report writing and presentation.

Discussions in groups on the research findings.

Learning Strategies
Activity 1: Brainstorming activity on types of engineering report writing and presentation.
Activity 2: Conduct research on types of engineering report writing and presentation.
Activity 3: Discussions and presentation of research findings.

Resources
Front Matter *Structural Engineering Handbook* Ed. Chen Wai-Fah
Structural Engineer's Pocket Book by Fiona Cobb

STEAM Activity Students work in groups to create solutions that will minimise noise pollution.

Assessment
The main purpose of assessment is to find out if students can use the skill of synthesis to identify and evaluate the social, environmental and cultural implications of technological change in engineering. Assessment should be linked to the performance indicator indicated in the lesson plan and the lesson objective.

Performance Assessment
1. Analyse and describe the environmental effect and pollution caused by the works of engineering.
2. State and describe the types of pollutions caused by engineering field.
3. Analyse and describe the methods of minimising pollutions.
4. Analyse and describe the types of engineering report writing and presentation.

Performance Assessment Scoring
Assessment can be scored using a rubric (analytical rubric), checklists, or rating scales.

Performance Standard/Criteria	Advanced	Meet Standard	Progressing	Not Yet
1. Analyse and describe the environmental effect and pollution caused by the works of engineering	Critically analyse and describe the environmental effect and pollution caused by the works of engineering	Correctly analyse and describe the environmental effect and pollution caused by the works of engineering	Partially analyse and describe the environmental effect and pollution caused by the works of engineering	Poorly analyse and describe the environmental effect and pollution caused by the works of engineering
2. State and describe the types of pollutions caused by engineering field	Accurately state and describe the types of pollutions caused by engineering field	Correctly state and describe the types of pollutions caused by engineering field	Partially state and describe the types of pollutions caused by engineering field	Poorly state and describe the types of pollutions caused by engineering field
3. Analyse and describe the methods of minimising pollutions	Critically analyse and describe the methods of minimising pollutions	Correctly analyse and describe the methods of minimising pollutions	Partially analyse and describe the methods of minimising pollutions	Poorly analyse and describe the methods of minimising pollutions
4. Analyse and describe the types of engineering report writing and presentation	Critically analyse and describe the types of engineering report writing and presentation	Correctly analyse and describe the types of engineering report writing and presentation	Poorly analyse and describe the types of engineering report writing and presentation	Cannot analyse and describe the types of engineering report writing and presentation

Planning and Programming

This is the Planning and Programming for Grade 9 and can be applied in Grade 12 to plan and program Construction and Technology as a subject.

The 8 steps in Planning and Programming Process

1. **This planning and programming sample is using grade 9 content but the steps described here will be applied to plan and program grade 10 content.** Identify the number of Strands and Units in the subject Syllabus
2. Identify the total number of Content Standards, Benchmarks and Number of Topics (Syllabus and Teacher Guide)
3. Consider the Facts and Considerations in the Planning and Programming Process (subject related)
4. Distribute the Content evenly across the 4 school terms in a Matrix (Proposed Template)
5. Expand and plot the distributed content into the complete Yearly Content Overview for the subject for the grade (Proposed Template)
6. Develop the Termly Programs (Proposed Template)
7. Develop the Weekly Teaching Program (Proposed Template) Daily Lesson Plan (SBC Template
8. Review, Evaluate and Re-plan the yearly, termly, weekly Programs

Planning and Programming Process

The Planning and Programming Process used by the Business and Technology Subjects is an 8 step process. This process begins from Unpacking the Content Standards and Benchmarks and ends with planning a daily lesson plan.

Step 1: Identify the number of Strands and Units in the subject Syllabus
Step 2: Identify the total number of Content Standards, Benchmarks and Number of Topics (Syllabus and Teacher Guide)
Step 3: Consider the Facts and Considerations in the Planning and Programming Process (subject related)
Step 4: Distribute the Content evenly across the 4 school terms in a Matrix (Proposed Template)
Step 5: Expand and plot the distributed content into the complete Yearly Content Overview for the subject for the grade (Proposed Template)
Step 6: Develop the Termly Programs (Proposed Template – 3 part programme)
Step 7: Develop the Weekly Teaching Program (Proposed Template) Daily Lesson Plan (SBC Template)
Step 8: Review, Evaluate and Re-plan the yearly, termly, weekly Programs

TECHNOLOGY AND INDUSTRIAL ARTS PLANNING AND PROGRAMMING PROCESS

Planning and Programming Process involves 8 steps.

Step 1: Identify the number of Strands and Units in the subject Syllabus.

It is important to first identify the strand and unit names for familiarisation and also the number of benchmarks in Grade 12 Construction Technology.

Construction Technology has 5 Units

Table of Strands and Units

The table below outlines the strand and units for Grade 12 Construction Technology subject. This helps teachers understand how to deal with units per strand when they are expanded into evidence outcomes and benchmarks at each grade.

The Strands, Units are outlined in the table below:

Step 1: Identify the number of Strands and Units in the subject Syllabus

STRANDS	UNITS
Construction Technology	Unit 1. Building Technology
	Unit 2. Electrical Technology
	Unit 3. Plumbing Technology
	Unit 4. Welding Technology
	Unit 5. Engineering Technology

Timetabling of Construction Technology as a standalone elective(Subject)

The teaching and learning of Construction Technology can be organised to be taught in a year by the Practical Skills Teacher.

Programming can be done using sequential and integration programming.

Stand: Construction Technology	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Benchmarks	6	6	4	6	5
Total Benchmarks	27				

1. Calculate the total number of Benchmarks for the strand.
2. Divide the total number of Benchmarks by the number of weeks in the term.
3. Distribute the number of benchmarks throughout the weeks.
4. For Construction Technology Grade 12, the total number of Benchmarks is 27 and will be divided by 4 terms in a year. This would be 6-7 Benchmarks in a term.

1. The Integration programming involves the teaching of the Construction Technology within a term. All the benchmarks (BM) are distributed by weeks. In grade 12, there are 27 Benchmarks for all the units.

1. Collect the total number of Benchmarks for the grade.
2. Divide the total number of Benchmarks by the number of terms.
3. Distribute the 27 Benchmarks to the 4 terms, indicate the Units by the weeks as they are programmed by using themes and or core curriculum eg Safety, technical drawings.

Standards-Based Lesson Planning

What are Standards-Based Lessons?

In a Standards-Based Lesson, the most important or key distinction is that, a student is expected to meet a defined standard for proficiency. When planning a lesson, the teacher ensures that the content and the methods of teaching the content enable students to learn both the skills and the concepts defined in the standard for that grade level and to demonstrate evidence of their learning.

Planning lessons that are built on standards and creating aligned assessments that measure student progress towards standards is the first step teacher must take to help their students reach success. A lesson plan is a step-by-step guide that provides a structure for an essential learning.

When planning a standards-based lesson, teacher instructions are very crucial for your lessons. How teachers instruct the students is what really points out an innovative teacher to an ordinary teacher. Teacher must engage and prepare motivating instructional activities that will provide the students with opportunities to demonstrate the benchmarks. For instance, teacher should at least identify 3-5 teaching strategies in a lesson; teacher lectures, ask questions, put students into groups for discussion and role play what was discussed.

Why is Standards-Based Lesson Planning Important?

There are many important benefits of having a clear and organised set of lesson plans. Good planning allows for more effective teaching and learning. The lesson plan is a guide and map for sthe materials and the teacher for the purpose of helping the students achieve the standards. Lesson plans also provide a record that allows good, reflective teachers to go back, analyse their own teaching (what went well, what didn't), and then improve on it in the future.

Standards-based lesson planning is vital because the content standards and benchmarks must be comparable, rigorous, and measurable and of course evidence based and be applicable in real life that we expect students to achieve. Therefore, teachers must plan effective lessons to teach students to meet these standards. As schools implement new standards, there will be much more evidence that teachers will use to support student learning to help them reach the highest levels of cognitive complexity. That is, students will be developing high-level cognitive skills.

Components of a Standards-Based Lesson Plan

An effective lesson plan has three basic components;

- aims and objectives of the course;
- teaching and learning activities;
- assessments to check student understanding of the topic.

Effective teaching demonstrates deep subject knowledge, including key concepts, current and relevant research, methodologies, tools and techniques, and meaningful applications.

Planning for under-achievers

Who are underachieving students?

Under achievers are students who fail or do not perform as expected. Underachievement may be caused by emotions (low self-esteem) and the environment (cultural influences, unsupportive family)

How can we help underachievement?

Underachievement varies between students. Not all students are in the same category of underachievement.

Given below a suggested strategies teachers may adopt to assist underachievers in the classroom.

- Examine the Problem Individually

It is important that underachieving students are addressed individually by focusing on the student's strengths.

- Create a Teacher-Parent Collaboration

Teachers and parents need to work together and pool their information and experience regarding the child. Teachers and parents begin by asking questions such as;

  - In what areas has the child shown exceptional ability?
  - What is the child's preferred learning styles?
  - What insights do parents and teachers have about the child's strengths and problem areas?

- Help student to plan every activity in the classroom
- Help students set realistic expectations

- Encourage and promote the student's interests and passions.
- Help children set short and long-term academic goals
- Talk with them about possible goals.
- Ensure that all students are challenged (but not frustrated) by classroom activities
- Always reinforce students

To help teachers plan effective lessons, there are sample lessons provided here. Teachers are encouraged to study the layout of the different components of these lessons and follow this design in their preparation and teaching of each lesson. Planning a good lesson helps the teacher in maintaining a standard teaching pattern and does not let the class deviate from the topic.

Sample of Standards-Based Lesson Planning

The following sample lesson can help teachers to plan effective lessons. Teachers are encouraged to study the layout of the different components of these lessons and follow this design in their preparation and teaching of each lesson. Planning a good lesson helps the teacher in maintaining a standard teaching pattern which should not deviate students' learning of the concept from the topic.

STRAND: CONSTRCUTION TECHNOLOGY

UNIT 2. Electrical Technology

Content Standard 3.2 Investigate, analyse and apply the technological processes, concepts, principles and practices related to Electrical Technology and its social contribution with regard to economic growth, entrepreneurship, sustainability and as a tool for change, improving quality of life responsive to individual, community and industrial needs.

Benchmark 12.3.2.1. Read, analyse and interpret electrical circuit diagrams in design and construction.
Topic 1: Design and Construction of Electrical circuits
Lesson 1: Circuit Design and Construction

Lesson Objective: Students will be able to:

a. Identify the components of a circuit design and construction.

Essential Knowledge, Skills, Values and Attitudes

Knowledge	Skills	Values	Attitudes
Circuit design and construction	identify	considerate	participatory

Teaching Strategies

· Students engage in brainstorming exercise to discover how circuits are designed and constructed.
· Students are engaged with computers to use designing software to construct and design circuits.
· Students are also engaged with breadboards, circuit kits to put the designed circuit into physical structure on breadboards or circuit kits.

Learning Strategies

Activity 1 Brainstorming activity on Circuit design and construction
Activity 2 Students are engaged with computers to design and simulate circuits
Activity 3 Students put together designed circuit using breadboards and circuit kits.

Teacher	Student
Introduction	
Present a circuit diagram of an electrical appliance and let students identify what it is and why they say what it is. Lead students to the lesson topic which is Circuit design and construction	Students study the model presented and work out what it is and why is called what it is. While identifying, they move forward to discovering the lesson topic
Body	
Modelling	
Brainstorm on what is circuit design and construction.	Students brainstorm in groups and in classes what circuit design and construction is.
Guided Practice	
Engage students in design circuits using computer software	Students are engaged to design circuits using computer software in pairs
Independent Practice	
Engage students to construct physical circuits using breadboards, circuit kits and even use manuals to assist them. Facilitate students' circuit presentation and testing	Construct designed circuits using circuit kits, breadboards aided with manuals. Present constructed circuit as a class discussion
Conclusion	
Conclude lesson with main concepts being explained	Take lesson notes
Assessment	
Assess presentation activity	Complete assessment task.

Resources
Pethebridge K & Neeson I ,2010, page 227
Breadboards, circuit kits, operational manual for electrical appliances

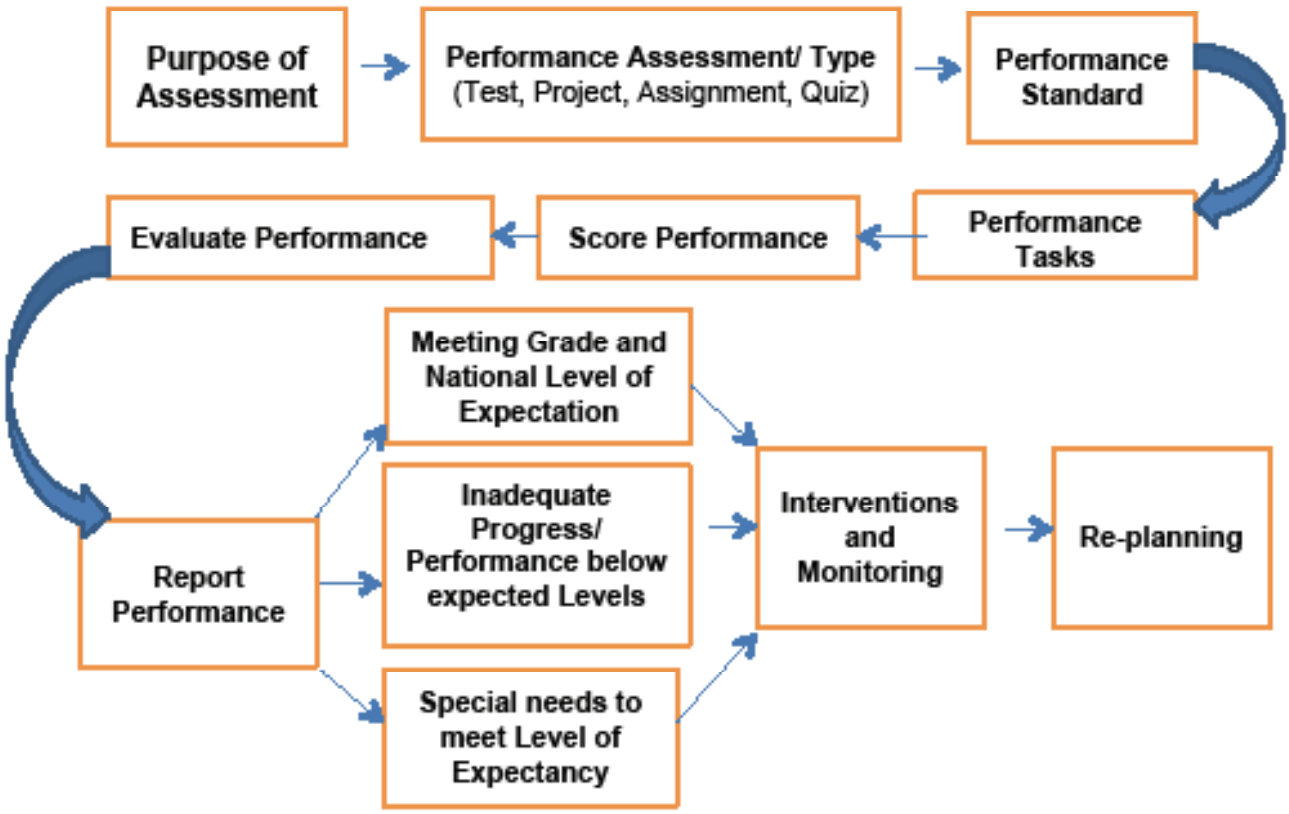
Assessment, Monitoring and Reporting

What is Standards-Based Assessment (SBA)?

Standards-Based Assessment is an on-going and a systematic process of assessing, evaluating, reporting and monitoring students' performance and progression towards meeting grade and national level expectations. It is the measurement of students' proficiency on a learning objective of a content standard and progression towards the attainment of that content standard and benchmark.

Standards-Based Assessment Cycle

The Standards-Based Assessment Cycle begins with the purpose to assess learning. Teachers must always clearly define the purpose and expectations of the assessment tasks or activities before starting the assessment. The cycle consist the delivery of the assessment, scoring of performance, monitoring or learning, evaluating learning and performance, reporting of achievement and underachievement, developing interventions for underachievers and advance learners and replanning assessment as demonstrated below;



Purpose of Standards-Based Assessment

Standards-Based Assessment (SBA) serves different purposes. These include instruction and learning purposes. The primary purpose of SBA is to improve student learning so that all students can attain the expected level of proficiency or quality of learning.

Enabling purposes of SBA is to:

- measure students' proficiency on well-defined content standards, benchmarks and learning objectives.
- ascertain students' attainment or progress towards the attainment of specific component of a content standard.
- ascertain what each student knows and can do and what each student needs to learn to reach the expected level of proficiency.
- enable teachers to make informed decisions and plans about how and what they would do to assist weak students to make adequate progress towards meeting the expected level of proficiency.
- enable students to know what they can do and help them to develop and implement strategies to improve their learning and proficiency level.
- communicate to parents, guardians, and relevant stakeholders the performance and progress towards the attainment of content standards or its components.
- compare students' performances and the performances of other students.

Principles of Standards-Based Assessment

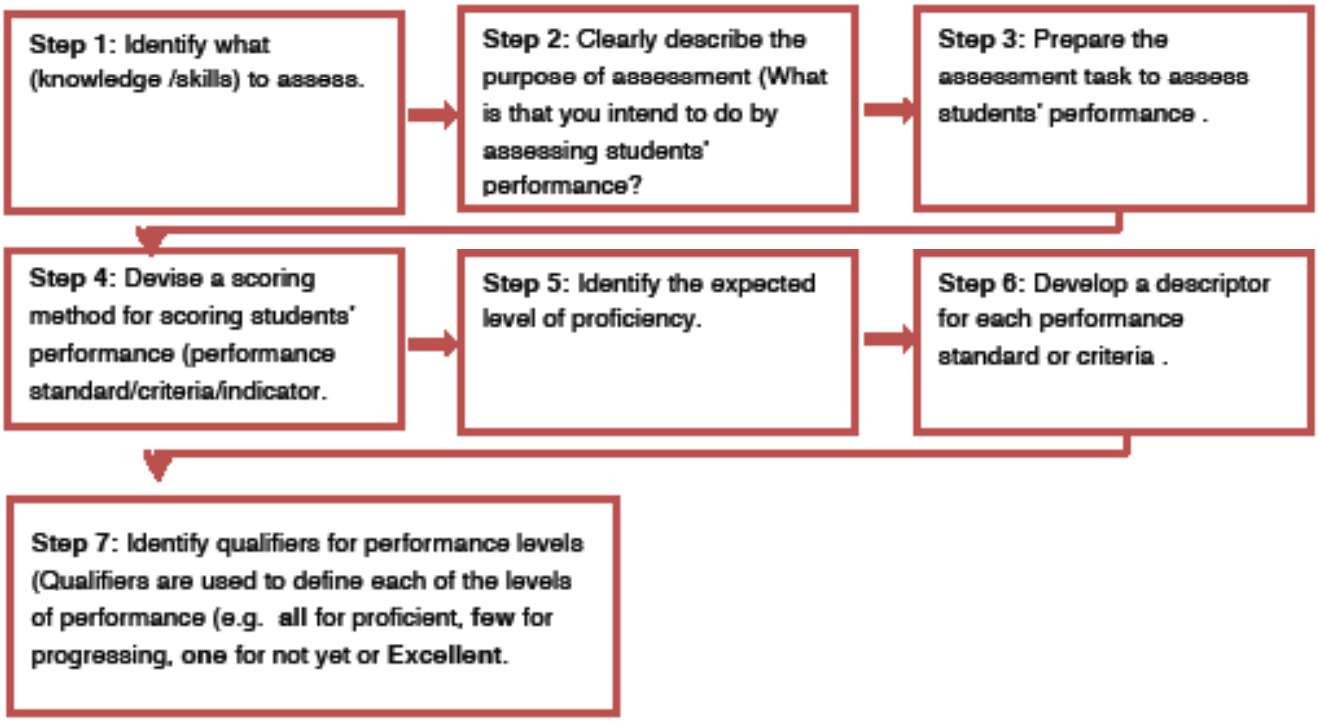
The principle of SBA is for assessment to be;

- emphasing on tasks that should encourage deeper learning,
- be an integral component of a course, unit or topic and not something to add on afterwards,
- a good assessment requires clarity of purpose, goals, standards and criteria,
- of practices that should use a range of measures allowing students to demonstrate what they know and can do,
- based on an understanding of how students learn,
- of practices that promote deeper understanding of learning processes by developing students' capacity for self-assessment,

- improving performance that involves feedback and reflection,
- on-going rather than episodic,
- given the required attention to outcomes and processes,
- be closely aligned and linked to learning objectives, benchmarks and content standards.

Standards-Based Assessment Process

Teachers are required to use the steps outlined below when planning assessment. These steps will guide you to develop effective assessments to improve student's learning as well as evaluating their progress towards meeting national and grade –level expectations.



Authentic Assessment

Authentic Assessments in Standards-based Assessment directly measure student's performance through "real life tasks" or "situations" that resemble "real life situations." Authentic assessment;

- Is performed in a real life context that approximates as much as possible, the use of a skill or concept in the real world.
- Is based on the development of a meaningful *product, performance or process*

- Students develop and demonstrate the application of their knowledge, skills, values and attitudes in real life situations which promote and support the development of deeper levels of understanding.
- Is mostly associated with assessment as or while learning and assessment for learning but occasionally or contextually in summative learning.
- includes assessment activities such as demonstrations, debates, field work, simulations, problem solving, project-based learning, Poster Presentations, Research, Laboratory work, Reflections, Problem-based activities, Role Play, Report/Essay, Field experience, Field report, Recounts etc.

Advantages of Authentic Activities

- Empower students to take ownership in their learning
- Appreciates Learning experience
- enables and encourages the Learning experiences to be used as a basis of learning
- Meaningful, relevant, practical
- Assess the actual learning experience which means; you do not need to "teach" and then assess, rather you assess actual learning experience while it is actually happening

Authentic Assessment Criteria

In standards-based Assessment, teachers are encouraged to step out of their traditional assessment and explore authentic assessment. The criteria in authentic assessment;

- Looks at students actively engaged in completing a task that represents the achievement of a learning objective or standard.
- Takes place in real life situations.
- Asks students to apply their knowledge, skills, values and attitudes in real life situations.
- Students are given the criteria against which they are being assessed.

A Comparison of Authentic and Traditional Assessment

Authentic Assessments	Traditional Assessments
▪ Portfolios, demonstrations, field work, case studies, assignments, lab reports ▪ Students take an active role in process ▪ Qualitative ▪ Interpretive	▪ Multiple choice tests, true-false, fill in the blanks, sentence completion, matching, diagram completions ▪ External –(teacher driven – assessing performance of teacher rather than the student) ▪ Teacher-centered (what is

▪ Focuses on performance, process and product ▪ High level thinking ▪ Use of rubric ▪ Use of criterion levels evaluation ▪ Part of teaching and learning Process ▪ Shows mastery and learning performance ▪ Generally extends over time ▪	appropriate and convenient for the teacher and what teacher thinks is good for students and decides what should be and should not be learnt) • Quantitative (driven to collect marks) • Objective • End product (only looking for the end product and not concerned about the performance and process) • Standardised or norm referenced • Isolated facts • Low level content • Generally occurs in "one setting

Standards-Based Assessment Types

In standards-Based Assessment, there are three broad assessments types.

1. Formative Assessment

Formative assessment includes "assessment *for* and *as*" and is conducted during the teaching and learning of activities of a topic.

Purposes of assessment for Learning

- On-going assessment that allows teachers to monitor students on a day-to-day basis.
- Provide continuous feedback and evidence to the teachers that should enable them to identify gaps and issues with their teaching, and improve their classroom teaching practice.
- Helps students to continuously evaluate, reflect on, and improve their learning

Purposes of assessment as Learning

- Occurs when students reflect on and monitor their progress to inform their future learning goals
- Helps students to continuously evaluate, reflect, and improve their own learning
- Helps students to understand the purpose of their learning and clarify learning goals

2. Summative Assessment

Summative assessment focuses on '*assessment of learning*' and is conducted after or at the conclusion of teaching and learning of activities or a topic.

Purposes of assessment of Learning

- Help teachers to determine what each student has achieved and how much progress he/she has made towards meeting national and grade-level expectations
- Help teachers to determine what each student has achieved at the end of a learning sequence or a unit.
- Enable teachers to ascertain each student's development against the unit or topic objectives and to set future directions for learning.
- Help students to evaluate, reflect on, and prepare for next stage of learning

Performance Assessment

Performance assessment is a form of testing that requires students to perform a task rather than select an answer from a ready-made list. For example, a student may be asked to explain historical events, generate scientific hypotheses, solve math problems, converse in a foreign language, or conduct research on an assigned topic. Teachers, then judge the quality of the student's work based on an agreed-upon set of criteria. It is an assessment which requires students to demonstrate that they have mastered specific skills and competencies by performing or producing something.

Types of performance assessment;

I. Products-Oriented

This refers to concrete tangible items that students create through either the visual, written or auditory media such as;

- Creating a health/physical activity poster
- Video a class game or performance and write a broadcast commentary
- Write a speech to be given at a school council meeting advocating for increased time for health and physical education in the curriculum
- Write the skill cues for a series of skill photo's
- Create a brochure to be handed out to parents during education week
- Develop an interview for a favourite sportsperson
- Write a review of a dance performance
- Essays
- Projects

II. *Process-Oriented Tasks*

It shows the thinking processes and learning strategies students use as they work such as;

- Survival scenarios
- Problem solving initiative/adventure/ activities
- Decision making such as scenario's related to health issues
- Event tasks such as creating a game, choreographing a dance/gymnastics routine, creating an obstacle course
- Game play analysis
- Peer assessment of skills or performances
- Self-assessment activities
- Goal setting, deciding a strategy and monitoring progress towards achievement

III. *Performances-Oriented*

It deals with observable affective or psycho-motor behaviours put into action such as;

- Skills check during game play
- Role plays
- Officiating a game
- Debates
- Performing dance/gymnastics routines
- Teaching a skill/game/dance to peers

Performance Standards

Performance standards are measurement standards that are observed through evidence outcomes and performance indicators. Evidence outcomes and Performance Indicators are used to measure students' performances, proficiency, competency, progression and achievement of the desired grade or level of expectation.

