NCCA

National Council for Curriculum and Assessment
An Chomhairle Náisiúnta Curaclaim agus Measúnachta

Leaving Certificate

Engineering Technology

Ordinary level and Higher level

Draft Syllabus

CONTENT

PREFACE

TECHNOLOGY EDUCATION AT SENIOR CYCLE

Introduction

Technology education is an essential component of the curriculum. In a world where encounters with a wide range of technologies are part of the daily life experience of all people at work or at leisure, students should be equipped to face these encounters with the confidence which comes from learning about, through and with a range of technologies. It is equally important that they gain an appreciation and understanding of the complex interface between technology and society. As citizens they should have the capacity to enter discussion on, and make personal judgements on, issues related to the impact of technology on their own lives, on society, and on the environment.

Through technology education students grow in competence, grow in confidence, become more enterprising and are empowered in terms of their ability to control elements of the physical environment. These are important educational outcomes, which contribute significantly to the provision of a broad and balanced curriculum and illustrate why participation in technology education represents a valuable educational experience.

The nature of technology education

Technology is a distinct form of creative activity where human beings interact with their environments, using appropriate materials and processes in response to needs, wants and opportunities. It integrates problem solving and practical skills in the production of useful artefacts and systems.

More specifically, the value of technology education comes from the use of the wide variety of abilities required to produce a drawing or make an artefact, leading to a sense of competence and a feeling of personal empowerment. The acquisition of manipulative skills is an important component of this sense of competence and can help to give students a feeling of control of their physical environment. In a rapidly changing global society, students need to appreciate that technological capability is necessary and relevant for all aspects of living and working. Many subjects can contribute to the development of a technological capability. However, the technology subjects, which incorporate the principles of design and realisation in a creative manner, are central to this development.

Technological capability includes

- the understanding of appropriate concepts and processes
- skills of design and realisation
- the ability to apply knowledge and skills by thinking and acting confidently, imaginatively, creatively and with sensitivity
- the ability to evaluate technological activities, artefacts and systems critically and constructively.

Leaving Certificate technology subjects

Within the Leaving Certificate, technology education is provided through the subjects Architectural Technology, Engineering Technology, Design and Communication Graphics, and Technology, thereby providing progression with junior cycle. These subjects contribute to a broad, balanced and general education of students, with particular reference to their vocational, further education and training aspirations on completion of the Leaving Certificate.

At a more practical level, the technology subjects at senior cycle share a number of common features. The syllabuses

- are constructed on the basis of core areas of study and optional areas of study, reflecting the different topics and sections within each subject area
- are offered at two levels, Ordinary and Higher
- have been designed for completion in 180 hours of class contact time
- place a strong emphasis on practical learning activity
- include a range of assessment components aimed at assessing student achievement in both practical and theoretical aspects of the subjects.

ENGINEERING TECHNOLOGY
INTRODUCTION AND RATIONALE

Introduction

The Engineering Technology syllabus reflects the changing needs of society. Knowledge, understanding, skill and attitudes acquired during the study of the subject will prepare students to participate fully in the modern technological world. It will contribute to the development of the student's entrepreneurial expertise, autonomous learning and a variety of transferable cognitive and practical skills. A strong emphasis is placed on problem solving, on research and on the design and manufacture of useful artefacts. Within this framework, skill in decision-making is also developed.

The study of Engineering Technology is a homogenous learning experience, which blends practical and theoretical learning into a seamless technology education.

The syllabus has been developed on a modular basis in order to utilise existing facilities and teacher expertise and to allow for the development of the subject within schools currently lacking the full range of recognised facilities. It provides continuity with Junior Certificate Metalwork but study of that course is not a requirement.

Rationale

Engineering Technology is devoted not only to the acquisition of technical skills, but is also concerned with the appreciation of the place and potential of technologies in society. There are many challenges in society that derive from the expansion of knowledge, expertise and information. The acquisition of skills that enable students to develop problem solving strategies and procedures is of paramount importance. The ability to discern the key problems to be solved in a given task will benefit the student greatly and will ultimately lead to increased innovation in the work place.

The workshop environment along with the methodologies used creates the setting for a unique medium of education. The focus of the syllabus is on discovery, innovation, improvisation, creating, researching, understanding, organising and problem solving. Function, form, accuracy and quality of finish of artefacts are important elements of the syllabus, as are verbal, written and graphic communications. The student develops a range of enduring learning processes from the cognitive and effective domains. The combined elements enhance and complete the educational experience.

AIMS

General aims of technology education

1. To contribute to a balanced education, giving students a broad and challenging experience that will enable them to acquire a body of knowledge, understanding, cognitive and manipulative skills and competencies and so prepare them to be creative participants in a technological world.
2. To enable students to integrate such knowledge and skills, together with qualities of co-operative enquiry and reflective thought, in developing solutions to technological problems, with due regard for issues of health and safety.
3. To facilitate the development of a range of communication skills, which will encourage students to express their creativity in a practical and imaginative way, using a variety of forms, including verbal, graphic and model.
4. To provide a context in which students can explore and appreciate the impact of past, present and future technologies on the economy, society, and the environment.

Syllabus Aims

5. To provide a learning environment in which students identify problems, needs or opportunities, and realise appropriate solutions or products through the design process.
6. To enable students appreciate the contribution of engineering and the role of engineering materials in the shaping of world history and commerce.
7. To enable students to appreciate the artistic and cultural heritage of native craft skills.
8. To encourage students to implement appropriate health & safety practices.
9. To stimulate student's appreciation of environmental issues, particularly those that are engineering related.
10. To offer a progression from junior cycle technological subjects and provide a platform for further studies.

OBJECTIVES

The objectives reflect the knowledge, understanding, skills, competencies and attitudes developed through the study of Engineering Technology.

Students will be able to:

- demonstrate a knowledge of syllabus content.
- demonstrate a knowledge and understanding of the underlying theoretical principles of engineering processes and procedures.
- understand how engineering technology contributes to the social, technological, historical, environmental and economic life of society.
- describe how the design process can be used in problem solving.
- understand how information technology can be used in developing ideas and communicating information and facts.
- research, generate and present ideas/solutions in a logical form using appropriate materials/techniques.
- realise tasks/projects from design briefs to appropriate standards.
- design and manufacture artefacts to specified criteria.
- produce from supplied drawings, artefacts/mechanisms to required accuracy and quality of finish in a specified time.
- select and install appropriate motive power and control systems to projects.
- assemble components by permanent and semi-permanent joining methods.
- operate workshop machinery and equipment competently and safely.
- apply elements of sketching, drawing and CAD using recognised conventions.
- control the properties of materials by appropriate treatments.
- investigate the characteristics of materials by experiments.
- express an understanding of the terminology central to the syllabus.
- interpret, analyse and evaluate given data.
- relate an appreciation of the applications of engineering technology in society.
- appreciate the need for health and safety requirements in the workplace and society.

SYLLABUS FRAMEWORK

Syllabus Structure

The syllabus consists of a core comprising practical and theoretical areas of study. All students are required to study the core. In addition, five optional areas of study are included from which students are required to select two. A diagrammatic representation of the syllabus framework is presented on page 8.

The core consists of practical and theoretical elements at an introductory level and is intended as a general introduction to engineering principles and techniques. All elements within the core extend to elements in the options for further study. Emphasis is placed on problem solving, research and design, manufacture of artefacts, health and safety. The core areas of study are:

- Health and Safety
- Manufacturing Techniques and Technology
- Material Science
- Drawing and Design
- Computer Aided Processes (CAD/CAM)
- Power and Energy
- Electronics
- Mechanisms
- Pneumatics.

The five options extend from the core and expand in depth and breath from the elements within the core. The options allow students to expand their knowledge in chosen areas and work to the strength and resources of individual schools. The five optional areas of study are:

- Computer Aided Processes (CAD/CAM)
- Decorative Metal Craft
- Power, Energy and Control
- Manufacturing Techniques and Technology
- Materials Science.