Performance Standards are concrete statements of how well students must learn what is set out in the content standards and benchmarks, often called the "be able to do" of "what students should know and be able to do." Performance standards indicate the quality that specifies how competent a students' demonstration or performance must be. They include

explanations of how well students must demonstrate the content, explaining "how good is good enough."

Performance standards:

- measure students' performance and proficiency (using performance indicators) in the use of a specific knowledge, skill, value, or attitude in real life or related situations
- provide the basis (performance indicators) for evaluating, reporting and monitoring students' level of proficiency in use of a specific knowledge, skills, value, or attitude
- are used to plan for individual instruction to help students not yet meeting expectations (desired level of mastery and proficiency) to make adequate progress towards the full attainment of benchmarks and content standards
- are used as the basis for measuring students' progress towards meeting grade-level benchmarks and content standards
- A stem statement for Performance Standards will begin with…."Students will be able to……"
- A stem statement for Performance Indicator will begin with …."Students can be able to……."

Assessment Strategies

It is important for teachers to know that, assessment is administered in different ways. Assessment does not mean a test only. There are many different ways to find out about student's strengths and weaknesses. Relying on only one method of assessing will not reflect student's achievement.

Provided in the appendices is a list of suggested strategies you can use to assess student's performances. These strategies are applicable in all the standards-based assessment types. ***Please refer to the Appendices to see the suggested strategies.***

Action Verbs to Assessment Strategies		
Cognitive Learning	**Action Verbs**	**Assessment Strategies**
Knowledge - to recall or remember facts without necessarily understanding them	Arrange, define, duplicate, label, memorise, name, order, recognise, relate, recall, reproduce, list, tell, describe, identify, show, label, collect, examine, tabulate, quote	▪ Prior knowledge inventory, misconception/preconception check ▪ Focused listing, empty outlines ▪ Pre-post test, quiz, quick poll
Comprehension – to understand and interpret learned information	Classify, describe, discuss, explain, express, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend, translate, review, restate, locate, recognise, report	▪ Minute paper, muddiest (or clearest) point ▪ Observe and evaluate a student artifact or performance task using a rubric ▪ Directed paraphrasing ▪ Pre-post test, quiz ▪ Interviews
Application – to put ideas and concepts to work in solving problems	Apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, calculate, complete, show, examine, modify, relate, change, experiment, discover	▪ Observe and evaluate a student artifact, performance, or task using a rubric ▪ Directed paraphrasing, real-world application (apply learning in a new context) ▪ Test, quiz ▪ Job/internship evaluation, skill ratings
Analysis – to break information into its components to see interrelationships and ideas	Analyse, appraise, calculate, categorise, compare, contrast, criticise, differentiate, discriminate, distinguish, examine, experiment, question, test, separate, order, connect, classify, arrange, divide, infer	▪ Pro and con grid, categorizing grid, compare and contrast, concept maps ▪ Observe and evaluate a student artifact, performance, or task using a rubric ▪ Journaling ▪ Job/internship evaluation, skill ratings
Evaluation – to judge	Appraise, argue, assess, attach,	▪ Reflection component of a

the value of information based on established criteria	defend, judge, predict, rate, support, evaluate, recommend, convince, judge, conclude, compare, summarise	portfolio or experience ▪ Journaling ▪ Peer evaluation
Affective Learning	appreciate, accept, attempt, challenge, defend, dispute, join, judge, praise, question, share, support	▪ Reflection component of a portfolio or experience ▪ Journaling ▪ Observe and evaluate group work ▪ Surveys, interviews, focus groups

ASSESSMENT STRATEGIES

Strategy	Description
Analogies	Students create an analogy between something they are familiar with and the new information they have learned. When asking students to explain the analogy, it will show the depth of their understanding of a topic.
Classroom Presentations	A classroom presentation is an assessment strategy that requires students to verbalize their knowledge, select and present samples of finished work, and organize their thoughts about a topic in order to present a summary of their learning. It may provide the basis for assessment upon completion of a student's project or essay.
Conferences	A conference is a formal or informal meeting between the teacher and a student for the purpose of exchanging information or sharing ideas. A conference might be held to explore the student's thinking and suggest next steps; assess the student's level of understanding of a particular concept or procedure; and review, clarify, and extend what the student has already completed
Discussions	Having a class discussion on a unit of study provides teachers with valuable information about what the students know about the subject. Focus the discussions on higher level thinking skills and allow students to reflect their learning before the discussion commences.
Essays	An essay is a writing sample in which a student constructs a response to a question, topic, or brief statement, and supplies supporting details or arguments. The essay allows the teacher to assess the student's understanding and/or ability to analyse and synthesize information.
Exhibitions/Demonstrations	An exhibition/demonstration is a performance in a public setting, during which a student explains and applies a process, procedure, etc., in concrete ways to show individual achievement of specific skills and knowledge.
Interviews	An interview is a face-to-face conversation in which teacher and student use inquiry to share their knowledge and understanding of a topic or problem, and

	can be used by the teacher to explore the student's thinking; assess the student's level of understanding of a concept or procedure and gather information, obtain clarification, determine positions, and probe for motivations.
Learning Logs	A learning log is an ongoing, visible record kept by a student and recording what he or she is doing or thinking while working on a particular task or assignment. It can be used to assess student progress and growth over time.
Observation	Observation is a process of systematically viewing and recording students while they work, for the purpose of making programming and instruction decisions. Observation can take place at any time and in any setting. It provides information on students' strengths and weaknesses, learning styles, interests, and attitudes.
Peer Assessment	Assessment by peers is a powerful way to gather information about students and their understanding. Students can use set criteria to assess the work of their classmates.
Performance Tasks	During a performance task, students create, produce, perform, or present works on "real world" issues. The performance task may be used to assess a skill or proficiency, and provides useful information on the process as well as the product.
Portfolios	A portfolio is a collection of samples of a student's work, and is focused, selective, reflective, and collaborative. It offers a visual demonstration of a student's achievement, capabilities, strengths, weaknesses, knowledge, and specific skills, over time and in a variety of contexts.
Questions And Answers (Oral)	In the question–and-answer strategy, the teacher poses a question and the student answers verbally, rather than in writing. This strategy helps the teacher to determine whether students understand what is being, or has been, presented, and helps students to extend their thinking, generate ideas, or solve problems.
Quizzes, Tests,	A quiz, test, or examination requires students to respond to prompts in order to demonstrate their knowledge (orally or in writing) or their skills (e.g.,

Examinations	through performance). Quizzes are usually short; examinations are usually longer. Quizzes, tests, or examinations can be adapted for exceptional students and for re-teaching and retesting.
Questionnaires	Questionnaires can be used for a variety of purposes. When used as a formative assessment strategy, they provide teachers with information on student learning that they can use to plan further instruction.
Response Journals	A response journal is a student's personal record containing written, reflective responses to material he or she is reading, viewing, listening to, or discussing. The response journal can be used as an assessment tool in all subject areas.
Selected Responses	Strictly speaking a part of quizzes, tests, and examinations, selected responses require students to identify the one correct answer. The strategy can take the form of multiple-choice or true/false formats. Selected response is a commonly used formal procedure for gathering objective evidence about student learning, specifically in memory, recall, and comprehension.
Student Self-Assessments	Self-assessment is a process by which the student gathers information about, and reflects on, his or her own learning. It is the student's own assessment of personal progress in terms of knowledge, skills, processes, or attitudes. Self-assessment leads students to a greater awareness and understanding of themselves as learners.

Scoring Methods for Performance Assessment

Assessment can be scored during or after the students have completed the assessment task. However, it is best done during a lesson- using a checklist, rating scales & rubrics.

A rubric is a coherent set of criteria for students' work that includes descriptions of levels of performance quality on the criteria. Rubrics have two major aspects: coherent sets of criteria and descriptions of levels of performance. Rubrics include;

(1) Descriptions of the of task
(2) The scales to be used
(3) The dimensions of the task
(4) The description of each dimension on the scale

A Rubric

- is a scoring guide that helps teachers evaluate student performance, based on a range of criteria.
- A rubric lists the criteria, or characteristics, that student work should exhibit and describes specific quality levels for those criteria.
- Rubrics are a great way to improve communication, learning, and grading fairness.
- Knowing how to create and use rubrics gives you a better understanding of assessment and another option for assessing student performance.
- are descriptive and not evaluative.
- Of course, rubrics can be used to evaluate, but the operating principle is to match the performance to the description rather than "judge" it.
- Thus rubrics are as good or bad as the criteria selected and the descriptions of the levels of performance under each.
- Effective rubrics have appropriate criteria and well-written descriptions of performance

Purpose of Rubrics

Like any other evaluation tool, rubrics are useful for certain purposes and not for others. *The main purpose of rubrics is to assess performances.* For some performances, you observe the student in the process of doing something, like using an electric drill or discussing an issue. For other performances, you observe the product that is the result of the student's work, like a finished bookshelf or a written report.

1. Support authentic assessment
While traditional tests measure how well students recall content, rubrics measure how well students can apply knowledge to authentic contexts or real-world tasks.

2. Clearly communicate expectations
Because rubrics define student "quality" in terms of objective criteria and standards, they clearly communicate how instructors will evaluate student performance.

3. Improve performance

Rubrics lead to better student performance. When students understand assignments and expectations before they begin, they are more likely to fulfil them. They know what specific criteria and standards of excellence will be used to rate their performance.

4. To inspire fairness
Because rubrics have detailed assessment information, students don't feel that grades are assigned subjectively or arbitrarily. Also, when you have more than one grader, a rubric allows all graders to apply the same criteria in the same way.

Although rubrics have many benefits—and make grading faster and easier—a good rubric takes time, effort and patience to construct. You'll probably need to change (change, not add to) your grading and assessment methods, based on what you believe about learning assessment. Rubrics are best for critical assessments, major projects, and other assignments that require a multi-dimensional performance evaluation. The trick is to know what type of rubric to create for your situation.

Reasons for Creating Rubrics/Marking schemes

Rubrics or marking schemes are created for;

1. Categories to assess-different components or elements that will assess
    - Factual information
    - Application
    - Analysis
    - Writing Skills
2. Criterion for assessment
    - Accuracy
    - Completeness
    - Length or number of examples
    - Supported with research
    - Range of answer
    - Description and support
3. Levels or points 3-5 levels
    - Exemplary. Proficient, acceptable, not acceptable
    - Excellent, good, fair, poor
    - 10 points, 5 points, 1 point

Parts of a Rubric

- A rubric is a matrix of criteria and their descriptors.
- The left side of a rubric matrix lists the criteria (performance standards) for the expected product or performance.

- Across the top of the rubric matrix is the rating scale that provides a set of values for rating the quality of performance for each criterion.
- Descriptors under the rating scale provide examples or concrete indicators for each level of performance.
- The dimensions of the task that qualifies the achievement

Criteria	Performance Standards (Descriptors)
BEYOND	Beyond Standard (s) -*Advanced in Performance and Understanding*
	Consistently demonstrates advanced conceptual mathematical understandings Consistently generates tasks that make connections between and among mathematical ideas Consistently applies strategies to unique situations Consistently demonstrated confidence to approach tasks beyond the proficiency level for grade Consistently initiates mathematical investigations
CONSISTENT	Meet Standard (s)-*Proficient in Performance and Understanding*
	Consistently demonstrates understanding of mathematical standards and cluster at the grade level Consistently demonstrated conceptual understanding Consistently applies multiple strategies flexibly in various situations Understands and fluently applies procedures with understanding Consistently demonstrates perseverance and precision Constructs logical mathematical arguments of thinking and reasoning Uses mathematical language correctly and appropriately
INCONSISTENT	Progressing-*Not Yet Proficient in Performance and Understanding*
	Inconsistently uses tools appropriately and strategically Demonstrates inconsistent understanding of key mathematical ideas at grade level Demonstrates inconsistent conceptual understanding of key mathematical ideas at grade level Inconsistent in understanding and application of grade level appropriate strategies Depends upon assistance of teacher and/or peers to understand and complete tasks Needs additional time to complete tasks Applies models of mathematical ideas inconsistently
SELDOM	Not Yet -*Limited Performance and Understanding*
	Exhibits minimal understanding of key mathematic ideas at grade level Rarely demonstrates conceptual understanding Seldom provides precise response Seldom use appropriate strategies Consistently requires assistance and alternative instruction Use tools inappropriately to model mathematics

Types of Rubrics

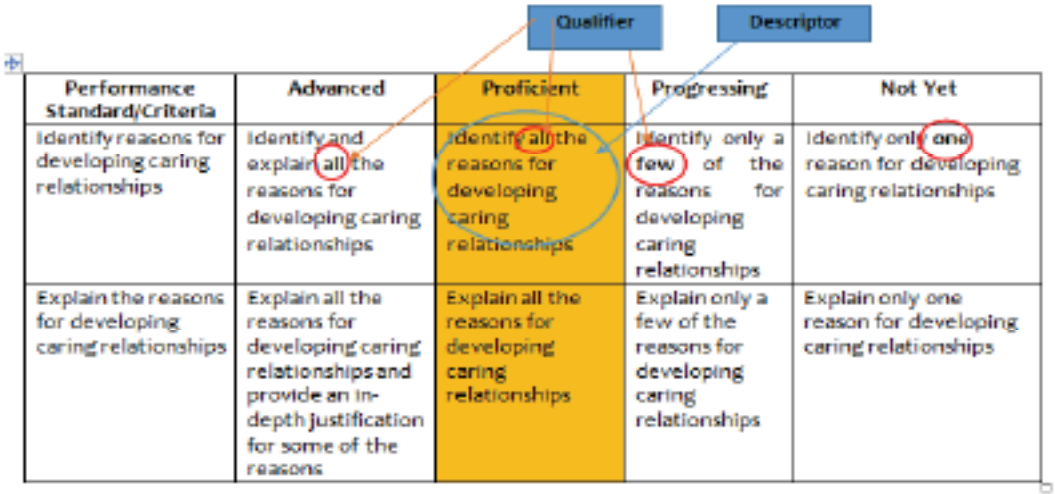
1. Analytic Rubric

Analytic rubrics describe work on each criterion separately. For most classroom purposes, analytic rubrics are best. Focusing on the criteria one at a time is better for instruction and better for formative assessment because students can see what aspects of their work need what kind of attention. Focusing on the criteria one at a time is good for any summative assessment (grading) that will also be used to make decisions about the future—for example, decisions about how to follow up on a unit or decisions about how to teach something next year.

Template for Analytic Rubrics

Criteria	Beginning	Developing	Accomplished	Exemplary	Score
Criteria 1	Description reflecting beginning	Description reflecting movement toward mastery level of performance	Description reflecting achievement of mastery level of performance	Description reflecting of highest level of performance	
Criteria 2	Description reflecting beginning level performance	Description reflecting movement toward mastery level of performance	Description reflecting achievement of mastery level of performance	Description reflecting of highest level of performance	
Criteria 3	Description reflecting beginning level performance	Description reflecting movement toward mastery level of performance	Description reflecting achievement of mastery level of performance	Description reflecting of highest level of performance	
Criteria 4	Description reflecting beginning level performance	Description reflecting movement toward mastery level of performance	Description reflecting achievement of mastery level of performance	Description reflecting of highest level of performance	

Sample Analytic Rubric



Performance Standard/Criteria	Advanced	Proficient	Progressing	Not Yet
Identify reasons for developing caring relationships	Identify and explain all the reasons for developing caring relationships	Identify all the reasons for developing caring relationships	Identify only a few of the reasons for developing caring relationships	Identify only one reason for developing caring relationships
Explain the reasons for developing caring relationships	Explain all the reasons for developing caring relationships and provide an in-depth justification for some of the reasons	Explain all the reasons for developing caring relationships	Explain only a few of the reasons for developing caring relationships	Explain only one reason for developing caring relationships

Holistic Rubrics

Holistic rubrics describe the work by applying all the criteria at the same time and enabling an overall judgment about the quality of the work. Holistic rubrics are based on criteria for good work and on observation of how the work meets those criteria.

One classroom purpose for which holistic rubrics are better than analytic rubrics is the situation in which students will not see the results of a final summative assessment and you will not really use the information for anything except a grade. Some high school final examinations fall into this category. Grading with rubrics is faster when there is only one decision to make, rather than a separate decision for each criterion.

Decide on type of rubric to be used (Holistic or Analytic)

1. When to use Holistic Rubric
    - There is no single correct answer/response to a task
    - The focus has no the overall quality, proficiency, or understanding of a specific content or skills.
    - You are assessing large numbers (eg. 150 portfolios)

Holistic Rubric						
Score	5	4	3	2	1	0
Description	Demonstrate complete understanding of the problem. All requirements of task are included in response.	Demonstrate considerable understanding of the problem. All requirements of task are included.	Demonstrate partial understanding of the problem. Most requirements of task are included.	Demonstrate little understanding of the problem. Many requirements of task are missing.	Demonstrate no understanding of the problem.	No response/ not attempted task

2. When to use Analytic Rubric
    - Several subjects are assessing the student work.
    - Description promote consistent scoring.
    - Stakeholders will be examining the rubric scores.
    - Substantial feedback to students or the subjects is desired.
    - Outlines of specific strengths/weaknesses are anticipated.

Analytic Rubric				
Criteria	4	3	2	1
Criteria # 1	Description reflecting highest level of performance.	Description reflecting mastery level of performance.	Description reflecting movement towards mastery level of performance.	Description reflecting beginning level of performance.
Criteria # 2	Description reflecting highest level of performance.	Description reflecting mastery level of performance.	Description reflecting movement towards mastery level of performance.	Description reflecting beginning level of performance.
Criteria # 3	Description reflecting highest level of performance.	Description reflecting mastery level of performance.	Description reflecting movement towards mastery level of performance.	Description reflecting beginning level of performance.
Criteria # 4	Description reflecting highest level of performance.	Description reflecting mastery level of performance.	Description reflecting movement towards mastery level of performance.	Description reflecting beginning level of performance.

Scoring of Performance for Formative Assessment
(Assessment as/while learning and Assessment for learning)

1. Scoring Assessment using Rating Scale

Rating Scales are a type of checklists that judge the degree to which a criteria is met. They generally have a scale of between 1-6 options.

Types of Rating Scales

A. Frequency Rating Scales

A frequency rating scale scores how often a task is done to meet criteria.

Sample Rating Scale Descriptive Words

1. Words that describe the skill of *selecting 'the right' information* at varying levels of quality

Excellent	Proficient	Adequate	Limited

Pertinent	relevant	suitable	trivial
Insightful	meaningful	appropriate	superficial
Significant	relevant	predictable	vague
Perceptive	thoughtful	basic	questionable
Precise	logical	partially correct	confusing
Purposeful	focused	appropriate	irrelevant

2. Words that describe the skill of *selecting 'enough' information* at varying levels of quality.

Excellent	Proficient	Adequate	Limited
comprehensive	thorough	cursory	superficial
in-depth	sufficient	partial	incomplete
rich & detailed	specific	simplistic	undeveloped
Extensive	substantial	partial	sketchy

3. Words that describe the skill of *evaluating product or connecting insights to personal experience* at varying levels of quality

Excellent	Proficient	Adequate	Limited
insightful	thoughtful	predictable	trivial
astute	relevant	appropriate	unfocused
perceptive	thoughtful	routine	trivial
intuitive	logical	rudimentary	unsubstantiated
innovative	credible	predictable	trite
compelling	meaningful	obvious	tenuous

4. Words that describe the skill of *designing or constructing* at varying levels of quality

Excellent	Proficient	Adequate	Limited
efficient	practical	viable	unworkable
innovative	effective	workable	ineffective

5. Words that describe the skill of *organizing or formatting information* at varying levels of quality

Excellent	Proficient	Adequate	Limited
skillful	systematic	simplistic	haphazard
purposeful	logical	methodical	disorganized

6. Words that describe the skill of *analyzing information or data* at varying levels of quality

Excellent	Proficient	Adequate	Limited
accurate	logical	partially accurate	flawed
insightful	logical	simplistic	unsupported
astute	credible	plausible	inaccurate
precise	relevant	basic	irrelevant

7. Words that describe the skill of *presenting or communicating information or selecting appropriate visuals* at varying levels of quality

Excellent	Proficient	Adequate	Limited
vivid	interesting	simplistic	lacks appeal
compelling	effective	predictable	does little to sustain interest
enhances	supports	partially supports	interferes with
engaging	interesting	straightforward	ineffective
skillful	effective	appropriate	inappropriate
intriguing	interesting	predictable	ineffective

Sample Scoring using Rating Scale to assess "Collaboration"

Criteria	Frequency			
	Always = 4	Sometimes = 3	Rarely = 2	Never - 1
1. Embraces everyone's' abilities and encourages participation	Always Embraces everyone's' abilities and encourages participation	Sometimes Embraces everyone's' abilities and encourages participation	Rarely Embraces everyone's' abilities and encourages participation	Never Embraces everyone's' abilities and encourages participation
2. Ensures everyone is tasked to and activity	Always Ensures everyone is tasked to and activity	Sometimes Ensures everyone is tasked to and activity	Rarely Ensures everyone is tasked to and activity	Never Ensures everyone is tasked to and activity
3. Encourages everyone to achieve together	Always Encourages everyone to achieve together	Sometimes Encourages everyone to achieve together	Rarely Encourages everyone to achieve together	Never Encourages everyone to achieve together

2. Scoring assessment using a Checklist

Check lists are one of the easiest methods of scoring assessment tasks. The criteria i.e. skills, cues or tasks are considered separately according to whether they have been accomplished.

Types of Checklists include

- Yes/No

- Tick/Cross
- Circling
- Narrow scale, e.g. Sometimes, rarely, never
- Colouring
- Symbols (signifiers), e.g. pictures, facials, artifacts, signs, drawings, concept maps)

Sample Scoring using Yes/No Checklist Scale to assess "Collaboration"

No	*Criteria*	*Write Yes (score 2) or No (score 1)*
1	*Embraces everyone's' abilities and encourages participation*	
2	*Ensures everyone is tasked to an activity*	
3	*Encourages everyone to achieve together*	

Sample Scoring using Tick/Cross Checklist Scale to assess "Collaboration"

No	*Criteria*	*Place a tick(score 2) or and X (score 1)*
1	*Embraces everyone's' abilities and encourages participation*	
2	*Ensures everyone is tasked to an activity*	
3	*Encourages everyone to achieve together*	

Samples of other scoring methods are in the Appendix Reference. These are based on Business Studies but can be applied in Technology and Industrial Arts

Scoring of Performance for Summative Assessment

Grade rating scales are better scoring tools for summative assessment of students' performance. They indicate students' level of performance using such as; A, B, C, D etc

A Grade is given after the accumulated total for a number of assessments has been completed either at the end of and assessment period, a topic, a term, a grade or year.

The subject assessment components, tasks and weightings should be able to guide the grading of achievements as demonstrated in a rubric designed for this purpose.

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The subject assessment components, tasks and weightings should be able to guide the grading of achievements as demonstrated in a rubric designed for this purpose.

Sample Scenario to score Summative Assessment

For instance; If TIA/BS has an assessment plan for a 100 marks per term, then the grading shall be scored at the end of each term. As per the Assessment weighting, TIA/BS can plan to score assessment of students per term according to this components:

- 1 x Project = maximum of 50marks
- 1 x Moderation = maximum of 50 marks
- 2 x tests = maximum of 30 marks
- 1 x portfolio = maximum of 5 marks
- 1 x participation = maximum of 5 marks

Assessment Components and Task Weighting

The Assessment components and Task Weighting is intended for a Termly Assessment Schedule. It anticipated that the assessment components with their weightings may be changed by the teachers' Business Studies Termly Teaching Programs accordingly but the total scores allocated for the THEORY ASSESSMENT COMPONENTS (TAC) of 40 Marks and PRACTICAL ASSESSMENT COMPONENTS (PAC) 60 Marks should remain as it is the determined as the required 40/60 Moderation Components (i.e. 100 marks) for Business Studies Assessments per Assessment Period.

THEORY ASSESSMENT COMPONENTS (TAC) (40 Marks)	TOTAL SCORE/100	PRACTICAL ASSESSMENT COMPONENTS (PAC) (60 Marks)	TOTAL SCORE/100
		Project Portfolio No. 1	10
		STEAM Project Portfolio No. 1	10
Test No. 1	15	Project No. 1	25
		STEAM Project No. 1	25
Assignment No. 1	10		

Test No. 2	15		
TOTAL THEORY SCORE	____/40	TOTAL PRACTICAL SCORE	____/60
TOTAL SCORES OF TAC + PAC = TOTAL SCORES OUT OF 100	_____/100		

Sample subject assessment structure

The internal assessment for the Technology and Industrial Arts/ Business Studies subject is based on the Grade 9 & 10 and Grade 11 and 12 Technology and Industrial Arts Syllabus. The final assessment should be based on a range and balance of assessment strategies and instruments. Assessment must be both normative and criterion.

Component	Weighting	Tasks	Assessment Referencing
Practical Work in response to design brief (Moderation and Projects included here?)	60 % (of mandatory total)	Development and application of design ideas, safe and skillful use of materials, tools and equipment to make a product and the identified processes	Criterion Referencing Rubrics?
Design folio with outcomes of research , investigations and planning	20 % (of mandatory total)	Folio showing results of investigation in response to design brief, rough notes or sketches of design ideas, timelines, final drawings or plans, processes used to make the product and evaluation reports	Criterion Referencing Rubrics?
Tests	20 % (of mandatory total)	Theory and also applications in theory	Normative
Marks	100 %	A combination of design folios, practical applications, moderations and tests.	

Sample Assessment

SBC embraces standards and as such, standards must also drive the administration of assessments to students. It is important that every student must be given the outline of the Assessment that has been planned for the term. Each Term will include 6 pieces (can have any number from 4-6) of assessment. Assessment is weighted accordingly.

Assessment Type	Description	Weighting
Topic Tests x 2	Students will be given two topic tests based on the	1 = 15 marks

	content learnt in the term. 1 will be given mid-term and 1 at end-term. The test will be comprised of 10 multiple choice questions and 5 short written answers.	1=10 marks
Portfolio	Individual Students will be assessed……	10 marks
Moderation	In groups of four - five, students work to critically engage with one another in the required design process. Students will address criteria provided in class and prepare and deliver a 5-10 minute presentation addressing the criteria.	30 marks
Project (Application)	In groups of three to four, students work to critically engage with one another in the assigned project. Students will address criteria provided in class and prepare and deliver a 5-10 minute presentation addressing the criteria.	20 marks
Participation	2 marks will be allocated each day for attendance. Another 3 marks will be awarded for active participation.	5 marks

STEAM Assessment

Steps in Developing a STEAM Activity

1. Identify the Real/Authentic Situations that can be solved through the STEAM Activity
2. Select a well-defined a Benchmark in your subject area that will carry the STEAM Activity
3. Identify related subject areas with their concepts to be used solve the Authentic Situation
4. Note down the Main parts of the Unit Of Work for the STEAM Activity
5. Write a Description of the Authentic Situation for the STEAM Activity based on the identified Authentic situation.
6. Write down the Task Descriptions for the STEAM Activity in order to approach the Authentic situation.
7. Develop the Rubric to Assess the STEAM Activity.

1. ***Authentic Situation identified for this STEAM Activity***

- Students spending too much time using their smart mobile phones on Facebook, Whatsapp and surfing the internet rather than their school work.
- Students still bringing their smart mobile phones to school despite the school rules telling them not to.
- Most schools need to fully utilise their School Rules, Mottos, Missions and Visions which determines the way they want to shape our students' Knowledge, Attitudes and Values, during and after, they leave the school at end of G10 and G12.
- Our schools in our country have been labeled as 'a very good school to a very bad school' due school student fights and vandalism of school properties.
- Stakeholders of the schools are blaming the school management for the school students behaviour problems and parents are transferring their students out of schools to others school in the country.

2. ***Select a well-defined Benchmark in your subject area that will carry/drive the STEAM Activity and its associated Big Idea (product, project etc.)***

   - **Sample:**

     i. **SUBJECT:** BUSINESS STUDIES

     ii. **BENCHMARK 9.2.5.1.** Analyse the impact of information technology on society.

     iii. **Big idea/product:** Video Clip

3. ***Identify other related subject areas with the appropriate concepts to solve the Authentic Situation(s)***

- **Identify related subject areas with their concepts/Knowledge, Skills, Attitudes and Values to be used to solve the Steam Authentic Situation**

SUBJECTS	BENCHMARKS	BIG IDEA/ PRODUCT	KNOWLEDGE	SKILLS	ATTITUDES	VALUES
1. Arts (Theatre Arts)	9.2.2.2		Video script	Script Writing		
2. Christian Civic Value Education (CCVE)	9.3.1.3		School Rules, Motto, Vision, Mission	Examine Civic values	Responsibility	Ownership, Love
3. Character Social Development (CSD)	9.1.5.1, 9.1.5.2, 9.1.5.3, 9.1.5.4, 9.1.5.5		School Rules, Motto, Vision, Mission	Asses experiences and mistakes	Caring, Positivity	Respect
4. English	9.2.2.1		Descriptive Writing	Descriptive Writing	Neatness	
5. Social Science (History)	9.2.2.3, 9.2.2.4		School history	Discuss school culture		Ownership
6. Social Science (Political Science)	9.3.3.1, 9.3.3.2		National development aspirations/demands of citizens	Anticipative skills		
7. Technology Industrial Arts (TIA)	9.4.1.4, 9.4.1.5, 9.4.1.6		Range of communications media products	Creative media communication	Alertness	
8. Business Studies	9.2.5.6.	Video clip	Media rich projects	Shooting with mobile	Creativity	Innovative

There must be an anchor subject benchmark for any STEAM assessment.

4. ***Descriptions of the Steam Authentic Situation***

   - **Paragraph 1 describes the problem/situation**
   - **Paragraph 2 describes the solution to the problem/situation and who will be responsible to take up the task**
   - **Paragraph 3 would mention any rewards/awards for an adequate solution to the problem/situation as a booster to create a competitive competition and a promoter of critical thinking amongst the students so that they can come out with the best products.**

5. ***Write down the Task Descriptions for the STEAM Activity***

   - **Plan and write a short write-up for your video-clip.**
   - **Use the notes to Make a 2-minute video clip to advertise and market your school to the public.**
   - **The short video clip must embrace the school rules, motto, and mission and vision statements.**
   - **It must also contain messages of new and competent management.**
   - **This video clip has to have the potential to positively change the image of the school**
   - **This 2-miunte video clip must be captivating and totally convincing to attract students to want to enroll at your school.**
   - **This clip must not be more than 2 minutes (maximum time limit)**
   - **Present your video clip to be assessed**
   - **Submit both your write-up (on a chart) together with your video clip**

6. ***Developing Rubrics to Assess the Steam Video Clips***

   1) **Decide on type of rubric to be used (Holistic or Analytic)**

2) Decide what point scale rubric to use (always use 3, 4 or 5 point-scale) and rating scales to use (descriptive words or numerals)
3) Plan the layout to develop the rubric
4) Decide what to assess from the Category of Tasks Description
5) Identify and List down the Category of Tasks Description for the Criteria
6) Reword the Tasks Descriptions to create Criteria

    - Plan and write a short write-up for your video-clip. (***The write up of the video***)
    - Use the notes to make a 2-minute video clip to advertise and market your school to the public. (***The development of the video***)
    - The short video clip must embrace the school rules, motto, and mission and vision statements. (***The content of the video***)
    - It must also contain messages of new and competent management. (***The content of the video***)
    - This clip must not be more than 2 minutes (maximum time limit) (***The presentation of the video***)
    - Submit both your write-up (on a chart) together with your video clip. (***The product***)

7) List the criteria against the Task Descriptions in a table
8) Unpack the Task Descriptions and identify the essential KSAV that can be assessed
9) Reword the Task Descriptions with the inclusion of KSAVs into a Descriptor statement for each criteria and distribute into each Competency Level/Level of Achievement
10) Determine appropriate variance of Qualifiers for each Descriptors of each Achievement Level
11) Determine the appropriate Descriptive Words or Number for Point Scales of the intended rubric.
12) Completed rubric sample: Video clip Assessment Rubric
13) Consider the Applications of the Steam Rubric

This is a sample for Business Studies and can be used to develop Technology and Industrial Arts Subject STEAM Assessment.

Sample 4

Strand 2: Business Management

Unit 5: Information Technology

Content Standard 2.5: Students will be able to explain the information technology concepts and examine the systems and tools needed to gather, access, analyse, synthesize, evaluate, manage, and disseminate information.

Benchmark: 9.2.5.1. Analyse the impact of information technology on society.

Topic: Impact of information technology on society.

Learning Objective: By the end of this Topic, students will be able to demonstrate a positive impact of information technology on society

Purpose of Assessing the Topic (Benchmark):
To assess whether students can be able to use mobile technology to positively impact their society and analyse this impacts

How the Performance Task will be done: Group Project Presentation

Performance Standard: By the end of the project, students will be able to use mobile technology to positively impact their community/society.

Situation (Authentic)

A school has been faced with the challenge of behavioral issues for some time now and the public has lost its confidence in the school to be a good or genuine school. Most parents fear sending their children to his school and always opt to transfer their children in very first instances. The Board of Governors of the school has decided to raise the Behavior Standards or Benchmarks to a certain degree to improve its image and standards of learning.

To meet the expectations of the BOG, the principal and teachers intend to market the school to the public of NCD to lure students to have the interest to enroll at the school. With such a PAST bad reputation, the school will really need to convince the public that they have raised their standards and that their school is worth enrolling in it. The Principal and the teachers now have a task on hand to convince the public to enroll their children there and they have to try every means to do so.

To achieve this, the school is now requesting the Business and Technology Department to design an assessment Task for a certain Grade to assist with the situation. The Business & Technology Department has opted to design the task for Grade 9 students as one of their projects towards their

assessments. The school principal also announces that the best video assessed by the B&T Department will be rewarded as it is also a competition.

Task Descriptions:

- Plan and write a short write-up for your video-clip.
- Use the notes to make a 2-minute video clip to advertise and market your school to the public.
- The short video clip must embrace the school rules, motto, and mission and vision statements.
- It must also contain messages of new and competent management.
- This video clip has to have the potential to positively change the image of the school
- This 2-miunte video clip must be captivating and totally convincing to attract students to want to enrol at your school.
- This clip must not be more than 2 minutes (maximum time limit)
- Submit both your write-up (on a chart) together with your video clip
- Teacher will present your video clips for the whole class to observe and use the rubric below to assess the video clip.

Materials: Smartphone, butcher papers, markers

1. Developing Rubrics to Assess Video Clips

    i. Decide on type of rubrics to be used (Holistic or Analytic)
    ii. After you decide, plan the rubrics
    iii. Planning to develop the rubric
    iv. Categorise the Tasks Description into Criteria's

Sample of Categorising tasks for the rubric

- Plan and write a short write-up for your video-clip. (The write up of the video)
- Use the notes to Make a 2-minute video clip to advertise and market your school to the public. (The development of the video)
- The short video clip must embrace the school rules, motto, and mission and vision statements. (The content of the video)
- It must also contain messages of new and competent management. (The content of the video)
- This video clip has to have the potential to positively change the image of the school (The content of the video)
- This 2-miunte video clip must be captivating and totally convincing to attract students to want to enrol at your school. (The content of the video)
- This clip must not be more than 2 minutes (maximum time limit) (The presentation of the video)
- Present your video clip to be assessed (The presentation of the video)
- Submit both your write-up (on a chart) together with your video clip. (The product)

2. **Identify and list down categories of tasks**

Category	Task Description
The write up of the video	Plan and write a short write-up for your video-clip.
The development of the video	Use the notes to Make a 2-minute video clip to advertise and market your school to the public.
The content of the video	• The short video clip must embrace the school rules, motto, and mission and vision statements. • It must also contain messages of new and competent management. • This video clip has to have the potential to positively change the image of the school • This 2-minute video clip must be captivating and totally convincing to attract students to want to enrol at your school.
The Presentation of the video	• This clip must not be more than 2 minutes (maximum time limit) • Present your video clip to be assessed
The product	Submit both your write-up (on a chart) together with your video clip.

3. **Unpack the Task Descriptions and Identify the essential KSAV that can be assessed**

Category	Task Description	Essential KSAVs
The write up of the video script	Plan and write a short write-up for your video-clip.	Skill : Procedural Writing
The development of the video	Use the notes to Make a 2-minute video clip to advertise and market your school to the public.	Values and attitudes: - Teamwork and cooperation - Creativity Knowledge: Know about the school
The content of the video	• The short video clip must embrace the school rules, motto, and mission and vision statements. • It must also contain messages of new and competent management. • This video clip has to have the potential to positively change the	Knowledge: Adequate content about the school Skill: convincing and persuasive Values and attitude:

	image of the school • This 2-minute video clip must be captivating and totally convincing to attract students to want to enrol at your school.	Encouraging and luring
The Presentation of the video	• This clip must not be more than 2 minutes (maximum time limit) • Present your video clip to be assessed	Skill: - Time management - delivery skills (posture, language) and - communication skills - social skills (relativity and connectivity) Values and attitude: confidence
The product	Submit both your write-up (on a chart) together with your video clip.	EKSAVs in the Write up and Presentation :

4. **Reword the Task Descriptions with the inclusion of KSAVs into a Descriptor statement for each criteria and distribute into each Competency Level/Level of Achievement**

5. **Determine the appropriate Descriptive Words or Number for Point Scales of the intended rubric.**

Criteria:	Advanced	Progressing	Novice	Mark
The write up of the video script	**Skill:** Procedural Writing Organised paper of video script writing procedures	Organised paper of video script writing procedures	Organised paper of video script writing procedures	/3
The development of the video	Values and attitudes: - Teamwork and cooperation - Creativity **Knowledge:** Know about the school The video corresponds to the 2-minutes script and illustrates teamwork	The video corresponds to the 2-minutes script and illustrates teamwork	The video corresponds to the 2-minutes script and illustrates teamwork	/3
Content of the video	**Knowledge:** Adequate content	The short video clip embraces the core	The short video clip embraces the	/3

	about the school Skill: convincing and persuasive Values and attitude: Encouraging and luring The short video clip embraces the core ideas of school rules, motto, and mission and vision statements.	ideas of school rules, motto, and mission and vision statements.	core ideas of school rules, motto, and mission and vision statements.	
Presentation of the video	Skill: - Time management - delivery skills (posture, language) and - communication skills - social skills (relativity and connectivity) Values and attitude: confidence The video clip captures essence of vital messages of the new and competent management with potentials to positively change the image of the school and captivating and convincing to attract students to want to enroll at the school.	The video clip captures essence of vital messages of the new and competent management with potentials to positively change the image of the school and captivating and convincing to attract students to want to enrol at the school.	The video clip captures essence of vital messages of the new and competent management with potentials to positively change the image of the school and captivating and convincing to attract students to want to enrol at the school.	/3
The product	EKSAVs in the Write up and Presentation: Video clip	Video clip submitted at the assessment deadline for presentations	Video clip submitted at the assessment deadline for presentations	/3

	submitted at the assessment deadline for presentations			

6. Completed rubric sample: Video clip Assessment Rubric

Criteria	Achieved	Progressing	Novice	Marks
Video Script Write up	Innovative and well organised paper with clarity of video script writing procedures	Well organised paper with clarity of video script writing procedures	Organised paper with some clarity of video script writing procedures	/3
Video Development	Appropriately considered details for the video are well corresponded to the 2-minutes script and illustrates a well-coordinated teamwork	Considered details for the video are mostly corresponded to the 2-minutes script and illustrates a coordinated teamwork	Some details considered for the video are partially corresponded to the 2-minutes script and illustrates a less coordinated teamwork	/3
Video Clip Content	▪ The short video clip fully embraces the core ideas of school rules, motto, and mission and vision statements.	▪ The short video clip mostly embraces the core ideas of school rules, motto, and mission and vision statements.	▪ The short video clip somewhat embraces the core ideas of school rules, motto, and mission and vision statements.	/3
Video Presentation	▪ The video clip fully captures essence of vital messages of the new and competent management with necessary potentials to positively change the image of the school and really captivating and totally convincing to attract students to want to enrol at the school.	▪ The video clip mostly captures the essence of vital messages of the new and competent management with most potentials to positively change the image of the school and mostly captivating and partially convincing to attract students to want to enrol at the school.	▪ The video clip somewhat captures the essence of vital messages of the new and competent management with some potentials to positively change the image of the school and almost captivating and less convincing to attract students to want to enrol at the school.	/3
Video Clip Submission Time	- Video clip submitted well before the assessment deadline for presentations	▪ Video clip submitted just before the assessment deadline for presentations	▪ Video clip submitted within the assessment time for presentations	/3

1. How to Score using the rubric

Scoring Rubrics

Criteria	Achieved 3	Progressing 2	Novice 1	Scoring
Video Script Write up -	Innovative and well organised paper with clarity of video script writing procedures	Well organised paper with clarity of video script writing procedures	Organised paper with some clarity of video script writing procedures	2/3
Video Development	Appropriately considered details for the video are well corresponded to the 2-minutes script and illustrates a well-coordinated teamwork	Considered details for the video are mostly corresponded to the 2-minutes script and illustrates a coordinated teamwork	Some details considered for the video are partially corresponded to the 2-minutes script and illustrates a less coordinated teamwork	1/3
Video Clip Content	▪ The short video clip fully embraces the core ideas of school rules, motto, and mission and vision statements.	▪ The short video clip mostly embraces the core ideas of school rules, motto, and mission and vision statements.	▪ The short video clip somewhat embraces the core ideas of school rules, motto, and mission and vision statements.	3/3
Video Presentation	▪ The video clip fully captures essence of vital messages of the new and competent management with necessary potentials to positively change the image of the school and really captivating and totally convincing to attract students to want to enrol at the school.	▪ The video clip mostly captures the essence of vital messages of the new and competent management with most potentials to positively change the image of the school and mostly captivating and partially convincing to attract students to want to enrol at the school.	▪ The video clip somewhat captures the essence of vital messages of the new and competent management with some potentials to positively change the image of the school and almost captivating and less convincing to attract students to want to enrol ▪ at the school.	3/3
Video Clip Submission Time	- Video clip submitted well before the assessment deadline for presentations	▪ Video clip submitted just before the assessment deadline for presentations	▪ Video clip submitted within the assessment time for presentations	2/3
11/15				

2. How to Grade using the rubric

Grading Rubrics

Score Range	Grade	Qualifier (Proficiency)	Descriptor	Percentage
13 – 15	A	Advanced	Description reflecting highest level of performance.	76 – 100%
9 - 12	B	Achieved	Description reflecting mastery level of performance.	46 – 75%
5 – 8	C	Progressing	Description reflecting movement towards mastery level of performance.	26 – 45%
0 - 4	D	Novice	Description reflecting beginning level of performance.	0 - 25%

3. How to Report using the rubric

A. Reporting an individual student's performance on the task

Assessment Task Report							
Assessment Task:			Video Development Project				
Name:		Grade:		Class:		Score and Grade:	/15
Criteria	**Achieved A**		**Progressing B**		**Novice C**		
Video Script Write up	**Innovative and well organised paper with clarity of video script writing procedures**		Well organised paper with clarity of video script writing procedures		**Organised paper with some clarity of video script writing procedures**		
Video Development	**Appropriately considered details for the video are well corresponded to the 2-minutes script and illustrates a well-coordinated teamwork**		**Considered details for the video are mostly corresponded to the 2-minutes script and illustrates a coordinated teamwork**		Some details considered for the video are partially corresponded to the 2-minutes script and illustrates a less coordinated teamwork		
Video Clip Content	• The short video clip fully embraces the core ideas of school rules, motto, and mission and vision statements.		**• The short video clip mostly embraces the core ideas of school rules, motto, and mission and vision statements.**		**• The short video clip somewhat embraces the core ideas of school rules, motto, and mission and vision statements.**		

Video Presentation	• The video clip fully captures essence of vital messages of the new and competent management with necessary potentials to positively change the image of the school and really captivating and totally convincing to attract students to want to enrol at the school.	• The video clip mostly captures the essence of vital messages of the new and competent management with most potentials to positively change the image of the school and mostly captivating and partially convincing to attract students to want to enrol at the school.	• The video clip somewhat captures the essence of vital messages of the new and competent management with some potentials to positively change the image of the school and almost captivating and less convincing to attract students to want to enrol at the school.
Video Clip Submission Time	– Video clip submitted well before the assessment deadline for presentations	• Video clip submitted just before the assessment deadline for presentations	• Video clip submitted within the assessment time for presentations

Note: The shaded is the student's proficiency score for each task.

Related links to this Business Studies Benchmark in Business Studies with other subject areas:

Subjects	Reference Benchmark Codes
1. Arts (Theatre Arts)	9.2.2.2
2. Christian Civic Value Education (CCVE)	9.3.1.3
3. Character Social Development (CSD)	9.1.5.1, 9.1.5.2, 9.1.5.3, 9.1.5.4, 9.1.5.5
4. English	9.2.2.1
5. Social Science (History)	9.2.2.3, 9.2.2.4
6. Social Science (Political Science)	9.3.3.1, 9.3.3.2
7. Technology Industrial Arts (TIA)	9.4.1.4, 9.4.1.5, 9.4.1.6

The anchor subject in this sample STEAM assessment is Technology and Industrial Arts.

Sample Scenario to score Summative Assessment

Moderation in Technology and Industrial Arts

What is moderation as assessment?

Moderation is the process of teachers sharing, working through and agreeing to expected standards of student achievement and progress. It supports teachers to compare their own judgments to either confirm or adjust them. The process involves teacher collaboration to establish a shared understanding of what achievement of standards looks like and whether or not the student has demonstrated achievement of the standard through the evidences of performance tasks. Teachers work towards making judgments of assessments of standards that are consistent and comparable.

Moderation Purposes

"Moderation is concerned with the consistency, comparability and fairness of professional judgments about the levels demonstrated by students." *(Maxwell, 2002)*.
Comparable judgments result from teachers understanding of the curriculum, and agreeing on benchmark assessed. The essence is that, there is common understanding of how to assess progress and achievement within and across schools.
Moderation helps teachers to make dependable, evidence-based decisions and leads to consistency.
There is a need for consistency of teacher judgments:

- over time – same evidence viewed at different times or different contexts leading to same judgment by same teacher
- against standards – equivalent application across different types of evidence
- by a teacher - between his/her students
- between teachers – within the same school and different schools
- between teaching years and levels.

Making consistent, reliable and valid decisions across different points in time is important when schools report on student progress, make decisions on school targets and resourcing, or compare different grades data with past information.

All schools experience variables that challenge the consistency of practice such as staff changes, changes in student numbers or changing education demands. Consistent moderation over time can prevent this in a number of ways.

- Always applying the same standardised criteria ensures consistency over time.
- Where nationally standards criteria or exemplars are available, these become the same external reference used each year or each time.

- Moderators will change over time but the same criteria and associated references will remain and continue to guide decisions.

The benefits of moderation

The benefits of involving students in moderation
- When students are actively involved they can participate in selecting evidence (e.g. samples of their work) that best demonstrate the intended learning outcomes.
- The process of assessment develops students' understanding of the desired outcomes and success criteria or expected rubrics developed.
- Making judgments is closely linked to developing the skills of self and peer-assessment.
- This can lead to shared expectations of learning and understandings of standards between teachers and students.
- Greater student confidence in teacher judgments.
- Provides greater transparency of the assessment process.

The benefits of moderation for teachers
- Brings together collective wisdom, resulting in greater consistency of judgment, and focused teaching.
- Provides greater confidence in teacher judgments and assurance that judgments are consistent with other professionals.
- Leads to shared expectations of learning and understandings of levels and progression of learning.
- Develops deeper understandings about content and progressions of learning.
- Improves quality of assessment.
- Alignment of expectations and judgments with curriculum expectations or progressions, and hence improved teaching and learning.
- Assurance to parents and others that interpretations of students' progress and achievement are in line with other professionals.

Process of Moderation
Purpose, learning area and context of the moderation:
It could be moderation of a proficiency based project or design portfolios or the understanding of how to take a running record or of judgments of student achievement and progress for reporting.

Who is involved?
Who needs to be involved? Who will be the coordinator?
It is preferable that the leader/coordinator has the authority to make decisions?
The timing, duration and frequency of moderation meetings:
Will they be extra meetings, or part of staff or team meetings, or non-contact days?
What is the attainment requirement for the moderation? School based certification?

The evidence of student learning that will be moderated:
- For a piece of writing, student writing samples will be used.

- For moderating a design portfolio, the task, text and questions the student responded to may be used, along with notes of student questions, samples of work done and annotated tasks in line with the assessment task and criteria .
- For supervision of an assessment tool: this could be a student's running record and the teacher
- For judgments of student achievement and progress for reporting to parents, a range will be required, covering both formal and informal collection of evidence.
- Developed rubrics written against national exemplar may be used as assessment tools of moderation which can be maintained and improved every year

When to use moderation in TIA

A. Moderation assessment for TIA will be project based and or evidence based assessment. This can be carried out in a year from grades 9-12. This could mean one project in one of the strands or an incorporation of all the strands of the subject TIA in grade 12 where each school makes the decision to undertake moderation as assessment. This could be the final moderation project that will incorporate all the strands in TIA. For grades 9,10, and 11, the moderated projects can be strand based.

Sample Grade 11 Moderation

Grade 11 Moderation Assessment
Construction Technology

This construction technology moderation project is Building a House

Content Standards

Subject	Benchmark
Engineering Technology [Anchor Benchmark]	11.3.5.3 Develop Written, oral and Presentation skills and apply these to engineering reports with application of graphics as a communication tool. 11.3.5.4 Apply appropriate computer aided designing program to create detail designs
Building Technology	11.3.1.2 Investigate and analyse appropriate materials and their specifications in building 11.3.1.3 Apply Drawing skills in surface development and intersection of solids related to project designs and specifications using AutoCAD program 11.3.1.4 Describe and apply appropriate Health and safety practices pertaining to wood and non-wood products 11.3.1.5 Explore and describe the fundamental building procedures 11.3.1.6 Estimate and apply building materials using AUTO-CAD - computer aided drafting of the building
Electrical Technology	11.3.2.1 Discover and interpret licensing and standard wiring requirements for an electrician in electrical technology. 11.3.2.2 Assess and apply standard safety, health and environmental practices.

	11.3.2.4 Distinguish between single phase and three phase system 11.3.2.5 Compare and analyse electronic and electrical drawings and illustrations and the skills according to engineering standards manually and using technology 11.3.2.6 Explore and analyse materials, tools, components and accessories used in the electrical installation process.
Plumbing Technology	11.3.3.1 Explore and analyse fundamental concept on water distribution system, drain, waste, vent system in Plumbing 11.3.3.3 Explore and categorise corrugated stainless steel tubing, Fixtures and faucets 11.3.3.4 Read and analyse blue prints and sketches of pipe system using CAD program
Welding Technology	11.3.4.6. Analyse and select suitable materials for machining or welding processes identifying forms of welding with precision measurement for quality output.

This project requires students to research and develop a design for a House and produce a range of presentation drawings with the option to also construct a 3D model of their design.
This project allows for creative design solutions as well as developing skills in technical presentation drawing, scientific enquiry and mathematical application. This project is an example of an integration of engineering, building, electrical, plumbing and welding technology,

Authentic situation
Papua New Guinea is prone to natural disasters and when disasters happen a lot of people are displaced from their homes and often left homeless. A new set of buildings have to be designed to give the displaced people a sense of security with a roof over their heads. The environment must be considered to choose materials that are environmentally friendly and suitable. The homes should be designed to be functional. The house should be space and cost efficient.

Assessment Task
Design a house that will accommodate displaced families. Use the design process to solve the design problem that will be cost, and space effective and within projected budget.
- Design Situation: Architects design both permanent and temporary dwellings and structures.
- Design Brief: Disasters can cause displacement of the local population, and the provision of permanent or temporary housing can be difficult. Students are to:
  - research and design their own low-cost, resource-efficient temporary dwelling, a House to be used in situations of population displacement
  - research the most efficient use of local materials and environmental conditions to create low-cost, energy-efficient sustainable housing, using the House model
  - design a low cost , energy efficient, functional and space efficient house with electrical wirings, plumbing fittings and welded materials.
  - submit a range of presentation drawings using both traditional and CAD methods, a documentation folio and, optionally, a 3D model of their design.