Core Areas of Study

Health & Safety
Materials Science
Computer Aided Processes (CAD/CAM)
Electronics
Pneumatics
Manufacturing Techniques and Technology
Drawing and Design
Power and Energy
Mechanisms

Optional Areas of Study

Students must study any two of the five options

Computer Aided Processes (CAD/CAM)

(topics include)
Drawing functions
Dimensioning
Drawing generation
Printing or Plotting
Computer Aided Machining
CAM Drive systems
Applications of CAM

Decorative Metal Craft

(topics include)
Geometric drawing
Beaten metalwork
Enamelling
Jewellery techniques
Etching
Hot and cold forming
Celtic metalwork

Power, Energy and Control

(topics include)
Power
Energy
Control devices
Computer interfacing
Efficiency of systems
Feedback mechanisms

Manufacturing Techniques & Technology

(topics include)
Manufacture
Machining
Hard soldering
Welding
Shaping of plastics
Joining
Heat treatments
Metrology

Materials Science

(topics include)
Structure of materials
Corrosion
Origin of materials
Production of materials
Materials testing
Recycling

Differentiation between Ordinary and Higher levels

The requirements outlined above apply equally to Ordinary level and to Higher-level students. In general terms, the syllabus at Ordinary level consists of clearly defined content aimed at providing an overview of engineering technology and its applications. At Higher-level, a more analytical, qualitative and quantitative treatment of topics is required. Material designated for examination at higher-level only is indicated by italic text.

Presentation of syllabus

Syllabus content is presented in a tabular format with columns devoted to

- Topics
- Treatment (students will learn about..)
- Learning Outcomes (students will be able to..)
- Applications in Society.

The syllabus as presented does not ascribe any greater or lesser importance to particular areas of study, nor does it imply a particular order of teaching. In these contexts, strategies developed for teaching the course should, in the first instance, promote the aims and objectives of the syllabus.

Health and Safety

The application and implementation of current health and safety procedures for all workshop activities must be observed. A safe working environment should be maintained for all activities and students should be taught the correct safety procedures when using workshop equipment, materials and tools. Students should be aware of the potential dangers and taught the correct safety procedures to minimise risks. Health and safety should be reinforced in the teaching of supporting theory.

ASSESSMENT

Assessment Components

There are two assessment components:

1. A project.
2. A terminal examination paper.

Project

The candidate's ability to integrate the knowledge and understanding, skills and competencies of the syllabus is assessed through his/her solution to a practical problem/project.

The following guidelines apply to the project

- Project design and manufacture requires a total of forty hours class time at both Ordinary and Higher levels.

- Higher-level students are required to undertake a **design and manufacture project** from a given brief. They must also submit an accompanying folder. The theme of the project will emanate from the core areas of study and be enhanced by the study of the options. The project must be manufactured in the school workshop.

- Ordinary level candidates are required to undertake a **dimensioned project from a drawing** with an element of design. They must also submit an accompanying folder. The project must be manufactured in the school workshop.

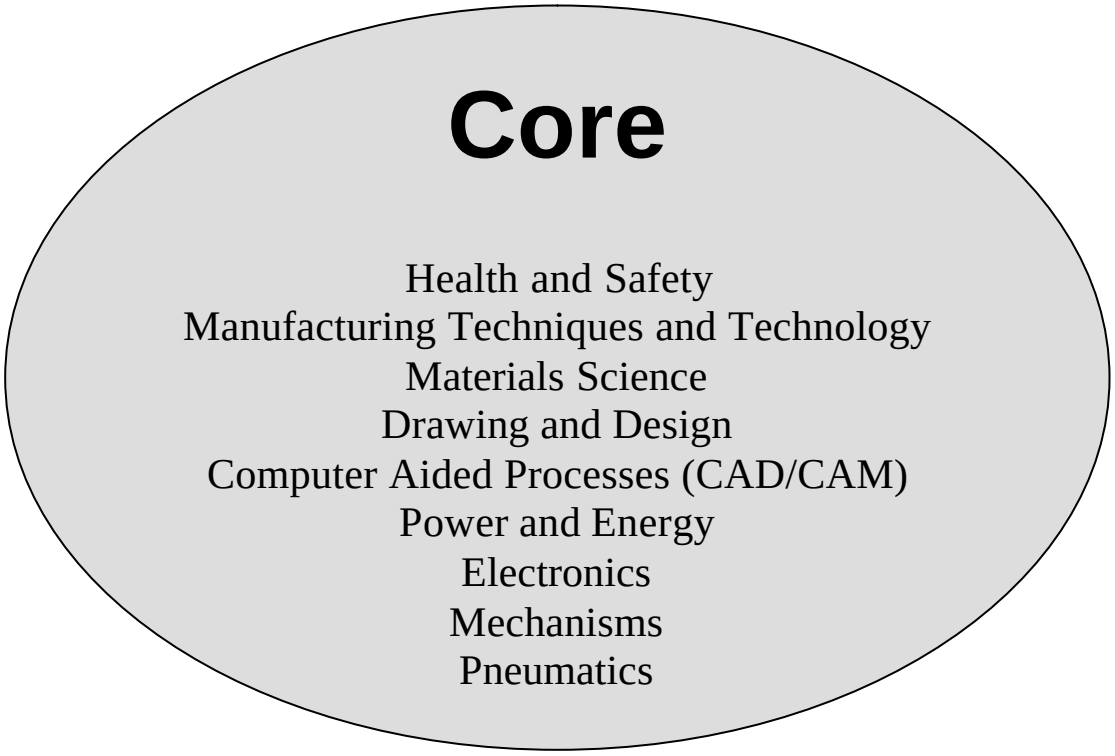
Terminal examination paper

The examination assesses the candidate's theoretical knowledge of syllabus content.

The following guidelines apply to the terminal examination paper:

- The paper at Ordinary level is of two hours duration while that at Higher level is of two and half hours duration

- Both Ordinary and Higher level papers include a Section A devoted to examining the core areas of study and a section B examining the optional areas of study. Fifty per cent of the marks for the terminal examination are allocated to Section A and 50% to Section B.


Core
Health and Safety
Manufacturing Techniques and Technology
Materials Science
Drawing and Design
Computer Aided Processes (CAD/CAM)
Power and Energy
Electronics
Mechanisms
Pneumatics

Health & Safety — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Work environment	♦ Behaviour in an engineering workshop/laboratory.	♦ describe how students should behave in an engineering workshop/laboratory to minimize risks.
Personal Protection	♦ Protective clothing. ♦ Eye protection. ♦ Ear protection. ♦ Respiratory protection. ♦ Skin protection.	♦ select appropriate protective clothing. ♦ select appropriate means to protect eyes, hearing, lungs, and skin.
Hand-tools	♦ Safety procedures for the use of hand tools.	♦ describe the proper methods of using workshop tools.
Machinery	♦ Safety procedures for operating workshop machinery.	♦ list proper safety procedures in the use of workshop machinery.
Electrical	♦ Safety procedures for operating electrical equipment.	♦ list the procedures to ensure the safe use of electrical equipment.
Gas	♦ Safety procedures for working with gas and gas appliances.	♦ list the safety procedures when working with gas appliances.
Adhesives	♦ Safety procedures for working with adhesives.	♦ list the safety precautions required when working with adhesives.
Chemicals	♦ Safety measures when using chemicals.	♦ list the measures to protect the body from the effects of using chemicals.
Computers	♦ The necessity for a proper working environment when using computer equipment.	♦ list the possible effects of using computers equipment that is incorrectly set up.