Marking
The moderation assessment will be to assess the portfolio, the process and the product. This assessment is both formative and summative. There must be close tracking of the project for the formative and summative assessment to be effectively carried out.

Criteria for assessing learning

Students will be assessed on their ability to;

- **design and build a prototype of a house with consideration to designing, technical drawing sketches, selecting materials and equipment and building the house**
- **the building of the house with electrical wiring, plumbing piping and welding the equipment.**

1. The DESIGN PORTFOLIO

As this is an ongoing or running file of student work the assessment criteria is developed formatively. This portfolio will show all evidence of work done in the designing, planning, making and evaluating the project of building a house.

The criteria are drawn from the description of the assessment activity.

Performance Standard/Criteria	Advanced 4	Meet Standard 3	Progressing 2	Not Yet 1
Create a folio with organisers, sketches, research notes and graphical presentations of data collected.	Shows sufficient samples of sketches, research notes and graphical presentations of data collected.	Shows samples of sketches, research notes and graphical presentations of data collected.	Shows minimal samples of sketches, research notes and graphical presentations of data collected.	Shows lack of samples of sketches, research notes and graphical presentations of data collected.
Technical drawings and or CAD	Produces evidence of high competency in Technical Drawing and using AutoCAD in sketching Domestic Buildings	Produces evidence of competency in Technical Drawing and using AutoCAD in sketching Domestic Buildings	Produces evidence of fair competency in Technical Drawing and using AutoCAD in sketching Domestic Buildings	Produces little/no evidence of competency in Technical Drawing and using AutoCAD in sketching Domestic Buildings
Anecdotal notes on building a cost effective, space effective and functional house	Shows sufficient evidence of written plans for building a cost effective, space effective and functional house.	Shows evidence of written plans for building a cost effective, space effective and functional house.	Shows minimal evidence of written plans for building a cost effective, space effective and functional house.	Shows lack of evidence of written plans for building a cost effective, space effective and functional house.
Data and Information	Shows sufficient samples of research, data and information on Engineering Principles and Processes and Design Solutions.	Shows samples of research, data and information on Engineering Principles and Processes and Design Solutions.	Shows minimal samples of research, data and information on Engineering Principles and Processes and Design Solutions.	Shows lack of samples of research, data and information on Engineering Principles and Processes and Design Solutions.
Demonstrated	Shows excellent	Shows fair	Shows minimal	Lacks

application of Mathematics and Science concepts.	demonstration of mathematics and science skills application in calculations, measurement and design drawings.	demonstration of mathematics and science skills application in calculations, measurement and design drawings.	demonstration of mathematics and science skills application in calculations, measurement and design drawings.	demonstration of mathematics and science skills application in calculations, measurement and design drawings.
Presentation of engineering designs and blueprints	Produces evidence of high competency in the development and presentation of engineering designs and blueprints.	Produces evidence of competency in the development and presentation of engineering designs and blueprints.	Produces evidence of fair competency in the development and presentation of engineering designs and blueprints.	Produces little/no evidence of competency in the development and presentation of engineering designs and blueprints.

2. Building Project Construction.

The development and construction of the project will be assessed using the following;

a. Design Solution/Product
b. Planning
c. Technical Drawing
d. Materials
e. Communication of designs
f. Building a model

a. Design Solution of the House

Performance Criteria	Advanced 4	Proficient 3	Progressing 2	Novice 1
Generate ideas for solutions	The design solutions show excellent relevance to the purpose of the project.	The design solutions show clear relevance to the purpose of the project	The design solutions show minimal relevance to the purpose of the project	The design solutions are not relevant to the purpose of the project.
Research and design.	Shows sufficient evidence of research and designs of their own low-cost, resource-efficient temporary dwelling.	Shows evidence of research and designs of their own low-cost, resource-efficient temporary dwelling.	Shows minimal evidence of research and designs of their own low-cost, resource-efficient temporary dwelling.	Lacks evidence of research and designs of their own low-cost, resource-efficient temporary dwelling.
Appropriate use of the elements of	Excellent presentation as either graphic or	Presentation as either graphic or free and provides	Poor presentation as either graphic or free and	No presentation as either graphic or free and

design in building construction	free and provides specific information about the design features.	specific information about the design features.	provides specific information about the design features.	provides specific information about the design features.
Presentation of and communication of design of the House Project	Excellent presentation of the development of ideas and concepts in a logical and sequential way.	Presentation of the development of ideas and concepts done in a logical and sequential way.	Mediocre presentation of the development of ideas and concepts done in a logical and sequential way.	Poor presentation of the development of ideas and concepts done in a logical and sequential way.

b. Planning

Performance Criteria	Advanced 4	Proficient 3	Progressing 2	Novice 1
Articulate series of goals of the project	Project goals identified and well articulated	Project goals have been articulated.	Project has minimal goals articulated.	Project activities occur with little thought or articulation of goals.
Articulate series of steps/processes & strategies to achieve goals	Team members have a clear understanding of all stakeholder roles and responsibilities, risks of the project, and sequence of activities needed to effectively complete the project.	Stakeholders are identified and roles and responsibilities defined; some breakdown of the required tasks completed; some team members aware of the sequence of steps needed to effectively complete the project.	Some stakeholders are identified and roles and responsibilities defined; minimal breakdown of the required tasks completed; few team members aware of the sequence of steps needed to effectively complete the project.	Little to no initiating or planning of project activities; team members show little to no awareness of roles, required activities, or sequence of steps needed to effectively complete the project.
Determine, procure, optimize all needed resources (human, material, and financial)	Resources properly identified for each area of the project; effective management of training and scheduling of human resources; budgeting and procurement of	Some of the resources needed to effectively complete the project have been identified; some estimation of cost, availability, training needs of resources	Few of the resources needed to effectively complete the project have been identified; some estimation of cost, availability, training needs of resources	Little to no initiation or planning of project activities; team members show little to no awareness of roles, required activities, or sequence of steps needed to effectively

	other resources are properly tracked and reported.	identified and optimized; some tracking of resources	identified and optimized; some tracking of resources	complete the project
Create and maintain budget	Costs of the project have been identified and a budget set; contingency funds set aside to cover potential overruns; project spending tracked; team members aware of budget and practice fiscal responsibility	Some costs of the project identified and availability of funds verified. Some costs being tracked; awareness of overall cost of the project is known.	Few costs of the project identified and availability of funds verified. Some costs being tracked; awareness of overall cost of the project may not be known.	Little to no planning of the overall costs of effectively completing the project; little to no tracking or costs; cost overruns may occur due to poor planning
Calculate time on task	Tasks and time necessary to complete project identified and estimated based on skill and availability of assigned resources	Majority of tasks and time necessary to complete project identified and estimated based on skill and availability of assigned resources.	Some tasks and time known and estimated, or only high-level planning estimates completed without consideration for skill and availability of assigned resources	Little to no estimation of time needed to complete tasks or tasks not fully identified.

c. Technical Drawing

Performance Criteria	Advanced 4	Proficient 3	Progressing 2	Novice 1
2D-3D drawings of the project	Produces evidence of high competency using AutoCAD in 2-3D drawings.	Produces evidence of competency using AutoCAD in 2-3D drawings.	Produces evidence of fair competency using AutoCAD in 2-3D drawings.	Produces little/no evidence of competency in using AutoCAD in 2-3D drawings.
Site Plans for the House	Plans are flawlessly drawn.	Plans demonstrate they have been drawn with precision and care.	Plans are satisfactory drawn	Plans are carelessly drawn.
Floor Plans of the House	Demonstrates thorough, conscious understanding of concepts involved in developing	Demonstrates well developed understanding of concepts involved in developing floor plans	Demonstrates some understanding of concepts involved in developing floor plans	Demonstrates little understanding of concepts involved in developing floor plans

	floor plans.			
Structural Plans of the House	Demonstrates thorough, conscious understanding of concepts involved in developing structural plans.	Demonstrates well developed understanding of concepts involved in developing structural plans.	Demonstrates some understanding of concepts involved in developing structural plans.	Demonstrates little understanding of concepts involved in developing structural plans.
Terrace Plans for the House	Plans are exceptionally neat and tidy.	Plans are sufficiently neat and tidy.	Plans exhibit some neatness and tidiness.	Plans exhibit little neatness and tidiness.
Cross section plans of the House	Demonstrates thorough, conscious understanding of concepts involved in developing cross section plans.	Demonstrates well developed understanding of concepts involved in developing cross section plans	Demonstrates some understanding of concepts involved in developing cross section plans	Demonstrates little understanding of concepts involved in developing cross section plans
Elevation	Plans are flawlessly drawn	Plans demonstrate they have been drawn with precision and care	Plans are satisfactory drawn	Plans are carelessly drawn

d. Materials

Performance Criteria	Advanced 4	Proficient 3	Progressing 2	Novice 1
Selection of the appropriate Timber Materials for construction.	Excellent selection of appropriate timber materials and its uses with estimated cost for the completion of the project.	Good selection of appropriate timber materials and its uses with estimated cost for the completion of the project.	Poor selection of appropriate timber materials and its uses with estimated cost for the completion of the project.	Very poor selection of appropriate timber materials and its uses with estimated cost for the completion of the project.
Selection of the appropriate Masonry Materials for construction.	Excellent selection of appropriate masonry materials and its uses with estimated cost for the completion of the project.	Good selection of appropriate masonry materials and its uses with estimated cost for the completion of the project.	Poor selection of appropriate masonry materials and its uses with estimated cost for the completion of the project.	Very poor selection of appropriate masonry materials and its uses with estimated cost for the completion of the project.
Selection of the appropriate Concrete Materials for construction.	Excellent selection of appropriate concrete materials and its uses with	Good selection of appropriate concrete materials and its uses with estimated cost for	Poor selection of appropriate concrete materials and its uses with estimated cost for	Very poor selection of appropriate concrete materials and its uses with

	estimated cost for the completion of the project.	the completion of the project.	the completion of the project.	estimated cost for the completion of the project.
Selection of the appropriate Steel Materials for construction.	Excellent selection of appropriate steel materials and its uses with estimated cost for the completion of the project.	Good selection of appropriate steel materials and its uses with estimated cost for the completion of the project.	Poor selection of appropriate steel materials and its uses with estimated cost for the completion of the project.	Very poor selection of appropriate steel materials and its uses with estimated cost for the completion of the project.
Selection of the appropriate PVC (polyvinyl chloride) Materials for construction.	Excellent selection of appropriate PVC materials and its uses with estimated cost for the completion of the project.	Good selection of appropriate PVC materials and its uses with estimated cost for the completion of the project.	Poor selection of appropriate PVC materials and its uses with estimated cost for the completion of the project.	Very poor selection of appropriate PVC materials and its uses with estimated cost for the completion of the project.

e. Communication of designs

Performance Criteria	Advanced 4	Proficient 3	Progressing 2	Novice 1
Presentation of and communication of design of the House Project	Excellent presentation of the development of ideas and concepts in a logical and sequential way.	Presentation of the development of ideas and concepts done in a logical and sequential way.	Mediocre presentation of the development of ideas and concepts done in a logical and sequential way.	Poor presentation of the development of ideas and concepts done in a logical and sequential way.

f. Building a Model/Prototype

Performance Criteria	Advanced 4	Proficient 3	Progressing 2	Novice 1
Completed Model of the House	House plans and model demonstrates high level of creativity and a high level of involvement in project	House plans and model demonstrates proficient level of creativity and a degree of time and effort in project	House plan and model demonstrates little creativity and little time and effort put toward project	House plan and model demonstrates no creativity and little time and effort put toward project

3. Design Process

Design Process Rubrics
Each of the stage of the design process is assessed at the duration of the project.

Identify the Problem

Performance Standard/Criteria	Advanced 4	Meet Standard 3	Progressing 2	Not Yet 1
Analyse the context and analyse issue and the problem	Analyse the context and analyse issue and the problem with logical results, justifications and examples.	Analyse the context and analyse issue and the problem with clear results and justifications	Analyse the context and analyse issue and the problem with no clear results	Do not analyse the context and analyse issue and the problem
Considerations of ideas of designs to address the issue.	More considerations of ideas and designs with examples	A lot of considerations of ideas and designs	Few considerations of ideas and designs.	No considerations of ideas and designs
Propose design solutions	Propose design solutions with clear and realistic expectations of results	Propose design solutions with clear expectations of results	Propose design solutions with no clear results	Do not propose design solutions
Selection of the appropriate design solution	Excellent selection of the appropriate design solution	Very good Selection of the appropriate design solution	Poor selection of the appropriate design solution	Do not select of the appropriate design solution

Do Research

Performance Standard/Criteria	Advanced 4	Meet Standard 3	Progressing 2	Not Yet 1
Design research	Excellent design	Very good	Poor design of	Do not design

questions	of research questions	design of research questions	research questions	research questions
Conduct research	Excellent Conduct of research	Very good Conduct of research	Few research done	Do not conduct research
Evidence of research findings	Excellent Evidence of research findings	Very good Evidence of research findings	Poor evidence of research findings	No evidence of research findings
Evidence of constraints and limits identified	Excellent evidence of constraints and limits identified	Very good evidence of constraints and limits identified	Poor evidence of constraints and limits identified	No evidence of constraints and limits identified
Evidence of critical considerations of how the solution is the most appropriate	Excellent evidence of critical considerations of how the solution is the most appropriate	Very good evidence of critical considerations of how the solution is the most appropriate	Poor evidence of critical considerations of how the solution is the most appropriate	No evidence of critical considerations of how the solution is the most appropriate

Develop Possible Solutions

Performance Standard/Criteria	Advanced 4	Meet Standard 3	Progressing 2	Not Yet 1
Brainstorm possible design solutions to address the problem identified	Excellent and logical brainstorm of possible design solutions to address the problem identified	Logical brainstorm of possible design solutions to address the problem identified	Some brainstorm done for possible design solutions to address the problem identified	No brainstorm of possible design solutions to address the problem identified
Evidence of variations of design solution being proposed	A good collection of evidence of variations of design solution	Clear and sufficient evidence of variations of design solution	Some evidence of variations of design solution being proposed	No evidence of variations of design solution being proposed

	being proposed	being proposed		
Identify the pros and cons of a possible design solution	Clearly identify the pros and cons of a possible design solution with checklist done,	Clearly identify the pros and cons of a possible design solution	Does identify the pros and cons of a possible design solution	Do not identify the pros and cons of a possible design solution

Choose One Solution

Performance Standard/Criteria	Advanced 4	Meet Standard 3	Progressing 2	Not Yet 1
Presentation of proposed design solutions in detail	Excellent presentation of proposed design solutions in detail	Very good presentation of proposed design solutions in detail	Poor presentation of proposed design solutions in less detail	No presentation of proposed design solutions in detail
Study of details of proposed design	Meticulous in-depth study of the details of the proposed design	Good and in-depth study of details of the proposed design	Minimal study of the details of proposed design	No study of the details of the proposed design
Considerations of constraints, cost and time in making the design solution	Clear and justified considerations of constraints, cost and time in making the design solution	Clear considerations of constraints, cost and time in making the design solution	Minimal considerations of constraints, cost and time in making the design solution	No considerations of constraints, cost and time in making the design solution
Selecting the appropriate design solution	Clear and justified selection of the appropriate design solution	Clear selection of the appropriate design solution	No clear selection of the appropriate design solution	No selection of the appropriate design solution

Design and Construct a Prototype

Performance Standard/Criteria	Advanced 4	Meet Standard 3	Progressing 2	Not Yet 1
Technical sketches of design product complete with measurements	All technical sketches of design product are complete with and guided explanations	All technical sketches of design product complete with measurements	Few technical sketches of design product with some measurements	No technical sketches of design product
Sketches are in 2D and 3D	All sketches are in 2D and 3D drawings and have very clear details	All sketches are in 2D and 3D drawings with clear details	Not all sketches are in 2D and 3D drawings	Sketches are not in 2D and 3D drawings
Materials are selected	Appropriate materials are selected well considering criteria for performance in making the prototype	Appropriate materials are selected well for good performance when making the prototype	Materials are selected for performance but not considering performance when making the prototype	Materials are not selected for performance in the making of the prototype
The processes in making the prototype	The processes in making the prototype are outlined and followed	The processes in making the prototype are followed	The processes in making the prototype are followed but with some stages missed.	The processes in making the prototype are not followed
Testing the prototype	Complete and successful testing of the prototype	Complete testing of the prototype	Incomplete testing of the prototype	No testing of the prototype done
Design of questions asked when the prototype is tested	Very Clear and well design of questions for testing the prototype	Clear and direct Design of questions for testing the prototype	Few questions designed for testing the prototype	No design of questions for testing the prototype
Keeping a record	Excellent record	Good and clear	Incomplete	No record kept

of the process of testing the prototype	kept of the process of testing the prototype	record kept of the process of testing the prototype	record kept of the process of testing the prototype	of the process of testing the prototype

Communicate Results

Performance Standard/Criteria	Advanced 4	Meet Standard 3	Progressing 2	Not Yet 1
Communicating the results of the prototype test using detailed diagrams	Very clear and detailed communication of the results of the prototype test using detailed diagrams	Clear communication of the results of the prototype test using detailed diagrams	No clear Communication of the results of the prototype test	No Communication the results of the prototype test
Use of mathematical evidence, sketches, graphs	Clear and detailed use of mathematical evidence, sketches, graphs including conclusions	Clear and detailed use of mathematical evidence, sketches, graphs	Minimal use of mathematical evidence, sketches, graphs	No use of mathematical evidence, sketches, graphs
Evidence of shared learning in analyzing the results of the test	Clear evidence of shared learning in analyzing the results of the test	Good evidence of shared learning in analyzing the results of the test	Minimal evidence of shared learning in analyzing the results of the test	No evidence of shared learning in analyzing the results of the test

Evaluate and Redesign

Performance Standard/Criteria	Advanced 4	Meet Standard 3	Progressing 2	Not Yet 1
Evaluate the results of the prototype test	Clear evaluation of the results of the prototype test with details shown	Clear evaluation of the results of the prototype test	No clear evaluation the results of the prototype test	No evaluation of the results of the prototype test
Considerations of what worked and what did not	Clear and confident considerations of what worked and what did not	Clear considerations of what worked and what did not	No clear considerations of what worked and what did not	No considerations of what worked and what did not
Evidence of decisions made after the prototype test, to re-modify or change the design solution	Clear and concrete evidence of decisions made after the prototype test, to re-modify or change the design solution	Very clear evidence of decisions made after the prototype test, to re-modify or change the design solution	No clear evidence of decisions made after the prototype test, to re-modify or change the design solution	No Evidence of decisions made after the prototype test, to re-modify or change the design solution

THE DESIGN SOLUTION (PRODUCT)

This assessment too can be used to evaluate the final product of the house if an actual house has been built on site.

Performance Criteria	Advanced	Proficient	Progressing	Novice
Engineering Design	Strictly followed the design process fulfilling all the stages.	Followed the design process fulfilling all the stages.	Followed the design process fulfilling some stages but yet incomplete	Not followed the design process and not fulfilling the stages.
Building Materials	Excellent selection of appropriate materials and its uses with estimated cost for the completion of the project.	Good selection of appropriate materials and its uses with estimated cost for the completion of the project.	Poor selection of appropriate materials and its uses with estimated cost for the completion of the project.	Very poor selection of appropriate materials and its uses with estimated cost for the completion of the project.
Construction	Team members	Team members	Team members	Team members

Steps	have a clear understanding of sequence of construction steps needed to effectively complete the project.	have a fair understanding of sequence of construction steps needed to effectively complete the project.	have minimal understanding of few sequence of construction steps needed to effectively complete the project.	have little or no clear understanding of the sequence of construction steps needed to effectively complete the project.
Electrical Installations	Excellent installation of appropriate low cost, energy efficient electrical wiring system that promotes conservation of energy.	Good installation of appropriate low cost, energy efficient electrical wiring system that promotes conservation of energy.	Poor installation of appropriate low cost, energy efficient electrical wiring system that promotes conservation of energy.	Very poor installation of appropriate low cost, energy efficient electrical wiring system that promotes conservation of energy.
Plumbing System	Excellent choice and installation of appropriate plumbing system that is low cost, efficient and environmentally friendly.	Good choice and installation of appropriate plumbing system that is low cost, efficient and environmentally friendly.	Poor installation of appropriate plumbing system that is low cost, efficient and environmentally friendly.	Very poor installation of appropriate plumbing system that is low cost, efficient and environmentally friendly.
Welded materials	Excellent selection of appropriate welded materials and welding for the completion of the project.	Good selection of appropriate welded materials fand welding for the completion of the project.	Poor selection of appropriate welded materials and welding for the completion of the project.	Very poor selection of appropriate materials and welding for the completion of the project.
Cost effective	Costs of the project have been identified and a budget set; contingency funds set aside to cover potential overruns; project spending tracked; team members aware of budget and practice fiscal responsibility	Some costs of the project identified and availability of funds verified. Some costs being tracked; awareness of overall cost of the project is known.	Few costs of the project identified and availability of funds verified. Some costs being tracked; awareness of overall cost of the project may not be known.	Little to no planning of the overall costs of effectively completing the project; little to no tracking or costs; cost overruns may occur due to poor planning
Space effective; ergonomics	The designed project takes an excellent effect of space and	The designed project takes good effect of space and	The designed project takes some effect of space and	The designed project takes no effect of space and furniture to

	furniture to suit the needs of the users.	furniture to suit the needs of the users.	furniture to suit the needs of the users.	suit the needs of the users and there is evidence of clutter.
Functionality of the house	Strictly followed the design process, planning and construction processes to build a fully functional and cost effective house.	Followed through the design process planning and construction processes to build a fully functional and cost effective house.	Followed the design process planning and construction processes to build a fully functional and cost effective house.	Not followed the design planning and construction processes to build a fully functional and cost effective house.

GRADING

The Grading of the Moderation Project will cover the three components.

Criteria	A 197-218	B 164-196	C 109-163	D 0-108
The Design Portfolio	An excellent and orderly compilation of all evidences of the project designing, making and evaluating.	An excellent compilation of all evidences of the project designing, making and evaluating.	A good compilation of evidences of the project designing, making and evaluating.	A poor compilation of evidences of the project designing, making and evaluating.
The House Construction Project	Completed construction of the house on time with controlled costs and time	Completed construction of the house on time	Completed construction of the house with no consideration for time and costs.	Poorly completed construction of the house.
The Design Process	Strictly followed the design process fulfilling all the stages.	Followed the design process fulfilling all the stages.	Followed the design process fulfilling some stages but yet incomplete	Not followed the design process and not fulfilling the stages.

CERTIFICATION

a. School based

b. Trade based/accreditation in line with VET competency and proficiency tests

Reporting, Monitoring and Evaluation

Recording, reporting, monitoring and evaluation are integral part of assessment for students from grades 9 to 12. Therefore, it is commended that recording, reporting, monitoring and evaluation of students achievements for Business and Technology Subjects must be done by grade levels in school based assessment or also referred to as internal school assessment.

The marks awarded to students in their internal assessment will be a combination of the internal assessment mark and the examination mark.

Internal assessment provides a measure of student's achievements based on a wider range of syllabus content and benchmarks than maybe covered by the external examination. Business and Technology subjects provide a summation of each student's achievement in Grades 9-12. The internal assessment mark must comply with the types of tasks and assessment rubrics specified in the holistic or analytic rubrics. The external examination provides a measure of student achievement of those aspects of the content standards that can be reliably measured in an examination setting.

Recording

Standards based recording and reporting is about student understanding and mastering a learning standard and less about grades. A standards based report card can list the most important skills students should learn in each subject at a particular grade level. Instead of letter grades, students receive marks or a code that show how well they have mastered the skills. The marks or codes that schools use to represent student progress are;

A- Advanced
B- Proficient
C- Progressing
D-Novice

The I standards are basically the learning standards and expectations for each grade level. SBC requires a new and effective way of recording and reporting to measure progress of student's performance such as in Project Based Learning. Reporting progress is based on the teaching and learning strategies for performance based learning which are accurately assessing the performance towards mastery. The teaching model is changing therefore the performance measurements of Standards-Based Reporting will be more reflective of learning in the classroom. Hence, SBA allows students to be able to know against which criteria they will judge their work, and the standards attached to each of the criteria. It tells students what is required and allows teachers to gain a sense of how students are doing overall based on their achievement of the standards and promotes mastery learning.

Schools must maintain and submit student assessment records according to the school based assessment policy. Teachers can record the evidence of students' demonstrations' of achieving the content standards and benchmarks using assessment instruments that are manageable. Here are some recommended recording methods;

- Individual or class checklists or class grid to record observations

- Comments on students work indicating what they have done well and where they need to improve
- Work samples being added to a portfolio
- Test marks
- Students assessments of their own performances using rubrics or assessment criteria and
- Students assessment of their peers using the assessment criteria

Students are given constructive feedback by the teacher on what they can do well and what they need to improve on. Likewise, teachers are focused on the content they are assessing and are able to apply fair, precise and consistent judgment.

Reporting

Teachers are obliged to report on what students have done or how well they have performed and how they improve further. Formal reporting through written reports and interviews are done to inform parents and guardians of the students learning progress and other related areas such as behavior. Teachers must ensure that the student has demonstrated and achieved the standards independently on a number of occasions. These can be done formally or informally. The achievements are reported to respected stakeholders in relation to;

- Weaknesses in the learner
- Strengths in the learner
- Parent and guardian support and
- Evaluation

Purpose of Reporting

- **Students Are Provided with Appropriate Feedback that Will Improve their Skills**

In a standards-based learning approach, teachers are expected to provide their students with quality feedback that will improve student learning. As opposed to the traditional grading system that only provides students with a single numerical or letter grade, the standards-based grading system requires teachers to provide their students with meaningful and appropriate feedback that will accelerate mastery of learning standards. It is believed that standards-based grading allowed students to identify their areas of growth and to improve on their own competencies.

Teachers need to communicate with their students what each proficiency score means and should be explained to the students' parents what each score means and how they can help their children demonstrate mastery of learning standards expected of them for the subject.

- **Students Can Track their Progress**

In a standards-based grading approach, students understand the meaning of each score that they receive. Because there are rubrics that explain the meaning of each proficiency score, students can easily monitor which standards need to be improved further and which learning standards have already been met. as such, students begin to monitor their progress and become accountable for their learning goals.

Interventions and Monitoring

Underachievement is poorer than expected performance. Students who consistently display performance demonstrative of underachievement are identified and interventions for regress are

planned to promote learning. Such interventions should be planned not as a general aspect but should address individual students' limitations in learning and should encourage learning.

- **Monitoring of Students Learning**

Monitoring of students learning is done through strategies that teacher devise to track their teaching and students achievement. This is through the assessment program, classroom teaching, and performance in performance-based learning and students self- assessment in achieving the learning standards.

- **Re-planning**

Re-planning of teaching programs and lesson planning are addressed apart from the planning and programming for all other students. This is specifically addressing underachievers. Re-planning includes teaching and learning strategies, resources, remedial activities which can be planned into the normal teaching times instead of creating extra times after classes.

Certification

Certifying of students must be done through an awarding system which will determine the level of achievement. This will be in a form of achievement statements suggested below;

Levels of achievement

1. Very high achievement
2. High achievement
3. Satisfactory achievement
4. Low achievement
5. Below requirement level

All teachers responsible for grades 9-12 must consider school based assessment levels of achievements to be affected across all Business and technology Subjects.

GLOSSARY

Building Glossary	
Aesthetics	Characteristics of a product or system that makes it look beautiful and attractive.
Analyse	Look carefully at a problem or need in order to explain its causes and effects, or carefully look at information to determine its validity and importance, or examine an item (e.g. a structure) and see how it functions and what it consists of.
artefact	A manufactured object.
	Anthropometrics (linked to ergonomics) Measurements of people's shapes and sizes. Such measurements are usually taken when products are designed for human use, e.g. furniture, eating utensils, hairdryers, sporting equipment cars, clothing, etc.
Biases	People's preconceived ideas or prejudices about some things or people before they actually meet or deal with them. These are normally in areas of human rights and inclusivity such as gender, race, ethics, religion, etc. For example most cameras are biased towards right-handed people, very few women enter the mechanical engineering industry , etc.
Biophysical environment	The land, air and water around us; it is also the space in which we find ourselves.
Classify	Arrange in groups according to similar features or qualities.
Compare	Describe the similarities and/or differences between two products, or items, or solutions or situations.
Compression	A squeezing force.
Constraints	Aspects that limit conditions within which the work or solution must be developed, e.g. time, materials, tools, human resource, cost, etc.
Control	The means by which systems are regulated, i.e. an adjustment of the process, which makes the actual result conform more closely to the desired result.
Conventions	Ways of showing information on designs or working drawings that are understood and recognised to have specific meaning.
Craft	The repetitive production of artefacts, usually for sale. It requires skill in planning the production and making of items and needs manual dexterity and artistic skill. Craft occupations include carpentry, sewing and pottery. It typically involves repetition where many items, often using existing patterns or plans, are manufactured during a production run. Although there is common ground, craft should not be confused with Technology, nor with Art
Criteria	Statements of a particular standard or requirement that a solution must satisfy.
data	Raw facts and figures (statistics, rainfall figures, temperature readings, etc.). Data may be processed into information.
Demonstrate	Show key features of an item or product.
Describe	Tell in words listing features and/or functions
Discuss	Write or speak about a topic or event or item or problem in order to get feedback / opinions from others.
design (noun)	The plan, sketch, model, drawing, etc. that outlines or shows the

	intention of the proposed solution.
design brief	A short and clear statement that gives the general outline of the problem to be solved as well as the purpose of the proposed solutions.
design process	A creative and interactive approach used to develop solutions to identified problems or human needs. The associated skills are investigating, designing (development of initial ideas), making, evaluating and communicating. The design process is utilised by engineers, architects, industrial designers, and many others when developing original ideas to meet needs or wants, and to solve problems.
enabling tasks	Activities used to teach and then practice specific skills in preparation for a more advanced task – sometimes also called resource tasks.
Ergonomics	Features of a product or system that makes it user-friendly.
Explain	Make clear by giving more information.
Findings	Things that have been discovered after a process of investigation or research.
Fitness-for-purpose	A solution should be evaluated in terms of the design brief, specifications and constraints AND whether it will meet the purpose for which it was designed.
Force	Sometimes described as a push or a pull. However, in Physics, the force may be in contact or it may act across a space (e.g. gravity, magnetism). The scientist is specifically concerned with the effect of a force on the motion of a body, viz. unbalanced forces cause acceleration, 'deceleration' or direction change. In Technology, designers are concerned only with contact forces (e.g. a load), and is specifically concerned with the effect the force has on the integrity of a structure, viz. will it bend, stretch, twist or will joints break leading to structural failure?
Forming	Changing a material's shape without cutting it.
Identify	Establish who/what something is e.g. identify a type of structure.
Illustrate	Explain or make something clear by using examples or words or diagrams.
Input	The command/information entered into a system.
information	Data that has been processed (recorded, classified, calculated, stored, etc.). Knowledge is gained when different kinds of information are compared and conclusions are drawn.
isometric	A 3D drawing where the lines of sight are set at 30 degrees.
machine	A device made up of a combination of simple mechanisms linked so as to form a system for the purpose of doing work. It can be designed to increase the mechanical advantage and decrease the velocity ratio OR to increase the velocity ratio while decreasing the mechanical advantage.
materials	Physical substances used in technology, e.g. wood, textiles, fabric, plastic, food, etc
mechanical advantage	A concept that describes how much easier mechanisms or machines can make a particular task. The amount of work done is the same, and the amount of energy expended is the same, but the effort used (force) is less because it is applied over a greater distance, and for a longer period of time.
mechanism	Parts that can turn one kind of force into another and give mechanical advantage or a distance advantage. Mechanisms can be combined to form a machine. The basic mechanisms are the lever and the

	wedge/inclined plane. Cams/ cranks and pulleys/gears are adaptations of the wheel and axle – which is itself a special case of the first class lever.
Mode	A way or manner in which a thing is done.
modelling	The testing of a solution, (product or system). This could include using small replicas (scale models), and intangible representations of the solution (mathematical models, computer models, etc.).
need	A necessity for basic function, e.g. food is a need.
Oblique	A 3D drawing where the depth of an object is projected at a 45 degree angle to the 2D front view.
opportunity	The chance to do something about a need or a want.
Orthographic	A type of 2D drawing. It usually shows three separate views of the same object (e.g. front, top and left views). The technique is used to draw formal working drawings.
output	The actual result obtained from a system.
Perspective	A 3D artistic drawing in which the lines of sight converge to vanishing points on the horizon. It can be drawn either to a single vanishing point or to double vanishing points (at this level).
technological processes	Any process using technology to perform a task e.g. generating electricity, extracting iron from iron ore, galvanising steel by electroplating, injection moulding a plastic bucket, etc.
tension	A force that stretches an object or material, a pulling force.
technological literacy	technological solution A plan that arises by using a systematic problem solving process (ideas, flowcharts, models, etc.). The ability to use, understand, manage and evaluate technology.
Product	The physical/tangible artefact that results from the process (model, poster, chart, etc.).
Preserving	A process that prolongs the natural life of a product.
Process	The part of a system that combines resources to produce an output that is in response to input.
Problem	Something that leads to a need or want and that can give rise to an opportunity.
Pulley	A wheel with a groove on its circumference. It is used to transmit movement and is used with a belt or a rope.
Recycle	To reuse all or part of a substance, including breaking it down to raw material status.
recyclable	A material that can be recycled.
safety	The way that a person works with tools, materials and equipment that does not harm themselves or others physically.
Science	The study and description of natural phenomena.
Shaping	A process used to change the shape or contour of materials – shaping always involves the removal or addition of material.
Specification	An organised, detailed description of the requirements/criteria that the solution or product must meet, e.g. safety, size, material, function, human rights, environment, etc.Note: Once a product has been manufactured, the original design specifications become the features of the product, i.e. specifications before = features after.
structure	Something that has been built, made or been put together in a particular way.
system	Something that is made up of interlinked parts that function together as a

	whole to accomplish a goal. For example a mechanical system has a combination of mechanisms that make it function as a whole; an electrical system has interrelated electrical parts that work together to make the system do what it was designed to do.
Tabulate	Arrange data or information in the form of columns and rows.
technological capability	The ability to use a combination of skills, knowledge, resources in a variety of contexts, to solve a technological problem. Capability leads to technological literacy.
want	Something that people would like but do not actually need (a convenience or a luxury).

Electrical Glossary	
amplitude modulation (AM)	a process of modulating the carrier wave in which the amplitude of the carrier wave is changed in sympathy with the modulating signal (information)
analogue	a system in which changing values are represented by a continuously variable electrical signal
audio	relating to a system concerned with frequencies within the range of human hearing
base	one terminal of a transistor through which 2% of the supply current will flow
binary logic	an assembly of digital logic elements which operate with two distinct states
binary number	a number system to the base 2
bandwidth	the range of frequencies to which a system will respond in the required manner
bipolar-transistor	a transistor in which current is carried through the semiconductor both by holes and electrons; it is a current operated device
bistable	a circuit which can have two stable states, and which can remain in either state indefinitely
Boolean algebra	a system of formal logic used for minimising complex digital systems
Capacitor	a component used in electronic circuits that has the ability to store electrical charge for a period of time
class A amplifier	a system of which the output is identical to the input in terms of frequency and shape but not in amplitude
class B amplifier	a system of which the output signal is altered in amplitude and shape representing half of the output signal
class C amplifier	a system of the output signal is altered in amplitude and shape to represent less than half of the input signal
collector	one terminal of a bipolar transistor through which 98% of the supply current will flow
conductor	a material through which an electric current can flow relatively easily
construction	encompasses the study of residential, commercial, industrial and recreational applications of Technology, including systems required to maintain and service them
conventional current	electric current, regarded as flowing from positive to negative
central processing unit (CPU)	the main number-processing and control section of a computer. In a microcomputer the CPU will be a microprocessor.

crystal	usually refers to quartz crystal, used as a precision timing element in many circuits; may refer to the term piezoelectric
Darlington pair	transistors used in cascade, giving high gain and high input impedance
decibel (dB)	one-tenth of a bell; a measure of power gain, on a logarithmic scale (e.g. a power level equal to 10 times the common logarithm of the ratio of the output power to the input power). The decibel is a convenient unit for representing a very large range of power gain.
delta network	a combination of three components connected to form a triangular configuration like the Greek letter delta; also known as a mesh connection
demodulation	the process of recovery of a modulating signal from a modulated carrier
design	includes the study of a variety of basic design processes that are used in solving technological challenges
diac	a bi-directional break over diode; often used for triggering a triac
digital electronics	the branch of electronics concerned with the processing of digital systems, usually in binary
diode	a component, either semiconductor or thermionic, that permits current to flow through it in one direction only
electron flow	regarded as the flow of electrons from negative to positive
emitter	one terminal of a bipolar transistor through which 100% of the supply current will flow
energy	focuses on domestic, industrial, generation and transmission services
farad	unit of capacitance; a very large unit, the largest practical unit being the microfarad
fibre-optic	a glass or plastic fibre used for the transmission of information through light
field-effect transistor	a type of transistor characterised by a very high input resistance that is a voltage operated device
flip-flop	general term for a bistable, astable or monostable circuit
frequency	the number of complete repetitions of a wave form in one second, expressed in Hertz
gain	the factor by which the output of a system exceeds the input
gate	a component in a digital logic circuit or one terminal of a field-effect transistor, or other semiconductor device
henry	unit of inductance
integrated circuit	an electronic system, or part of a system, produced on a silicon chip using microelectronic techniques
impedance	the ratio of the voltage applied to a circuit to the current flowing in the circuit; similar to resistance, but applicable to alternating currents and voltages
insulator	a material through which electric current will not easily flow
Karnaugh mapping	a visual technique used in the planning of digital systems for the minimisation of logic circuits
liquid crystal display (LCD)	a reflective display used in digital systems for the presentation of output; characterised by a very low power consumption
light-emitting diode (LED)	an electronic component in which electric current is converted directly into visible or infrared light
logic	the basic principles and applications of truth tables, interconnections

	of on/off circuit elements, and other factors involved in mathematical computation in a computer; also used as a general term for various types of gates, flip-flops, and other on/off circuits used to perform problem-solving functions in a digital computer
manufacturing and materials	product design, process and production planning, raw materials, manufacturing processes and quality control
microcomputer	a computer in which the central processing unit is a microprocessor
microprocessor	a central processing unit constructed using large-scale integration in which all the CPU circuits are fitted into a single integrated circuit
modulation	variation of the frequency, phase or magnitude of a high frequency waveform in accordance with a waveform of lower frequency
monostable	a circuit with a single stable state
multimeter	a general-purpose measuring instrument, usually able to measure resistance, current and voltage
negative feedback	feedback applied to a system in such a way that it tends to reduce the output
NPN	one of the two alternative types of bipolar transistors
Ohm	the unit of resistance (Ω)
operational amplifier	a highly stable, gain, DC amplifier, usually produced as a single integrated circuit
opto-electronics	electronic systems or devices that involve the use of light
Oscillator	an electronic system that produces a regular periodic output
Oscilloscope	an instrument for displaying electrical waveforms on a cathode ray tube
photo-resistor	also known as an LDR (light-dependent resistor); a resistor whose value depends upon the amount of light falling on it
piezoelectric effect	the direct conversion of electrical to mechanical energy or vice versa in some crystalline materials
programmable logic controller (PLC)	a control device, normally used in industrial control applications, that employs the hardware architecture of a computer and a programming language
PNP	one of the two alternative types of bipolar transistor
power supply	source of electrical energy
positive feedback	feedback applied to a system in such a way that it tends to increase the output
protective device	a particular type of equipment used in electric power systems to detect abnormal conditions and to initiate appropriate corrective action
rectification	the process of changing an alternating current to a unidirectional current
relay	an electromechanical device in which an electric current controls a switch
resistance	the property of a material that resists the flow of electrical current
speaker	an electromechanical device for converting electrical energy into sound (e.g. a loudspeaker)
star network	a set of three or more branches with one terminal of each connected at a common node to give the form of a star; also known as a Y connection
technological process	the identification, design, development and evaluation of processes and products related to Electrical Technology
thyristor	a component similar to a semiconductor diode but having in addition a

	gate connection by which the component, normally non-conducting, can be triggered into conduction
tolerance	generally the amount by which a specified component value can vary from the marked value
triac	a semiconductor component similar to the thyristor but which will conduct in either direction
uni-junction transistor	a semiconductor device used in some oscillators
voltage regulation	a process to maintain the terminal voltage within required limits despite variations in input voltage or load
wavelength	the physical distance between two similar and successive points on an alternating wave
zener diode	a semiconductor diode, used for voltage regulation. When the zener diode is reverse-biased, it exhibits a sudden increase in conductivity at a certain specific voltage

Plumbing Glossary	
Back Flow	The act of water traveling from one system back into any part of the main distribution system (usually by siphoning).
Back Flow Preventer	A device to prevent backflow i.e. into a potable water supply. Usually required for sprinkler systems, handheld showers, pullout faucet spouts, kitchen sprayers, etc..
Back Pressure	Pressure that resists the flow of fluid in a piping system
Back Siphonage	The negative pressure that causes backflow..
Back Vent	: Plumbing fixture's separate vent in a building drainage system
Back Wash	The process of cleaning a filter by reversing the flow of water through it. Accumulated sediments are sent to waste.
Black Water	The discharge from water closet and urinal is called Black water.
Building Drain (BD)	The building drain is the part of the lowest horizontal piping of a drainage system which receives the discharge from soil, waste and other drainage pipes inside the walls of the building and conveys it to the building sewer beginning one meter outside the building wall...
Building drainage system	consists of plumbing fixtures, drainage pipes & fittings and septic tanks/public sewer
Building Sewer	The building sewer is the part of the horizontal piping of a drainage system which extends from the end of the building drain and which receives the discharge of building drain and convey it to a public sewer, private sewer, individual sewage disposal system or other point of disposal
Check Valve	A type of backflow preventer installed in a pipe run that allows water to flow in only one direction.
Drain/waste/soil pipes	are large pipes that carry waste water and other wastes away from the home and into appropriate places such as septic tanks or sewer mains.
DWV	In modern plumbing, a drain-waste-vent (or DWV) is a system that allows air to enter the plumbing system to maintain proper air pressure to enable the removal of sewage and greywater from a dwelling. Drain refers to water produced at fixtures such as sinks, and showers; waste refers to water from toilets. As the water runs down, proper venting is required to allow water to flow freely, and avoid a vacuum from being created. As the water runs down air must be allowed into the waste pipe either through a roof vent (external), or an internal vent
Frost Line	The line joining the points of greatest depths below ground level up to

	which the moisture in the soil freezes.
Faucet	a fixture for drawing or regulating the flow of liquid especially from a pipe
Galvanizing	The process of applying a coating of zinc to the finished product to provide corrosion protection. The coating can be applied by hot dipping or electrolytic deposition.
Grey Water	The discharge from bathtubs, showers, wash basins, kitchen sink, washing machine which does not contain human excreta is called Grey Water.
Hard Water	Natural water containing impurities in various proportions. Traditional hardness is a measure of calcium or dissolved solids in a solution, measured in parts per million. Hard water generally ranges from 100 to 250 ppm.
High Altitudes	Elevations higher than 1 500 m above mean sea level (MSL).
Hydraulic Pressure	Pressure that exists in a system containing non-compressible liquid.
Invert Level	The distance between the ground surface level to the base interior level of a sewer pipe
Lagging	. Thermal insulation on pipes.
Leach Field	Porous soil area, through which septic tank leach lines run, emptying the treated waste.
Leach Lines	Pipes that carry effluent from the septic system out to the leach field.
Leach pit	Leach pits/ Soak pits/ Seepage pits are used to remove contaminants and impurities from the liquid that emerges from the septic tank and safely disperses the same into the soil.
Leakage	Loss of fluid usually due to mechanical breakdown or gasket wear.
Manhole	Access opening to a hole, usually with a cover, through which a person may enter a sewer, boiler, drain, etc. (usually round to prevent the cover from falling into the opening).
Manhole Cover	A manhole cover is a removable plate forming the lid over the opening of a manhole, to prevent anyone or anything from falling in, and to keep out unauthorized persons and material.
Outlet / Discharge	The opening through which the water exits the pump
Outlet Sewer	Pipe section in a septic system which runs between the septic tank and the drainage field.
Overflow Tube	The vertical tube inside a toilet tank that directs water into the bowl in case the ballcock malfunctions. It is usually part of the flush valve. It prevents potential water damage caused by a tank overflow. A "constant-running" condition alerts the user to a problem. On most toilets, the overflow tube also has a refill tube flowing into it, which directs water from the ballcock through the overflow tube to the bowl, after a siphon break.
Pipes	a hollow cylinder used to move liquids, gases or oil. Pipes come in several types and sizes. They can be divided into three main categories: metallic pipes, cement pipes and plastic pipes. Metallic pipes include steel pipes, galvanised iron pipes and cast iron pipes. Cement pipes include concrete cement pipes and asbestos cement pipes
Pipe fittings	A fitting or adapter is used in pipe systems to connect straight sections of pipe or tube, adapt to different sizes or shapes, and for other purposes such as regulating (or measuring) fluid flow.[1] These fittings are used in plumbing to manipulate the conveyance of water, gas, or liquid waste in domestic or commercial environments, within a system of pipes or tubes.
Plumber	A plumber is a person who installs and maintains piping for water and

	their drains and waste systems in a dwelling, business or industrial facility. He installs bathroom appliances such as showers, toilets, sinks, kitchen appliances (e.g. dishwashers), water heaters required in a new or remodelled houses or buildings. Plumbers need various skills to perform their jobs successfully like blueprint reading, ability to locate through diagrams locations for installation of pipes, fitting pipes together for the correct functioning of plumbing systems. A plumber shall be aware of basic Plumbing Codes and Standards specified.
Plumbing	Pipes, fixtures and other apparatus inside a building for bringing in water supply and removing the waste water out of the building constitute plumbing system. Plumbing is a skilled trade of working with the above pipes, fixtures and apparatus for use with water and drainage.
Plumbing Fixture	A general term applied to any plumbing receptacle, device or appliance that can be temporarily or permanently fixed in place. It is connected to the drinking-water supply or to the drainage system either by an indirect or direct connection.
Plumbing Vent Pipes	are an integral part of a plumbing system as they allow the piping to "breathe". Air flow is necessary to equalize pressure in plumbing systems and plumbing vents allow for proper flow of air through the pipes.
Pressure Pipes	that carry fresh water to various fixtures.
Raw Water	Water supplied to the plant before any treatment.
Sanitary Fitting	Fitting that joins the assorted pipes in a drain, waste, and vent system, designed to allow solid material to pass through without clogging.
Sanitary Sewer	House drain that carries wastewater away from the house to a sewer system or septic tank.
Scale:	A thin coating or layer, usually calcium on the bottom of a tank or interior parts that may prevent heat transfer.
Sewer Gas:	Gases, esp. methane, which may be combustible and poisonous from the decay of organic materials in the sewer system.
Septic Tank (ST)	A Septic Tank is a watertight concrete box, buried in the ground just outside the home. The septic tank acts as a small-scale sewage treatment system common in areas where no connection to main sewerage system provided by the local body. It helps in disposing of household sewage / wastewater safely.
Septage	Black Water which undergoes treatment in septic tank is called Septage
Sewage	is the water, carrying body wastes including human excreta and other house hold waste. a) The discharge from water closet and urinal is called Soil or Black Water. b) The discharge from bathtubs, showers, wash basins, kitchen sink, washing machine which does not contain human excreta is called Waste Water / Sullage / Grey Water.
Sewerage system	Sewerage system is a closed system of pipes from the waste receptacle to the final disposal point either on land or into a body of water and the flow is gravitational or free flow and not under pressure as in the case of water supply pipes
Sovent Single Stack DWV System	The Sovent System is an engineered single stack drainage system. It offers a different concept of waste and venting by slowing the velocity of liquids and solids through a series of aerator fittings and double offsets. Before entering the building drain a deaerator fitting is placed at the base of the stack to minimize solid build up and slow the drainage before entering the building drain.