Manufacturing Techniques & Technology — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		
Marking out	• Marking out instruments.	• interpret drawing instructions and mark out desired shapes using a variety of measuring and marking out instruments.
Shaping	• The use of regular hand and power cutting tools.	• cut desired shapes using manual and power assisted tools.
Bending & folding	• Bending angles, scrolls and twists. • Strip heated/hot wire bending. • Strip heated/hot wire bending of sheet.	• bend and shape light gauge metals. • heat, bend and shape plastics. • heat, bend and shape plastic sheet.
Surface finish	• Filing, emery and steel wool finishes. • Painting & Dip Coating.	• present artefacts with a quality finish. • prepare and apply protective/decorative coating to metals.
Lathe	• Removing material from two axes. • Forming. • Drilling. • Taper Turning.	• Face off and machine components to set diameters. • produce chamfers. • create centre holes, pilot and drill using tailstock. • set up half included angle on the compound slide to machine shoı tapers.

Manufacturing Techniques & Technology — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical (continued)		
Drilling machine	• Drilling.	• use straight & taper shank twist drills to drill holes in materials. • use the drilling machine to produce, pilot, tapping, clearance, countersunk & counter bored holes with second drill bit.
	• Adjusting machine speed.	• adjust machine speeds as appropriate for different size drills.
Soldering	• Joining of light sheet metal. • Fluxes.	• produce permanent and semi-permanent joints using suitable materials by means of standard techniques.
Welding	• Resistance welding of light sheet metal.	• permanently fabricate by resistance welding thin sections of a variety of metals.
Adhesive	• Use of common adhesives.	• choose and use appropriate adhesive for a variety of materials.
Fasteners	• Pop rivets, self-tapping screws, machine screws, pins and threading.	• choose appropriate fasteners for assembly.

Manufacturing Techniques & Technology — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory		
Marking out & measurement	• Marking out instruments.	• explain the use of a range of marking out instruments such as the rule, measuring tape, squares, surface gauge, and protractor.
	• Vernier Caliper's and Micrometer.	• read Vernier Calipers and Micrometer. • explain the range of accuracy's available.
Cutting tool geometry	• *Point angles of single point cutting tools.*	• *explain the cutting action of single point cutting tools.* • *identify the rake, clearance and cutting tool angle.*
	• *Materials used in workshop-cutting tools.*	• *list the materials used in workshop cutting tools.*
	• *Cutting speed.*	• *explain the importance of choosing the correct speed when machining.*
Surface finish	• Surface finish as a means of quality control.	• explain the importance of surface finish as an element in quality control.
	• Methods of protecting materials.	• explain the principles of painting and plastic coating as used for protection and decorative purposes.

Manufacturing Techniques & Technology — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory (continued)		
Lathe	♦ Features: - ♦ Headstock. ♦ Tailstock. ♦ Topslide. ♦ Apron. ♦ Bed.	♦ list the main parts of the lathe.
	♦ Accessories: - ♦ Tool post, Tool holder and Centre drill.	♦ describe the function of the lathe and it's accessories.
	♦ Work holding using the 3 Jaw chuck.	♦ explain how work is held in the lathe using a 3-jaw chuck.
	♦ Main lathe operations as used in school workshops.	♦ list the main lathe operations.
Drilling machine and operations	♦ Drilling machines.	♦ list a variety of fixed pedestal and hand held drilling machines and their uses.
	♦ Parallel and morse taper drill bits.	♦ Distinguish between morse taper and parallel drill bits. ♦ *list the angles of the cutting point of a twist drill for mild steel.*
	♦ Countersinking and counter-boring.	♦ describe the process of countersinking and counter-boring.
Joining	♦ Principles of soldering, resistance welding, riveting, screw fasteners, pins and adhesives.	♦ describe appropriate joining methods for different materials and applications.