Stack	Any vertical pipe in the system like vertical soil or vent pipe is called stack.
Vent Stack	Upper portion of the soil stack above the topmost fixture through which gases and odors escape

Welding Glossary	
acceptable weld	A weld that meets the applicable requirements.
acetone:	A colorless, flammable, volatile liquid used as a paint remover and as a solvent for oils and other organic compounds. Used in acetylene cylinders to saturate the monolithic filler material to stabilize the acetylene
acetylene feather	The intense white, feathery-edged portion adjacent to the cone of a carburizing oxyacetylene flame.
actual throat	The shortest distance between the weld root and the face of a fillet weld.
adhesion	A state of being stuck together. The joining together of parts that are normally separate.
aluminum	One of the chemical elements, a silvery, lightweight, easily worked metal that resists corrosion
ampere	A unit of electrical current measuring the rate of flow of electrons through a circuit. One ampere is equivalent to the current produced by one volt applied across a resistance of one ohm.
annealing	A process of heating then cooling metal to acquire desired qualities such as ductility
anode	The positive terminal of an electrical source.
alloy	A substance with metallic properties, composed of two or more chemical elements of which at least one is a metal
alloying element	Elements added in a large enough percentage to change the characteristics of the metal. Such elements may be chromium, manganese, nickel, tungsten, or vanadium; these elements are added to produce specific physical properties such as hardness, toughness, ductility, strength, resistance to corrosion, or resistance to wear.
alloy steel:	A plain carbon steel to which another element, other than iron and carbon, has been added in a percentage large enough to alter its characteristics
alternating current (AC)	An electric current that reverses its direction periodically.
alternative fuels	Propane, methylacetylene propadiene (MPS), natural gas, or fuel gases, other than acetylene, used for welding or cutting.
arc blow	The deflection of an arc from its normal path because of magnetic forces.
arc force	The axial force developed by an arc plasma.
arc gap	A nonstandard term used for the arc length.
arc gouging	Thermal gouging that uses an arc cutting process variation to form a bevel or groove.
arc plasma	A gas that has been heated by an arc to at least a partially ionized condition, enabling it to conduct electric current.
arc spraying	A thermal spraying process using an arc between two consumable electrodes of surfacing materials as a heat source and a compressed gas to atomize and propel the surfacing material to the substrate
arc strike	A discontinuity resulting from an arc, consisting of any localized re-melted metal, heat-affected metal, or change in the surface profile of any metal object.
arc time	The time during which an arc is maintained in making an arc weld.

arc welding	Arc welding is a group of welding processes in which fusion is produced by heating with an electric arc or arcs with or without the application of pressure and with or without the use of filler metal.
arc voltage	The voltage across the arc.
as welded	The condition of weld metal, welded joint, and weldments after welding, but prior to any subsequent thermal or mechanical treatment.
axis of a weld:	A line through the length of a weld, perpendicular to and at the geometric center of its cross-section.
backing	A material or device placed against the back side of the joint, or at both sides of a weld in electroslag and electrogas welding, to support and retain molten weld metal. The material may be partially fused or remain unfused during welding and may be either metal or nonmetal.
backstep sequence	A longitudinal sequence in which weld passes are made in the direction opposite to the progress of welding.
bare electrode	A filler metal electrode consisting of a single metal or alloy that has been produced into a wire, strip, or bar form and that has had no coating or covering applied to it other than that which was incidental to its manufacture or preservation.
base metal (material)	The metal (material) to be welded, brazed, soldered, or cut
butt joint	A joint between two members aligned approximately in the same plane.
concavity	The maximum distance from the face of a concave fillet weld perpendicular to a line joining the weld toes.
convexity	The maximum distance from the face of a convex fillet weld perpendicular to a line joining the weld toes.
covered electrode	A composite filler metal electrode consisting of a core of a bare electrode or metal cored electrode to which a covering sufficient to provide a slag layer on the weld metal has been applied. The covering may contain materials providing such functions as shielding from the atmosphere, deoxidation, and arc stabilization and can serve as a source of metallic additions to the weld.
crater	In arc welding, a depression at the termination of a weld bead or in the molten weld pool
depth of fusion	The distance that fusion extends into the base metal or previous pass from the surface melted during welding.
DC or direct current	Electric current which flows only in one direction. In welding, an arc welding process wherein the power supply at the arc is direct current.
fillet weld	A weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, T-joint or corner joint.
fillet weld leg	The distance from the joint root to the toe of the fillet weld.
flat position	The welding position used to weld from the upper side of the joint; the face of the weld is approximately horizontal.
flux	Material used to prevent, dissolve, or facilitate removal of oxides and other undesirable surface substances
gas metal arc welding(GMAW)	An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal (consumable) electrode and the work. Shielding is obtained entirely from an externally supplied gas or gas mixture.
gas tungsten arc welding(GTAW)	An arc welding process that produces coalescence of metals by heating them with an arc between a tungsten (non-consumable) electrode and the work. Shielding is obtained from a gas or gas mixture. Pressure may or may not be used and filler metal may or may not be used. (This

	process has sometimes been called TIG welding, a non-preferred term.)
groove weld	A weld made in the groove between the work pieces.
heat-affected zone	That portion of the base metal that has not been melted, but whose mechanical properties or microstructure have been altered by the heat or welding, brazing, soldering, or cutting.
horizontal position	(a) fillet weld - The position in which welding is performed on the upper side of an approximately horizontal surface and against an approximately vertical surface. (b) groove weld - The position of welding in which the weld axis lies in an approximately horizontal plane and the weld face lies in an approximately vertical plane.
joint penetration	The depth a weld extends from its face into a joint, exclusive of reinforcement.
lap joint	A joint between two overlapping members in parallel planes
machine welding	Welding with equipment that performs the welding operation under the constant observation and control of a welding operator. The equipment may or may not load and unload the work pieces.
manual welding	A welding operation performed and controlled completely by hand.
melting rate	The weight or length of electrode melted in a unit of time
open circuit voltage	The voltage between the output terminals of the welding machine when no current is flowing in the welding circuit.
overhead position	The position in which welding is performed from the underside of the joint.
overlap	The protrusion of weld metal beyond the weld toe or weld root.
peening	The mechanical working of metals using impact blows.
porosity	Cavity type discontinuities formed by gas entrapment during solidification.
post heating	The application of heat to an assembly after welding, brazing, soldering, thermal spraying or cutting operation.
pre heating	The application of heat to the base metal immediately before welding, brazing, soldering, thermal spraying, or cutting
root opening	A separation at the joint root between the work pieces.
root penetration	The depth that a weld extends into the joint root.
seal weld	Threaded joint sealed, without thread compound, by back welding.
semiautomatic arc welding	Arc welding with equipment that controls only the filler metal feed. The advance of the welding is manually controlled
shielded metal arc welding (SMAW)	An arc welding process that produces coalescence of metals by heating them with an arc between a covered metal electrode and the workpieces. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.
spatter	The metal particles expelled during fusion welding which do not form a part of the weld.
stress relief heat treatment	Uniform heating of a structure or a portion thereof to a sufficient temperature to relieve the major portion of the residual stresses, followed by uniform cooling.
stringer bead	A type of weld bead made without appreciable weaving motion.
tack weld	A weld made to hold parts of a weldment in proper alignment until the final welds are made.
tungsten electrode	A non-filler metal electrode used in arc welding or cutting made principally of tungsten
underbead crack	A crack in the heat-affected zone generally not extending to the surface of the base metal.
undercut	A groove melted into the base metal adjacent to the weld toe or weld root

	and left unfilled by weld metal
vertical position	The position of welding in which the weld axis is approximately vertical.
weave bead	A type of weld bead made with transverse oscillation.
weld	A localised coalescence of metals or non-metals produced either by heating the materials to welding temperature, with or without the application of pressure, or by the application of pressure alone, and with or without the use of filler material.
weld face	The exposed surface of a weld on the side from which welding was done.
weld metal That	portion of a weld which has been melted during welding.
weld pass	A single progressional of welding or surfacing along a joint or substrate. The result of a pass is a weld bead, layer, or spray deposit.
weld pool	The localized volume of molten metal in a weld prior to its solidification as weld metal. weld root: The points, as shown in cross section, at which the back of the weld intersects the base metal surfaces
weld size	(a) groove weld size - The joint penetration of a groove weld. (b) fillet weld size - For equal leg fillet welds, the leg lengths of the largest isosceles right triangle which can be inscribed within the fillet weld cross section For unequal leg fillet welds, the leg lengths of the largest right triangle that can be inscribed within the fillet weld cross section.
weld toe	The junction of the weld face and the base metal
welding procedure	The detailed methods and practices involved in the production of a weldment.
welding rod	A form of welding filler metal, normally packaged in straight lengths, that does not conduct electrical current.
weldment	An assembly whose component parts are joined by welding.

Engineering Glossary	
Acceptance	The process of assessing whether a system satisfies all its requirements
Acceptance test	A test that assesses whether a system satisfies all requirements.
Activity Diagram	A diagram type in UML which models the flow of actions in a system or in a component including the data flows and areas of responsibility where necessary.
Actor	Generally in Requirements Engineering, a person, a system or a technical device in the context of a system that interacts with a system.
Adequacy (of a requirement)	The degree to which a requirement expresses the stakeholders true desires and needs.
Application domain	Those parts of the real world that are relevant for determining the context of a system.
Artifact	An intermediate or final result of system development; for example, a requirements specification.
Attribute	A characteristic property of an entity.
Baseline	A stable, change-controlled configuration of artifacts
Behaviour model	A model describing the behaviour of a system or component
Bug	A defect
Changeability (of an artefact)	The degree to which an artifact enables a required modification of the artifact.
Checking (requirements)	Comprises requirements validation and checking requirements for qualities such as unambiguity or comprehensibility.
Class	Represents a set of objects of the same kind by describing the structure

	of the objects, the ways they can be manipulated and how they behave.
Completeness (of requirements)	For a single requirement: the degree to which a requirement contains all necessary information which is necessary to for developing a system that satisfies a stakeholders' desires and needs.
Compliance	The capability of an artifact to adhere to standards, regulations, laws, or other formally imposed documents.
Component	In general; a delimit able part of a system.
Configuration	A consistent set of logically coherent units. The units are individually identifiable artifacts in at most one version per unit.
Conformity (of requirements)	A degree to which a requirements specification conforms to regulations given in some standard.
Consistency (of requirements)	The degree to which a set of requirements is free of contradicting statements.
Constraint	A requirement that limits the solution space beyond what is necessary for meeting the given functional requirements and quality requirements and quality requirements.
Context	In general; the network of thoughts and meanings needed for understanding phenomena. It is also the part of a system's environment being relevant for understanding the system and its requirements.
Context boundary	Boundary between the context of a system and those parts of the application domain that are irrelevant for the system and its requirements.
Context diagram	A diagrammatic representation of a context model.
Context model	A model describing a system in its context.
Correctness	The degree to which the information contained in an artifact is proven as true this is also a synonym of adequacy.
Customer	A person or organisation who receives a product or service.
Customer requirements specification	A course description of the required capabilities of a system from the customer's perspective.
Dataflow diagram	A diagram modelling the functionality of a system or component by processes (also called activities), data stores and data flows. Incoming data flows trigger processes which then consume the received data, transform them, read/write persistent data held in data stores and then produce new data flows which may be intermediate results that trigger other processes or final results that leave the system.
Defect	A spot in an artifact that is incorrectly described or crafted. It can also be called a fault or a bug.
Domain	A range of relevant things (for some given matter).
Effectiveness	The degree to which something actually happens in the way it ought to happen.
Efficiency	The degree to which a result is achieved with minimum consumption of resources.
End user	User
Entity	In general; an element or set of elements that may stand for any conceivable item, e.g., a system, a part of a reality, a thing, an organisation, a process etc.
Entity relationship diagram	A graphic representation of an entity relationship model.
Error	A discrepancy between an observed or result and the specified behaviour or result. AN error is typically a symptom for the existence of a fault or defect in some artifact. Though there may be not much distinction between the notions of error and fault.

Fault	Defect
Fault tolerance	The capability of a system to continue normal operations despite the presence of (hardware and software)faults.
Feature	A delimitable characteristic of a system that provides value for stakeholders.
Goal	A desired state of affairs that a stakeholder wants to achieve. They describe the intentions of stakeholders that may conflict with one another.
Inspection	A kind of review where the artifact under review is inspected by a group of experts according to given criteria. The experts' findings are then collected and consolidated.
Language	A structured set of signs for expressing and communicating information. Signs are elements that are used for communication; expressions in a language, symbols, gestures etc.
Model	An abstract representation of an existing reality or a reality to be created.
Modeling language	A language expressing models of a different kind. Maybe textual, graphic or a some combination thereof.
Performance requirement	A requirement describing a performance characteristic (timing, speed, volume, capacity,)
Prototype	In manufacturing; apiece which is built prior to the start of mass production.
Quality	The degree to which a set of inherent characteristics of an entity fulfils requirements.
Redundancy	Multiple occurrence of the same information or resource.
Reliability	The capability of a system to maintain a specified level of functionality and performance when used under specified conditions.
Requirement	A condition or capability needed by a user to solve a problem or achieve an objective.
Requirements analysis	Analysis of elicited requirements in order to understand and document them.
Requirements baseline	A baseline for a set of requirements.
Requirements engineer	A person who- in collaboration with stakeholders-elicits, documents, validates and manages requirements.
Review	A formally organised endeavour for checking an artifact by a group of experts. Checking may be performed with respect to both contents and conformance.
Risk	AN event that threatens the success of an endeavour. A risk is assessed in terms of its probability and potential damage.
Safety	The capability of a system to achieve an acceptable level of probability that operating the system will not result in harming people, property or the environment.
Scope (of a system)	The range of things that can be shaped and designed when developing a system.
Security	The capability of a system to protect (a) its data and resources against unauthorised use and (b) its legitimate users against denial of service.
Sequence diagram	A diagram type in UML which models the interactions between a selected set of objects and/ or actors in the sequential order that those interactions occur.
Specification	A systematically represented description of the properties of an entity (a system, a device, etc.) that satisfies criteria.
Stakeholder	A person or organisation that has a (direct or indirect) influence on a

	systems requirements.
Standard	A uniform regulation for perceiving, manufacturing or executing something.
System context	A requirement
System requirements specification	A requirements specification pertaining to a system.
Tool (in software engineering)	A (software) system that helps develop, operate and maintain systems.
Traceability (of requirements)	The ability to trace a requirement(1) back to its origins, (2) forward to its implementation in design and code,(3) to requirements it depends on (and vice-versa). Origins maybe stakeholders, documents, rationales, etc.
UML	Abbreviation for Unified Modeling Language, a standardised language for modelling problems or solutions
Usability	The capability of a system to be understood, learned, used, and liked by its users.
Use case	A description of the interactions possible between actors and a system. The boundary between the actors and the use cases constitutes the system boundary.
Use case diagram	A diagram type in UML that models the actors and the use cases of a system.
User	A person who uses the functionality provided by a system. Also called an end user.
Validation (of requirements)	The process of checking whether documented requirements match the stakeholders' needs.
Verifiability (of requirements)	The degree to which the fulfilment of a requirement by an implemented system can be checked. E.g. by defining acceptance test cases, measurements or inspection procedures.
Version (of an entity)	If an entity exists in multiple exists in multiple, time ordered occurrences, where each occurrence has been created by modifying one of its predecessors, every occurrence is a version of that entity.
View	An excerpt from an artefact, containing only those parts one is currently interested in. A view can abstract or aggregate parts of the artefact.
Viewpoint	A certain perspective on the requirements of a system.
Walkthrough	A kind of review where the author of an artefact under review walks a group of experts systematically through the artefact. The experts' findings are then collected and consolidated.

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APPENDICES

APPENDIX 1: BLOOMS TAXONOMY

LEVEL OF UNDERSTANDING	KEY VERBS
CREATING Can the student create a new product or point of view?	Construct, design, and develop, generate, hypothesise, invent, plan, produce, compose, create, make, perform, plan, produce, assemble, formulate,
EVALUATING Can the student justify a stand or decision?	Appraise, argue, assess, choose, conclude, critique, decide, defend, evaluate, judge, justify, predict, prioritise, provoke, rank, rate, select, support, monitor,
ANALYZING Can the student distinguish between the different parts?	Analysing, characterise, classify, compare, contrast, debate, criticise, deconstruct, deduce, differentiate, discriminate, distinguish, examine, organize, outline, relate, research, separate, experiment, question, test,
APPLYING Can the student use the information in a new way	Apply, change, choose, compute, dramatize, implement, interview, prepare, produce, role play, select, show, transfer, use, demonstrate, illustrate, interpret, operate, sketch, solve, write,
UNDERSTANDING Can the student comprehend ideas or concepts?	Classify, compare, exemplify, conclude, demonstrate, discuss, explain, identify, illustrate, interpret, paraphrase, predict, report, translate, describe, classify,
REMEMBERING Can the student recall or remember the information?	Define, describe, draw, find, identify, label, list, match, name, quote, recall, recite, tell, write, duplicate, memorise, recall, repeat, reproduce, state,

APPENDIX 2: 21ST CENTURY SKILLS

WAYS OF THINKING	**Creativity and innovation** ▪ **Think creatively** ▪ **Work creatively with others** ▪ **Implement innovations** **Critical thinking, problem solving and decision making** ▪ **Reason effectively and evaluate evidence** ▪ **Solve problems** ▪ **Articulate findings** **Learning to learn and meta-cognition** ▪ **Self-motivation** ▪ **Positive appreciation of learning** ▪ **Adaptability and flexibility**
WAYS OF WORKING	Communication • Competency in written and oral language • Open minded and preparedness to listen • Sensitivity to cultural differences Collaboration and teamwork • Interact effectively with others • Work effectively in diverse teams • Prioritise, plan and manage projects
TOOLS FOR WORKING	**Information literacy** ▪ **Access and evaluate information** ▪ **Use and manage information** ▪ **Apply technology effectively** **ICT literacy** ▪ **Open to new ideas, information, tools and ways of thinking** ▪ **Use ICT accurately, creatively, ethically and legally** ▪ **Be aware of cultural and social differences** ▪ **Apply technology appropriately and effectively**
LIVING IN THE WORLD	Citizenship – global and local • Awareness and understanding of rights and responsibilities as a global citizen • Preparedness to participate in community activities • Respect the values and privacy of others Personal and social responsibility • Communicate constructively in different social situations • Understand different viewpoints and perspectives Life and career • Adapt to change • Manage goals and time • Be a self-directed learner • Interact effectively with others

APPENDIX 3: TEACHING AND LEARNING STRATEGIES

STRATEGY	TEACHER	STUDENTS
CASE STUDY Used to extend students' understanding of real life issues	Provide students with case studies related to the topic of the lesson and allow them to analyse and evaluate.	Study the case study and identify the problem addressed. They analyse the problem and suggest solutions supported by conceptual justifications and make presentations. This enriches the students' existing knowledge of the topic.
DEBATE A method used to increase students' interest, involvement and participation	Provide the topic or question of debate on current issues affecting a bigger population, clearly outlining the expectations of the debate. Explain the steps involved in debating and set a criteria/standard to be achieved.	Conduct researches to gather supporting evidence about the selected topic and summarising the points. They are engaged in collaborative learning by delegating and sharing tasks to group members. When debating, they improve their communication skills.
DISCUSSION The purpose of discussion is to educate students about the process of group thinking and collective decision.	The teacher opens a discussion on certain topic by asking essential questions. During the discussion, the teacher reinforces and emphasises on important points from students responses. Teacher guide the direction to motivate students to explore the topic in greater depth and the topic in more detail. Use how and why follow-up questions to guide the discussion toward the objective of helping students understand the subject and summarise main ideas.	Students ponder over the question and answer by providing ideas, experiences and examples. Students participate in the discussion by exchanging ideas with others.
GAMES AND SIMULATIONS Encourages motivation and creates a spirit of competition and challenge to enhance learning	Being creative and select appropriate games for the topic of the lesson. Give clear instructions and guidelines. The game selected must be fun and build a competitive spirit to score more than their peers to win small prices.	Go into groups and organize. Follow the instructions and play to win
OBSERVATION Method used to allow students to work independently to discover why and how things	Give instructions and monitor every activity students do the activity.	Students possess instinct of curiosity and are curious to see the things for themselves and particularly those things which exist around them. A thing observed and a fact discovered

happen as the way they are. It builds curiosity.		by the child for himself becomes a part of mental life of the child. It is certainly more valuable to him than the same fact or facts learnt from the teacher or a book. Students Observe and ask essential questions Record Interpret
PEER TEACHING & LEARNING ***(power point presentations, pair learning)*** **Students teach each other using different ways to learn from each other. It encourages; team work, develops confidence, feel free to ask questions, improves communication skills and most importantly develop the spirit of inquiry.**	**Distribute topics to groups to research and teach others in the classroom.** **Go through the basics of how to present their peer teaching.**	**Go into their established working groups.** **Develop a plan for the topic.** **Each group member is allocated a task to work on.** **Research and collect information about the topic allocated to the group.** **Outline the important points from the research and present their findings in class.**
PERFORMANCE-RELATED TASKS *(dramatization, song/lyrics, wall magazines)* Encourages creativity and take on the overarching ideas of the topic and are able to recall them at a later date	Students are given the opportunity to perform using the main ideas of a topic. Provide the guidelines, expectations and the set criteria	Go into their established working groups. Being creative and create dramas, songs/lyrics or wall magazines in line with the topic.
PROJECT **(individual/group)** **Helps students complete tasks individually or collectively**	**Teacher outline the steps and procedures of how to do and the criteria**	**Students are involved in investigations and finding solutions to problems to real life experiences. They carry out researches to analyse the causes and effects of problems to provide achievable solutions. Students carefully utilise the problem-solving approach to complete projects.**
USE MEDIA & TECHNOLOGY to teach and generate engagement <u>depending on the age of the students</u>	Show a full movie, an animated one, a few episodes from documentaries, you tube movies and others depending on the lesson. Provide questions for students to answer before viewing	Viewing can provoke questions, debates, critical thinking, emotion and reaction. After viewing, students engage in critical thinking and debate

APPENDIX 4: STEAM

This Sample STEAM Lesson Planning is for Business Studies but can be applied to Technology and Industrial Arts.

Strand 2: Business Management

Unit 5: Information Technology

Content Standard 2.5: Students will be able to explain the information technology concepts and examine the systems and tools needed to gather, access, analyse, synthesize, evaluate, manage, and disseminate information.

Benchmark: 12.2.5.2. Explain the steps involved in entering and manipulating text and data using a variety of input technologies.

Topic: Steps in entering and manipulating text and data using a variety of input technologies

Learning Objective: By the end of this topic, students will be able to explore the steps in entering and manipulating text and data using a variety of input technologies.

Purpose of Assessing the Topic (Benchmark):
To assess whether students can be able to use the MS Excel to positively explore the steps in entering and manipulating text and data using a variety of input technologies

How the Performance Task will be done: Group Project Presentation

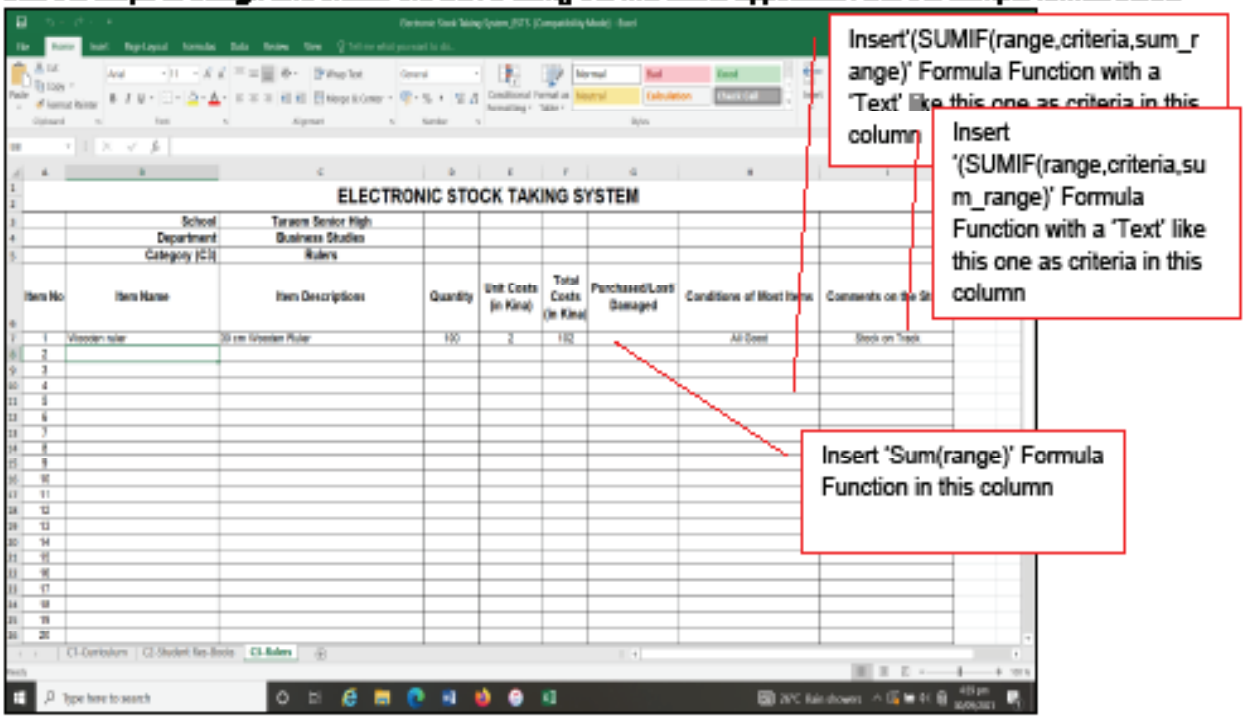
Performance Standard: By the end of the project, students will be able to use the MS Excel application to positively explore the steps in entering and manipulating text and data using a variety of input technologies.

Situation (Authentic)

Your school should have been accounting for all the stock of the materials it has. The stocks of materials may include the materials like all the electronic equipment, the tools in the tool store, the sports equipment and materials and the departmental equipment and materials. There is a manual stock taking system (stock book) to take stock of all the equipment and materials in the school. With the manual stock taking system currently used in schools, the Principal and the teachers have experiences with improper stocks quantity checks and stocks updates.
When this was report by the Principal in a BOG meeting, the BOG moved a motion for the development of a functional Electronic Stock Taking System (ESTS) using the current available technology. In order to meet the expectations of the BOG, the principal and teachers task the Grade 12 students to participate in the creation of the ESTS using the MS Excel application.
To achieve this, the school is now requesting the Business Studies Department to design an Assessment Task for a grade to assist and guide the activity. The Business Studies Department has opted to design the Task for Grade 12 students as one of their projects towards their assessments. The school principal also announces that the best ESTS assessed by the Business Studies Department will be rewarded as it is also a competition.

Task Descriptions:

- Select a Subject Department or a Specialist Room (Store-room, Tool-room) in your school to Collect Data of different items for your Electronic Stock Taking System (ESTS) project.
- Plan and write the steps of creating the Electronic Stock Taking System.
- Use the steps to design and create the ESTS using the MS Excel application like the sample format below



- The ESTS must contain appropriate contents and formulae functions.
- It must also contain comments to justify the status of the individual stocks.
- This ESTS has to be user-friendly to the school officials to use.
- Presentation of the MS Excel of ESTS must not be more than 2 minutes (maximum time limit)
- Submit your MS Excel ESTS for assessment.
- Whole class to observe and use the rubric below to assess the Presentation of the MS Excel of ESTS.

Materials: Computer, Tablets, Smartphones, MS Excel Application

Related Benchmarks to this Business Studies Benchmark in Business Studies and other Subject areas:

Subjects	Reference Benchmark Codes
8. Arts (Visual Arts)	12.3.2.2
9. Character Social Development (CSD)	12.1.5.2, 12.1.5.3
10. English	12.2.1.2
11. Business Studies	12.2.5.1
12. General Mathematics	12.4.1.3
13. Technology Industrial Arts (TIA)	12.4.1.4

A Sample Scoring Rubric

Annotation 1
A statement (descriptors) describing the expected the level of competency for each prescribed criteria

Annotation 2
Rating scales includes either numerical or descriptive labels

Annotation 3
Indicators or qualifiers ensures that the levels reflect variance in quality

Annotation 4
Shaded descriptors indicating Student's Marks for the corresponding

Criteria	Achieved 3	Progressing 2	Novice 1	Scoring
Collecting Data for Electronic Stock Taking System (ESTS)	Well organized paper with clarity identifying, classifying and enumerating the different items.	Organized paper with some clarity identifying, classifying and enumerating the different items.	Poorly organized paper that lacked clarity identifying, classifying and enumerating the different items.	2/3
Development of ESTS	Collaboratively organise and categorise data of different items. Illustrate the most likeable way the Data can displayed in the MS Excel Application format.	Display some collaboration to organise and categorise data of different items. Illustrate a likeable way the Data can displayed in the MS Excel Application format.	Display very little collaboration to organise and categorise data of different items. Illustrate a way the Data can displayed in the MS Excel Application format.	1/3
Content and Formulae Functions in ESTS	Typed accurately all the appropriate contents for each columns and typed in the all correct formulae function symbols for the 'SUMrange function' and 'SUMIF function' in all their correct MS Excel cell references	Typed most contents in their appropriate columns and typed in most of the correct formulae function symbols for the 'SUMrange function' and 'SUMIF function' in some of their MS Excel cell references	Typed very few contents in their appropriate columns and typed in very few formulae function symbols for the 'SUMrange function' and 'SUMIF function' in very few of their MS Excel cell references	3/3
Presentation of ESTS	Displayed time consciousness with adequate delivery skills (posture, language), expected communication skills and social skill (relativity and connectivity)	Mostly time consciousness with some adequate delivery skills (posture, language), some expected communication skills and some social skill (relativity and connectivity) displayed	Very little time consciousness with little adequate delivery skills (posture, language), little expected communication skills and little social skill (relativity and connectivity) displayed	3/3

Portfolio of ESTS Developments and MS Excel ESTS – The Product	A comprehensive portfolio with all the Steps in planning, designing and developing the ESTS with a complete and functional MS Excel of the ESTS.	**A portfolio with most of the Steps in planning, designing and developing the ESTS with a complete and malfunctioned MS Excel of ESTS.**	**A portfolio with very few of the Steps in planning, designing and developing the ESTS with an incomplete and malfunctioned MS Excel of ESTS.**	**3/3**
				12/15

A Sample Portfolio

1. **Idea Generation**

   a. Inform the students that most the projects (like shirt, bowl, furniture) are based on existing ideas to solve a problem. Ask the students to choose from these list words/phrase (substitute, combine, adapt, modify, put to another use, eliminate, reverse/rearrange) one word/phrase that provokes your thoughts about their project idea to solve an existing problem. The word/phrase selected by students will direct the approach the students take towards the ideas of the students projects.

   Write this word/phrase in the space provided below.

   _____

   b. Guide the students to explain how this word/phrase is in line with their ideas of a project.

   _____

   _____

   _____

   c. Assist students to develop an inquiry question based on their project idea.

   _____

2. **Research**

   Inform the students that their project idea needs to be validated to ensure that the product get the people who will pay for it and that they won't waste time, money, and effort on an idea that won't sell.

   a. Students to validate the product ideas by to conducting a survey to get feedbacks from the potential buyers. The students will have to prepare a survey questionnaire with a number of essential questions on their product ideas like the one below.

   Survey on Project Idea: (Name of the project idea)

   b. Explain how useful is the furniture/garment to you?

   _____

   c. Explain how often do you have this dish?

   _____

d. How much would you like to spend on this garment/furniture if you intend to buy it?

_____

b. At this stage, students should consider the Safety precautions to be taken in the stages of **Planning, Prototyping, Production and Marketing**. They can do this by responding to related questions as show in the examples below.

1) What is the First aid symbol?

Students draw the FIRST AID SYMBOL here

2) Explain what is workshop safety?

_____

_____

3) How can safety be enforced in working practices to minimize the risks associated working environment?

_____

_____

4) In the following stages (Planning, Prototyping, Production and Marketing), the students will draw 2 items/tools and describe the type of injury that may occur through the incorrect use of each of the items/tools

1. Planning Stage	
Item/Equipment/Tool	*Injury that may occur*
Name: _____ *(Drawing of the item/equipment/tool)*	1. 2. 3.
Name: _____ *(Drawing of the item/equipment/tool)*	1. 2. 3.
2. Prototyping Stage	
Name: _____	1.

(Drawing of the item/equipment/tool)	*2.*
	3.
Name: _____ *(Drawing of the item/equipment/tool)*	*1.*
	2.
	3.

5) The students will have state what action they should take to assist the teacher next to each of the injuries described below.

Injury	*Action taken by student*
A student using knife a cuts his/her finger.	*1.*
	2.
A student cooking burns his/her hand on a hot pot	*1.*
	2.

3. Planning

Explain to the students that it is important to take the time to plan carefully before they begin to build your prototype. They need to decide on a number thing when building their prototype. Inform the students characteristics of materials/food to be used texture, design, hardness, durability and colour) etc. All of these is determine by the purpose and the function of the project.

a. Tasting

1) In terms food, students need to actually taste ingredients separately first and after the different ingredients are combined. They will also identify the various ways to cook them. Students will have find out ways to improve the taste for their intended project dish.

b. Sketching

1) In terms of fabric garments and construction technology projects, students have to sketches of the various prototypes needs to prepared and evaluated for their practicality and usefulness. They also need to consider the purpose and function of their project for they will determine the materials to be used, the characteristics for the materials to be used. Students have to determine ways to improve the design of their fabric garment and construction technology projects.

4. **Prototyping**

   a. For Fabrics and construction technology, the students will have to select projects sketches that will be made into prototypes, be sampled and do detailed working diagrams/patterns/templates to ergonomics standards. Students evaluate their prototype and make appropriate changes on the detailed working diagrams/patterns/templates to meet the ergonomics standards.
   b. As for food, students written up a recipe and cook sample dishes various ways. Students will make appropriate taste evaluation of each dish to select the one to use as the project.

5. **Production**

   a. Students need to be selective gathering the required materials and food ingredients as per their materials/recipe list to for the project based on their prototypes and the ergonomics standards. This is because of the conditions of the raw materials to be used for their project. The materials have to be evaluated for defects or damages acquired by the materials to select the appropriate materials. Students should select the materials according to the descriptions of materials needed for their project.

   b. For Food, students have to use the confirmed recipe from the prototype to prepare and create the dish.

   c. Students will use the confirmed outlined garment patterns/templates to measure and cut out the material list for their project. For technology construction, students utilise the confirmed cutting list and the detailed working diagram to cut out the materials for their project like the one below.

Project Name	
Total Unit (No of Project)	

Material List				
Quantity	**Name of Material(s)**	**Description(s)**	**Unit Cost**	**Total Cost**

d. While working on the projects, the students will have to fill in and complete the table of the Procedures in the Production of their project

Procedure (How to make my Project)

NO	OPERATIONS	NEEDED TOOLS/EQUIPMENT
1		
2		
3		
4		
5		
6		
7		

6. Costing

a. The students are required to calculate the cost of their project. To calculate their project, they have to calculate the cost of all the materials used in their project, the labour cost (based on their rate per hour) and these adds up to the selling/marketing cost. Students have to add 30% markup of the selling/marketing cost to determine the selling price.

b. Students should also evaluate the responses from product research survey as they could influence the cost the project.

c. The cost for making the project are:

4) Material costs: K____

5) Labor costs (No of Hours Spent X Your Rate): 10 hrs x K____ = K____

6) Selling/Marketing cost: K____

g. Students will use the simple formula below to calculate a good markup percentage for their project:

MARKUP PERCENTAGE = (SELLING PRICE – UNIT COST) / UNIT COST x 100%

h. They simply take the sales price minus the unit cost, and divide that number by the unit cost. Then, multiply by 100 to determine the markup percentage.

For example, if the project costs K50 to make and the selling price is K75, then the markup percentage would be 50%: (K75 – K50) / K50 = 0.50 x 100 = 50%.

7. Marketing

a. Students need to review the responses/feedback from the Surveys done on the project idea and inform the interested people of the completed project.

b. Students could put out flyers, brochures and posters to promote the completed project to the public.

c. Students could create promotional webpages on social media to market the product

A Sample Student Self-Assessment

Student Self-Assessment/Teacher Assessment						**Date: / /**			
Project Name:						**Term:**			
Student Name:		**Grade:**		**Class:**		**Total Score:**			
		Give yourself a score of 3, or 2, or 1, or 0 for performances				Teacher scores of students' performances			
	CRITERIA	**Students' scores**				**Teacher's scores**			
		3	**2**	**1**	**0**	**3**	**2**	**1**	**0**
1	**Idea Generation** a. Selection of word/phrase in line with project idea								
	b. Explanation of the word/phrase in-line with project and development of main issue question								
2	**Research** a. Development of a survey questionnaire with a number of essential questions on their project ideas								
	b. Safety for stages of Planning, Prototyping, Production and Marketing.								

	i. Draw safety precaution sign								
	ii. Tool/items and injuries that may occur								
	iii. Injuries and actions taken by students								
3	**Planning** a. Identify the various ways to cook them and find out ways to improve the taste for their intended project dish								
4	**Prototyping** a. Select projects sketches that will be made into prototypes, be sampled and do detailed working diagrams/patterns/templates to ergonomics standards								
5	**Production** a. Select the materials according to the descriptions of materials needed for their project.								
6	**Costing** a. Calculate their project, they have to calculate the cost of all the materials used in their project, the labour cost (based on their rate per hour) and these adds up to the selling/marketing cost.								
7	**Marketing** a. Review the responses/feedback from the Surveys done on the project idea and inform the interested people of the completed project. b. Create promotional webpages on social media to market the product								

A Sample Peer Student Assessment

Student Self-Assessment/Teacher Assessment										**Date: / /**			
Project Name:										**Term:**			
Student Name:					**Grade:**					**Total**			
Peer's Name:					**Class:**					**Score: /**			
		Give yourself a score of 3, or 2, or 1, or 0 for performances				Give your peer a score of 3, or 2, or 1, or 0 for performances				Teacher scores of students' performances			
	CRITERIA	**Students' scores**				**Peer's scores**				**Teacher's scores**			
		3	**2**	**1**	**0**	**3**	**2**	**1**	**0**	**3**	**2**	**1**	**0**
1	**Idea Generation** c. Selection of word/phrase in line with project idea												
	d. Explanation of the word/phrase in-line with project and development of main issue question												
2	**Research** c. Development of a survey questionnaire with a number of essential questions on their project ideas												
	d. Safety for stages of **Planning, Prototyping, Production and Marketing.** iv. Draw safety precaution sign												
	v. Tool/items and injuries that may occur												
	vi. Injuries and actions taken by students												
3	**Planning** b. Identify the various ways to cook them and find out ways to improve the taste for their intended project dish												

4	**Prototyping** b. Select projects sketches that will be made into prototypes, be sampled and do detailed working diagrams/patterns/templates to ergonomics standards												
5	**Production** b. Select the materials according to the descriptions of materials needed for their project.												
6	**Costing** b. Calculate their project, they have to calculate the cost of all the materials used in their project, the labour cost (based on their rate per hour) and these adds up to the selling/marketing cost.												
7	**Marketing** c. Review the responses/feedback from the Surveys done on the project idea and inform the interested people of the completed project. d. Create promotional webpages on social media to market the product												

Samples of Student Response System Applications

These are web based apps that work with a multitude of devices and operating systems. Here are the 4 best student response systems that interface with multiple devices.

1. Kahoot

Kahoot is a utility that allows teachers to create quizzes and surveys, and then send them to students. Teachers may allow students an unlimited amount of time to respond to questions, or they may set a time limit on each questions. Points are awarded to students both for correct answers and for responding quickly with those correct responses. Teachers can track students as they make progress.

2. Socrative

Socrative works excellently both for students working on their own or for students who are collaborating with one another. Socrative offers several different ways for instructors to engage their students. There are space races in which students can compete in teams or as individuals to answer questions as quickly and accurately as possible. Polls allow instructors to receive student feedback.

3. Infuse Learning

Infuse learning is (was!) an excellent student response system for teachers who must support students with a variety of learning styles. With infusion a teacher can create questions, quizzes and writing prompts and send them to students who are participating in virtual classrooms or in an online learning program. What makes Infuse Learning unique is that it allows the teacher to give the student multiple response options.

4. Verso

This is a free utility that teachers can use to create virtual classrooms. Verso works with the teacher's Google Drive account. This means that links, files, videos, images, and documents from the instructor's Google Drive can be added to the Verso classroom for students to access. Students who enter the classroom will be shown new items that have been added to the classroom since their last visit.

https://www.emergingedtech.com/2015/09/top-5-multi-platform-student-response-systems/

APPENDIX 5: LESSON PLAN TEMPLATE

Strand: .....

Unit: .....

Content Standard: .....

Benchmark: .....

Topic 1: .....

Lesson Topic: .....

Instructional Objective (s): By the end of the lesson, students will be able to;

- .....
- .....
- .....

Essential Questions:

- .....
- .....
- .....

Knowledge:

- .....
- .....

Skill(s):

- .....
- .....

Values:

- .....
- .....

Attitudes:

- .....
- .....

Teaching and Learning Strategies

Teacher will …..	Student will ….
Introduction (time in minutes)	
Body (time in minutes)	
Modeling	
Guided Practice	
Independent Practice	
Conclusion (time in minutes)	

APPENDIX 6: ASSESSMENT TEMPLATE

Performance Assessment Template

Subject: _____

Strand:_____

Unit: _____

Content Standard: _____

Benchmark: _____

Topic: _____

Learning Objective: _____

Purpose of Assessment: _____

Assessment Strategy: _____

Duration: _____

Time/Date of Administration: _____

Due Date/Time: _____

Performance Standard: _____

Performance Tasks

Performance Assessment Criteria:_____

Assessment Scoring: _____

Scoring Tool: _____

APPENDIX 7: Portfolio

(Business Studies, Technology & Industrial Arts and CCVE subject Specific)

This refers to a collection of student work and additional information gathered over a period of time that demonstrates learning progress.

Sample Student Portfolio Template

STUDENT PROJECT PORTFOLIO NO: _____

NAME: _____ **CLASS:** _____ **TERM:** _____ **DATE:** ___/___/___

SUBJECT: _____

STRAND: _____

UNIT: _____

CONTENT STANDARD #: _____

_____

_____

_____

BENCHMARK #: _____

_____

_____

_____

5. **NAME OF PROJECT:** _____
6. **PURPOSE OF THE PROJECT:** (State briefly the reason why you will make the project. Have a complete visualization of any project you wish to make so as to know its usefulness)
   a) _____
   b) _____
7. **Idea Generation**

   a. Most projects are based on existing ideas. Choose from these list words/phrase (substitute, combine, adapt, modify, put to another use, eliminate, reverse/rearrange) one word/phrase that provokes your thoughts about your project and goes in line with your own ideas about your project. Write this word/phrase in the space provided below.

   _____

   b. Explain how this word/phrase is in line with your ideas about your own project.

   _____

   _____

   _____

8. Research

Your project idea needs to be validated to ensure you're creating a product people will pay for and that you won't waste time, money, and effort on an idea that won't sell. There are several ways you can validate your product ideas, including:

a. Talking about your idea with family and friends. If you decide to use this validation method, prepare a sheet to record your feedbacks like the one below.

Your Project Idea:	(*Write down your project idea*)

Family and friends Names	Feedbacks/Responses
1.	
2.	
3.	
4.	

b. Sending out a survey to get feedback. If you decide to use this validation method, prepare a survey questionnaire like the one below.

Survey on Project Idea: (*Write down your project idea*)

i) Explain how useful is the furniture/garment to you?

_____

ii) Explain how often do you have this dish?

_____

iii) How much would you like to spend on this garment/furniture if you intend to buy it?

_____

c. Consider Safety precautions to be taken in the stages of Planning, Prototyping, Production and Marketing.

i) Elementary first aid and procedures: What is the First aid symbol?

Draw the FIRST AID SYMBOL here

ii) Explain what is workshop safety?

ii) How can safety be enforced in working practices to minimise the risks associated working environment?

_____

_____

d) For each of the following stages (Planning, Prototyping, Production and Marketing), draw 2 items/tools and describe the type of injury that may occur through the incorrect use of each of the items/tools

3. Planning Stage	
Item/Tool	**Injury that may occur**
Name: _____ (*Drawing of the item/tool*)	1.
	2.
	3.
Name: _____ (*Drawing of the item/tool*)	1.
	2.
	3.
4. Prototyping Stage	
Name: _____ (*Drawing of the item/tool*)	1.
	2.
	3.
Name: _____ (*Drawing of the item/tool*)	1.
	2.
	3.

e) For each of the injuries described below, state what action you should take to assist the teacher.

Injury	**Action taken by student**
A student using knife a cuts his/her finger.	1.
	2.

A student cooking burns his/her hand on a hot pot	1.
	2.

9. **Planning**

It's important to take the time to plan before you begin to build your prototype.

Tasting

In terms food, ingredients have to be tasted separately and combination of different ingredients needs to tasted together to select a prototype.

Sketching

In terms of fabric garments and technology projects, sketches of the various prototypes needs to prepared and evaluated for their practicality and usefulness

10. **Prototyping**

a. Selected projects sketches will be made into prototypes, be sampled and detailed.
b. As for food, a recipe would be outlined and cooked to make a sample dish. Make appropriate taste evaluation to improve the dish
c. Fabric garments and technology projects create detailed working diagrams from the prototype for patterns or templates if required.

11. **Production**

a. Gather the required materials and food items as per your list to for the project idea.

b. For Food, use the confirmed recipe from the prototype to prepare and create the dish.

c. Use the confirmed outlined garment patterns/templates to measure and cut out the material pieces for your project idea.

d. For technology construction, use the confirmed cutting list and the detailed working diagram to cut out the materials for your project

Product Name	
Total Unit (No of Project)	

Material List				
Quantity	Name of Material(s)	Descriptions(s)	Unit Cost	Total Cost

e. Complete the table of the Procedures in the Production

Procedure (How to make my Project)

NO	OPERATIONS	NEEDED TOOLS/EQUIPMENT
1		
2		
3		
4		
5		
6		
7		

12. Costing

d. The cost for making the T-shirt are:

7) Material costs: K____

8) Labor costs (No of Hours Spent X Your Rate): 10 hrs x K____ = K____

9) Selling/Marketing cost: K____

You could add a _____% markup on top of the K____ total it cost to make your product as the "plus" of cost-plus pricing. Here's what the formula looks like:

Cost (K____) x Markup (K____) = Selling price (K___)

13. Marketing

a. Review the responses/feedback from the Surveys done for the project idea and inform the interested people of the completed project

b. Put out fliers to advertise the project to public

c. Use social media to market the product

Scoring of Performance for Formative Assessment

(Assessment as/while learning and Assessment for learning)

1. Scoring Assessment using Rating Scale

Rating Scales are a type of checklists that judge the degree to which a criteria is met. They generally have a scale of between 1-6 options.

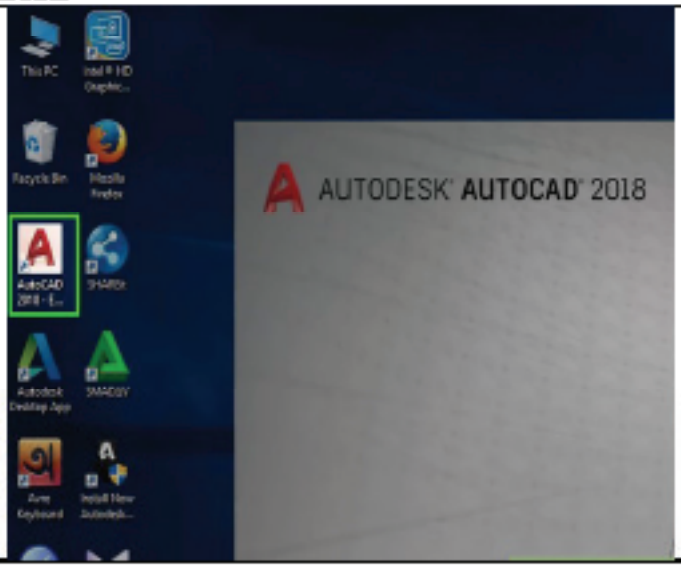
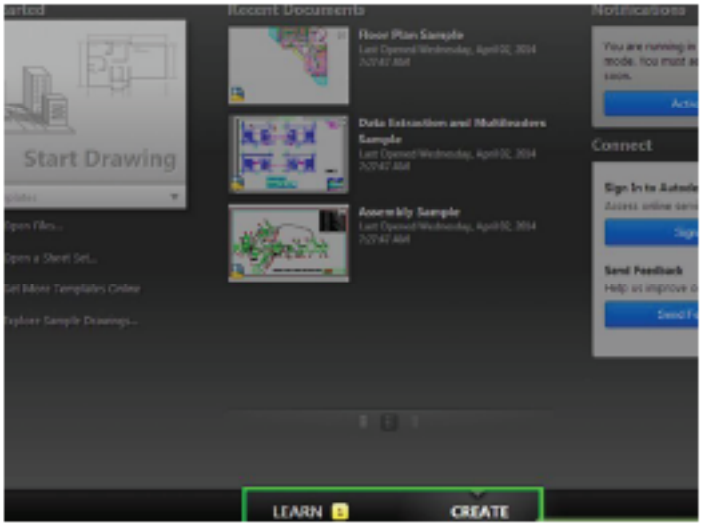
Assessment Performance Records for Term to give grading

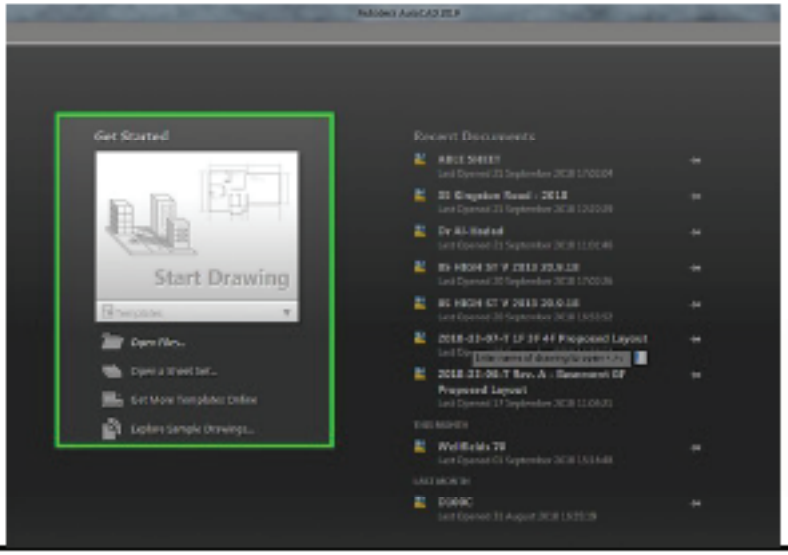
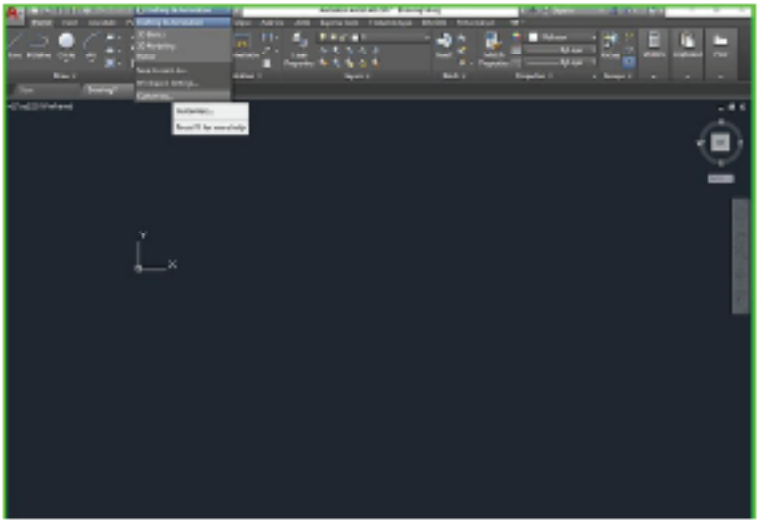
Student's performance in any assessments must be recorded to obtain a final score to be able to give a grading.

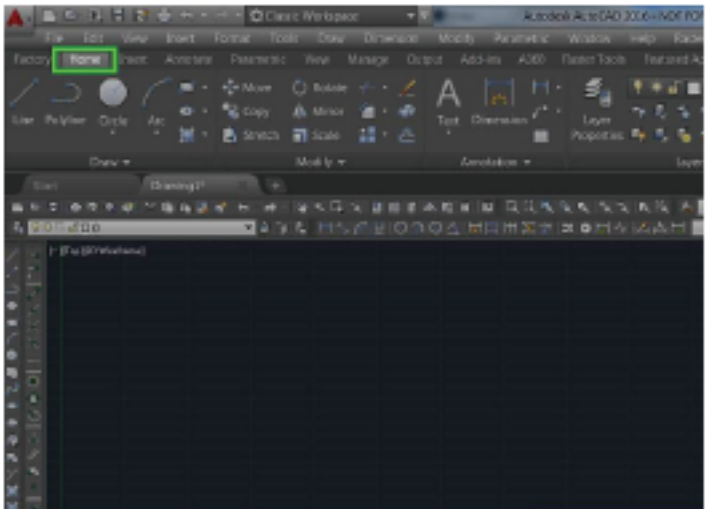
Subject/Strand: _____Grade/Class:_____ Term____

NO	Name	Project 20 marks	Test 1 15 marks	Test 2 10 marks	Portfolio 10 marks	Moderation 30 marks	Participation 5 marks	Total Raw Score
1	Gil							/100
2	Jil							/100
3	Zil							/100
4	Bil							/100
Etc.								/100

APPENDIX 8: BASIC AUTOCAD STEPS

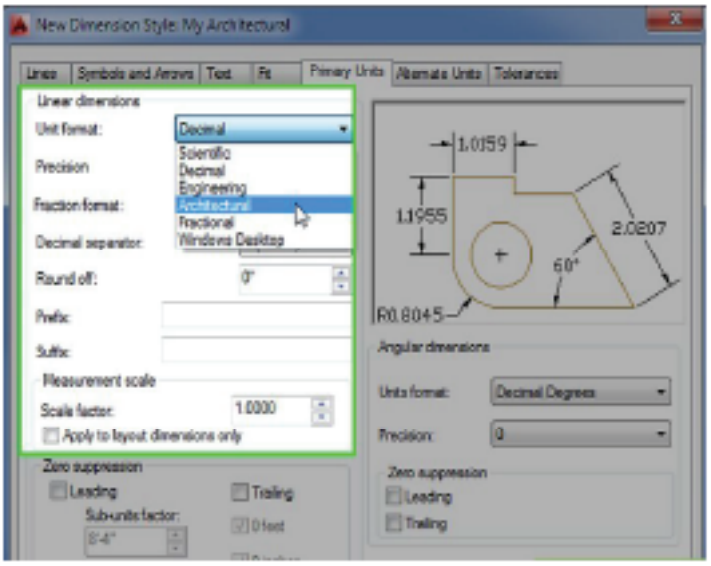
METHOD ONE Getting Started	
1 Open AutoCAD. You'll find it in the Windows menu or your Mac's Applications folder. If you haven't already installed AutoCAD, visit https://www.autodesk.com to download and install it now	
2 Browse the Start screen. When you open AutoCAD, you'll see two tabs on the bottom—LEARN and CREATE (the default tab). If you click the LEARN tab, you'll find helpful videos to get you started with your project. If you click back to the CREATE tab, you'll find the following areas: ▪ In the "Get Started" section on the left, you can select Start Drawing to create a new project, Open Files to choose an existing project, or click the Templates menu to start from a template.[1] ▪ If there are any recent AutoCAD documents to work on, they'll appear in the Recent Documents section at the middle of the screen. ▪ If any updates are available, they'll appear in the Notifications area at the top-right corner. ▪ You can also sign in to your A360 account by	

clicking Sign In at the bottom-right corner.	
3 Click Start Drawing or open an existing file. If you want to start a new project from a template, choose that template instead.[2] ▪ If you don't see the option to do so, click the File menu and select New to create a new drawing now.	
4 Familiarize yourself with the workspace layout. Once you've opened a drawing, take some time to acquaint yourself with the locations of menus and tools: ▪ The drawing area is the part of the workspace with a gridded background. At the top-left corner of this area are two tabs: one is for the current drawing (which will have a name like "Drawing1") and the other can take you back to the Start screen. If you open more than one drawing at once, each will have its own tab above the drawing area. ▪ The Y-axis appears in green on the left side of the drawing area, and the X-axis is the red line along the bottom. ▪ The Viewcube is the square with a directional compass around it—you can use this to adjust your	

perspective when working in 3D. ▪ The ribbon toolbar at the top above the drawing area contains your tools on a series of tabs (Home, Insert, Annotate, etc.). ▪ Click the View tab at the top to show and hide tools and features on the workspace. ▪ The "Type a command" area at the bottom lets you type in commands and tool functions once you get a bit more acquainted with the app.[3]	
5 Click the Home tab. It's at the top-left corner of AutoCAD. You'll see your drawing tools in the "Draw" area on the left side of the ribbon toolbar. ▪ Hover your mouse over any of the tools to see more information about what they do, as well as instructions for finding more help about their uses. ▪ As you draw with any tool, you'll see useful measurements near the cursor, such as length and angle.	

6

Set your default measurement formats. If you need to change the way the scale, length, or angle measurements appear on the screen, units into the command prompt and pressing Enter or Return to bring up the Drawing Units panel. For example, if you're seeing measurements in microns and you need to see them in meters, you can make that change here whenever you want.

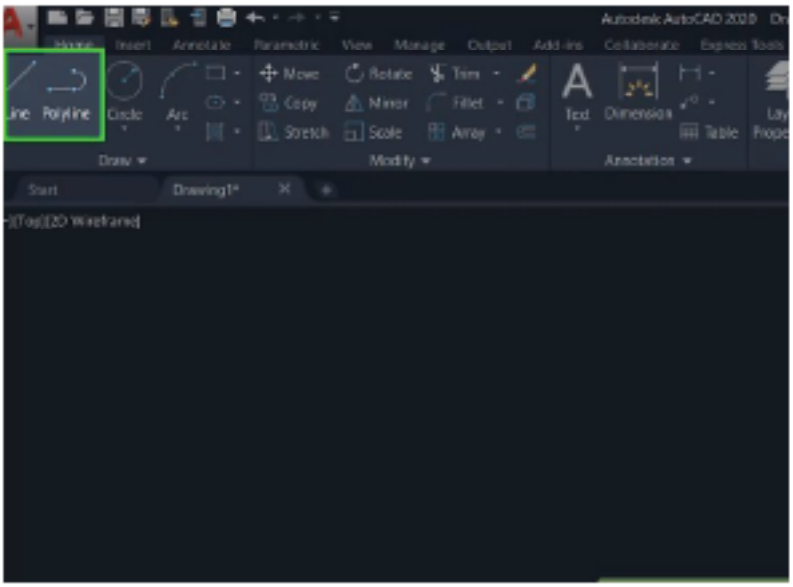


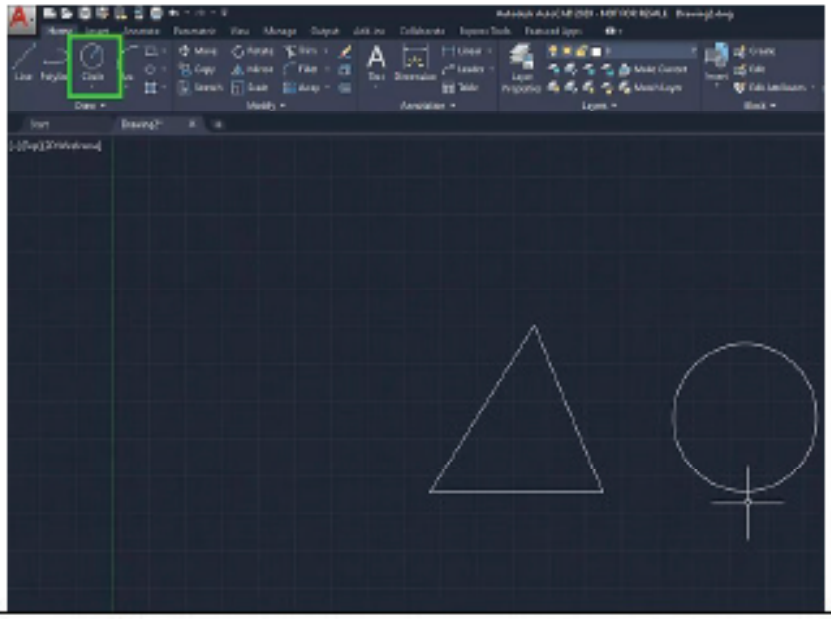
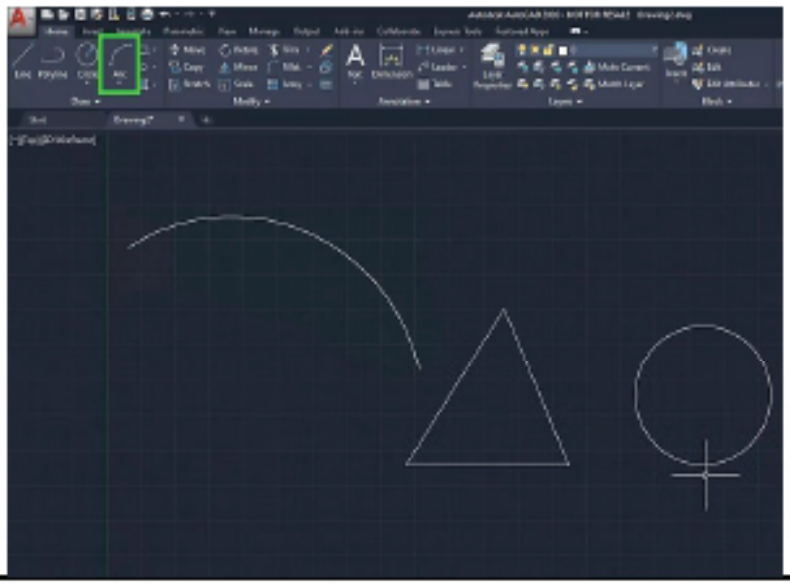
METHOD TWO Drawing in AutoCAD

1

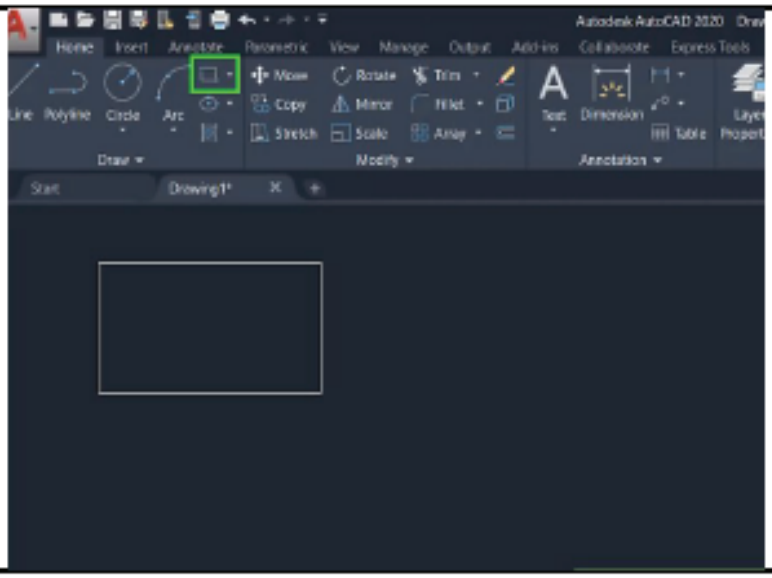
Click the Line or Polyline tool to draw lines. Both tools are at the top-left corner. The Line tool is for drawing individual line segments, while the Polyline tool lets you create a single object from a series of line segments. To draw your first lines:

- Click the mouse at the starting point of your line segment.
- Move the mouse to the place where you'd like to end the segment, and click the mouse at the ending point. If you're using the Line tool, this completes your first segment/line.
- If you're using the Polyline tool, move the mouse again and click to continue creating segments. When you're finished, hit the Esc key to stop drawing.
- If you need to set precise measurements for your segments (and this is true



for any tool), type the desired measurement into the box near the cursor instead of clicking a segment endpoint. When you press Enter or Return, the endpoint will be placed at the distance you entered.	
2 Click the Circle tool to draw a circle. It's to the right of the Polyline tool in the toolbar. To draw a circle: ▪ Click the location on the drawing area where the circle's center should be. ▪ Drag the mouse outward and click to select the radius.	
3 Click the Arc tool to draw a curved line. It's to the right of the Circle tool in the toolbar. To draw an arced line: ▪ Click the mouse at the starting point. ▪ Move the mouse and then click to end the segment. ▪ Move the mouse in the direction of the curve you want and click to curve the line.	
4 Click the Rectangle tool to create a rectangle. The rectangle tool is simple—click the first point, which will be any	

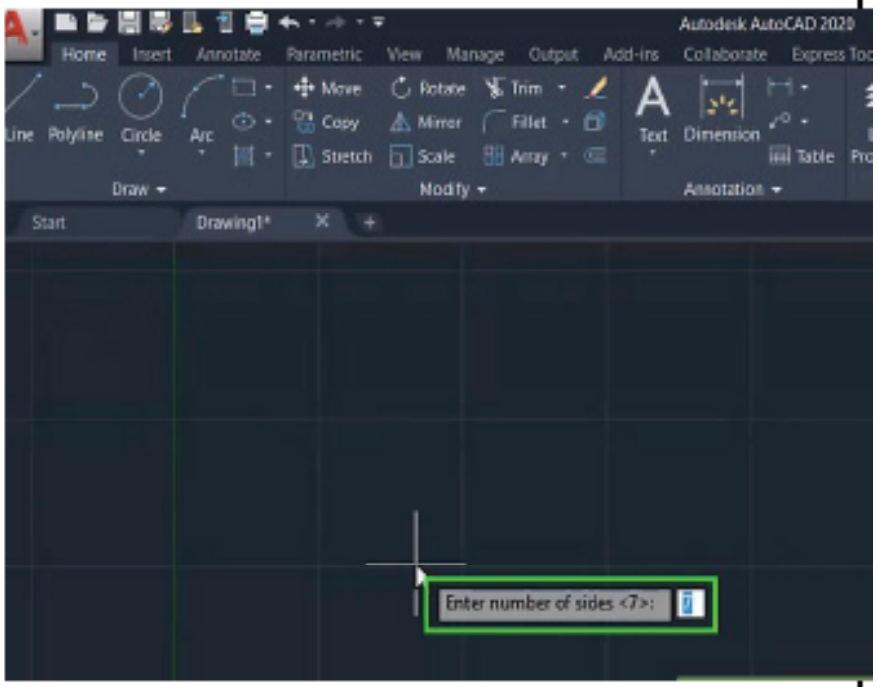
corner of the rectangle, and then drag the mouse until the rectangle is the size you want. Click the mouse to place the rectangle.



5

Click the Polygon tool to a multi-sided shape. Here's how:

- Move the cursor to the drawing area—you'll see a box that says "Enter the number of sides." Type the number of sized and press **Enter** or **Return**.
- Click the center point of your shape.
- Move the mouse to the desired size and click to place the shape.



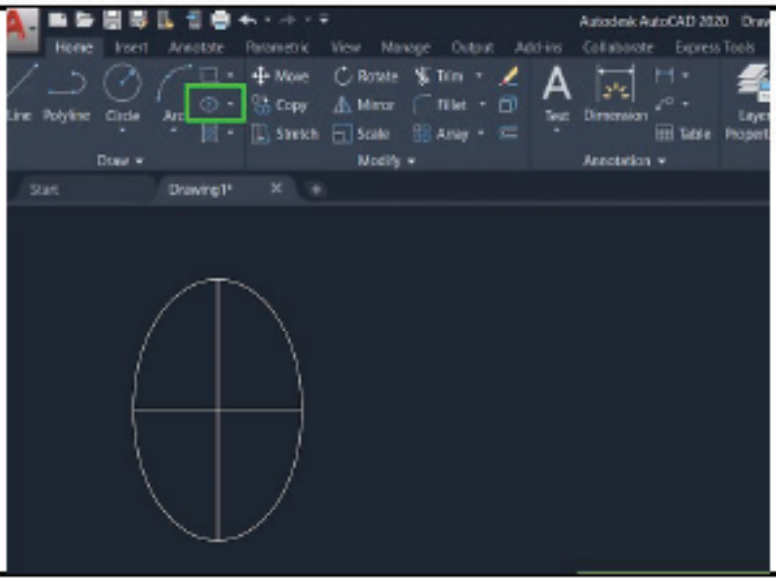
6

Click the Elipse tool to create an oval. An ellipse is created by placing three points. Here's how:

- Click the desired center point.
- Move the mouse to the

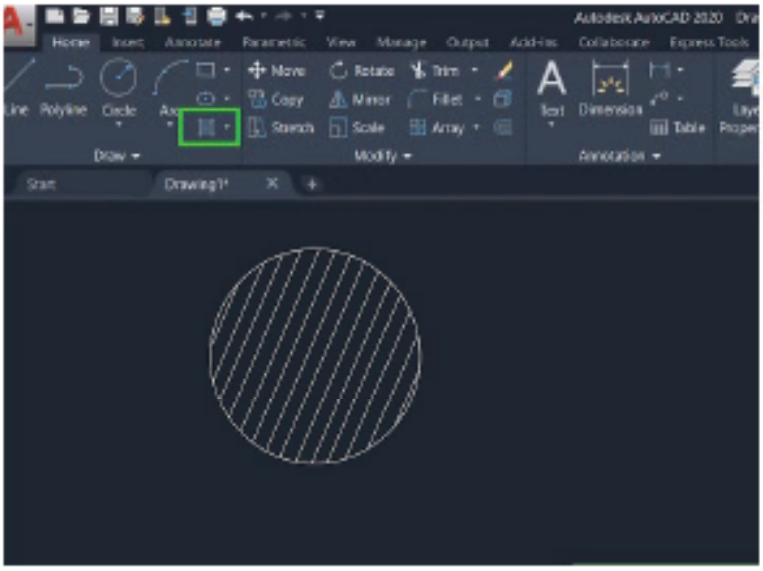
desired size and click a second point.

- Move the mouse to shape the ellipse and click to place the shape.



7

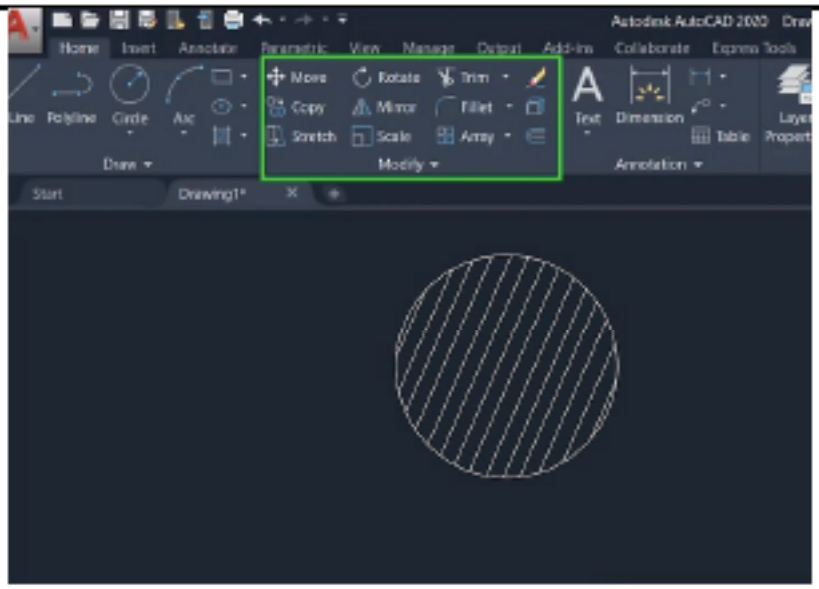
Use the Hatch tool to fill a shape with a pattern. It's the square at the bottom-right corner of the Draw panel in the toolbar. Click the tool, then click a shape to fill it. You can choose any of the patterns or solid fills that appear in the "Pattern" panel that shows in the toolbar while Hatch is enabled.



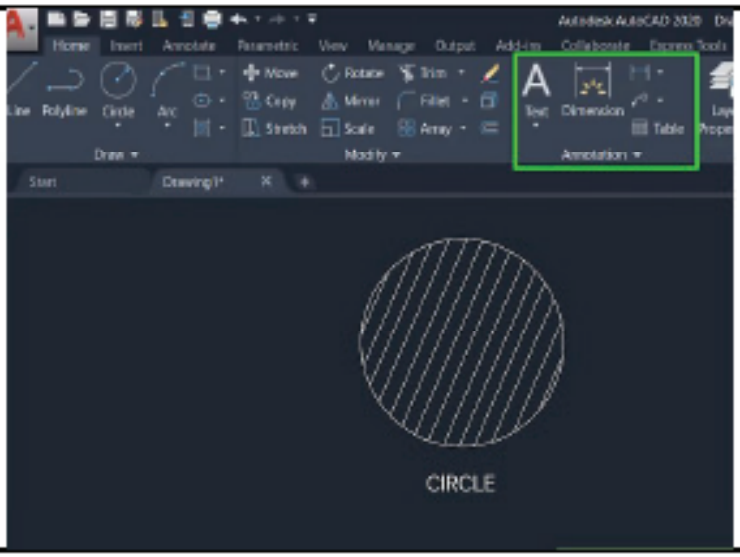
8

Use the tools in the "Modify" panel to edit your shapes. First, if you just click a shape or line without selecting a tool first, anchor points will appear—you can drag these anchor points to modify the shape if you'd like. There are lots of other modifications you can make:

- **Click Move to move a line or shape. After clicking the tool, click the object you want to move, and then drag it anywhere. You can**

select multiple objects at once to move them as a group ▪ Click Rotate and then a shape to turn it clockwise or counterclockwise. If you want to flip the image, use the Mirror tool. ▪ Click Scale and then a shape to change its size. Check out How to Scale in AutoCAD to learn more about what you can do with scaling. ▪ Click Stretch if you want to resize an image by stretching it rather than keeping it scaled. ▪ Click one of the Array tools (Rectangular Array, Path Array, or Polar Array) to create an array of the object you select. ▪ The Trim tool lets you cut a segment or side of an object that meets the border of another object, turning them into a single object. ▪ The Fillet and Chamfer tools let you create curved and sharp vertices by intersecting two selected sides.	
9 Click the Annotate tab to add text and tables. The tab is next to the "Insert" tab at the top. This is where you can create text boxes, add tables with multiple rows and/or columns, and more. ▪ Click Single Line or Multi Line on the top-left side of the ribbon toolbar to switch between text styles. ▪ Any text you add will also act as a single object that you can move. ▪ This tab also has a	

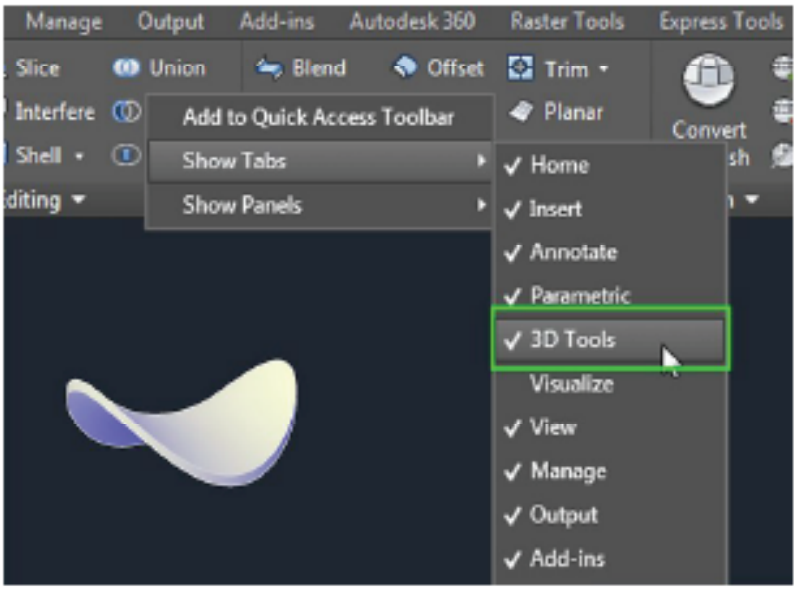
"Dimensions" panel that lets you annotate dimensions of shapes and lines.

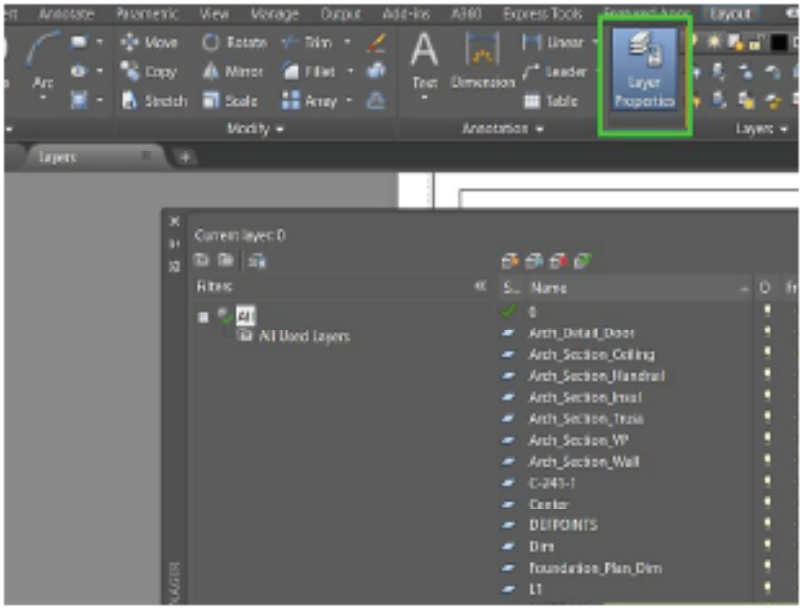


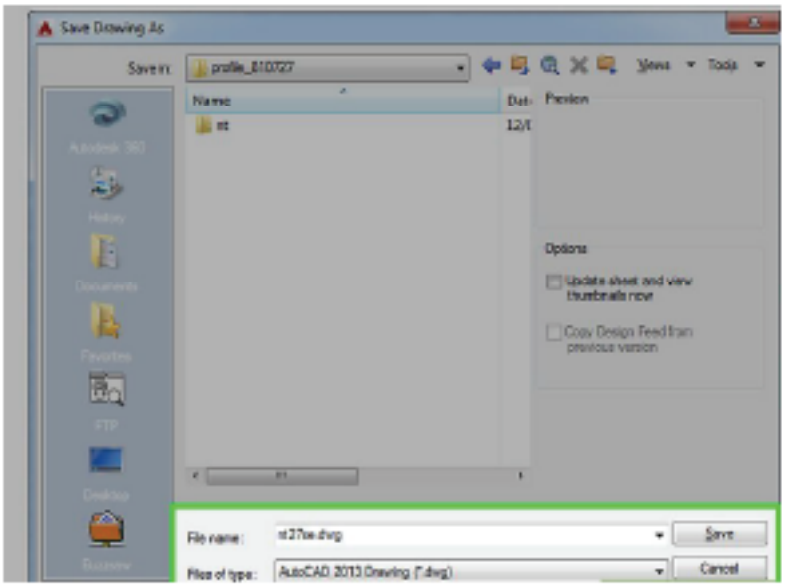
10

Work with 3D objects. There are two ways to switch to a 3D view—one is to drag the Viewcube at the top-right corner of the drawing area in any direction, and the other is to click the Orbit icon in the right panel—it's the circle with an upward-pointing arrow inside.

- Click the 3D Tools tab at the top to open editing tools specific to 3D design. If you don't see this tab, right-click the blank area after the last tab above the ribbon toolbar, open Show tabs, and select 3D Tools.
- Click the down-arrow below "Box" in the "Modeling" panel of the toolbar view and select different 3D objects to draw (e.g., Cone, Sphere, Pyramid). You'll draw the images similar to how you did in regular 2D format, but this time you'll have another axis (the blue line) to work with.
- The shapes will appear as 3D line drawings rather than with volume. You can change this by clicking 2D Wireframe near the top-



left corner of the drawing area and selecting another view, such as Shaded, Realistic, or X-ray. - To turn a 2D object into a 3D one, use the Extrude tool to increase its depth, and/or Revolve to rotate it around an axis.[5] - You can modify 3D objects similarly to 2D objects—click an object to show the blue draggable nodes, then move them around as needed. - The "Solid Editing" and "Surfaces" panels contain advanced editing tools for creating and editing complex shapes.	
11 Place drawings on different layers. When you're working on more complicated drawings, it can be beneficial to place parts on different layers that you can edit, hide, view, and rearrange.[6] Here's some basics to get you started with layers: - On the Home tab, click the Layer Properties icon in the "Layers" panel to display the Layer Properties panel. This shows all layers and what you can do with them. - Click the icon of three sheets of paper with a red-and-yellow circle on its left side (it's the first icon on top of the Layer Properties panel) to create and name a new layer. Now you'll have two layers in the panel. - Double-click a layer to	

select it. The layer with the checkmark is the current layer. ▪ Click the lightbulb on a layer to toggle to hide it/show it. If you're working with particularly large files, use the sun icon to freeze the layer instead of hiding it.	
12 Save your drawing. To save what you're working on, click the A menu at the top-left corner and select Save As, and choose Drawing. This lets you save your work as a DWG file, which is the default AutoCAD format. ▪ Now that you've got the basics down, try drawing an L-shaped stairway or a step pyramid! ▪ As you become proficient with AutoCAD, you'll be able to convert lines into surfaces, surfaces into 3D solids, add realistic material representations, and manipulate light and shadows.	

‘ISSUE FREE NOT FOR SALE’