Materials Science	Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		
Materials Testing	• Comparative tests to illustrate the following properties or phenomenon of mild steel, high carbon steel, aluminium and copper: - ◦ Hardness. ◦ Conductivity. ◦ Toughness. ◦ Elasticity. ◦ Malleability. ◦ Magnetism.	• prepare and use workshop experiments to compare the properties of materials.
	• Use the following tests to identify various thermoplastics and thermosetting plastics: - ◦ Visual. ◦ Tactile. ◦ Cut. ◦ Float. ◦ Thermal	• prepare and use the tests specified to identify the different thermoplastics and thermosetting plastics indicated. ◦ Polyvinyl chloride. ◦ Nylon. ◦ Polyethylene. ◦ Acrylic. ◦ Polystyrene. ◦ Phenol formaldehyde. ◦ Polyurethane. ◦ Polyester Resin. ◦ Polycarbonate.
Structure of Materials	• Hardening and Tempering.	• harden and temper high carbon steel to change its properties.
	• Annealing.	• anneal steel and copper to change their properties.

Materials Science	Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory		

Properties of Materials	• The properties of: -
	  • Ferrous metals.
	  • Non-ferrous metals.
	  • Pure metals.
	  • Precious metals.
	  • Alloys & Composites.
		• give reason for selecting materials as a result of their properties.
		• list the properties of materials.
		• compare the properties of different groups of metals.

Origin and production of materials	• *Types of mining.*	• *describe the following mining methods: Opencast, open-pit, dredging, underground and solution mining.*
	• Mining, *concentration and extraction of iron ore.*	• describe the mining process *and explain how the iron ore can be extracted.* • list the ores of iron, aluminium, copper and zinc.
	• Production of plain carbon steels.	• explain the production of carbon steels with reference to the Blast, Basic Oxygen and Electric Arc furnaces.
	• *Sources of plastics.*	• *list the sources of plastics.*

	• *Polymerisation*
	  • *Addition Polymerisation.*
	  • *Condensation Polymerisation.*
	  • Copolymerisation.
		• *Describe the polymerisation and copolymerisation of Polyethylene, Phenol-Formaldehyde and Polyvinyl acetate.*

Materials Science — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory (continued)		
Recycling	♦ Advantages of recycling metal, plastic and glass.	♦ explain why materials are re-cycled. ♦ explain the potential of materials for re-cycling.
Structure of Materials	♦ States of matter, solid, liquid and gas.	♦ identify the different states of matter.
	♦ Heat Treatment: - ♦ Hardening & Tempering ♦ Annealing. ♦ Normalising.	♦ describe how to change the structure of steel by: - ♦ Hardening & Tempering ♦ Annealing ♦ Normalising ♦ describe how to change the structure of copper by: - ♦ Hardening ♦ Annealing
	♦ Upper and lower critical lines and eutectoid point on steel equilibrium diagrams.	♦ interpret the upper and lower lines and eutectoid points for steel between 0% to 1.4% carbon content and up to 1000^0C. ♦ *describe how to use the steel equilibrium diagram to identify areas for:-* ♦ *Annealing.* ♦ *Hardening and tempering.* ♦ explain how oxide colours can be used for:- ♦ tempering of steel.

Materials Science		**Core**
Topic	**Treatment of Topic** **Students will learn about..**	**Learning Outcomes** **Students will be able to..**
Support Theory (continued)		
Corrosion	• Chemical and *electrochemical forms* of corrosion.	• describe oxidation and *electrochemical* corrosion. • *explain the corrosive effects of metals with reference to the electrochemical series.*
	• Prevention of corrosion.	• explain the necessity for corrosion prevention in various settings.
	• Chemical *and electrochemical forms of* protection.	• explain how oxide coatings can be used in material protection. • *describe how the electrochemical series can be used in corrosion protection.*
	• Design.	• describe appropriate material selection criteria so as to minimize corrosion in different settings.

Drawing & Design — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		
Freehand sketching	♦ Visual images.	♦ sketch 2D explanatory line diagrams.
Orthographic drawing	♦ Orthographic drawings.	♦ use instruments and freehand drawing to produce orthographic views.
Pictorial drawing	♦ Producing pictorial representations.	♦ produce representations of artefacts on isometric grid paper.
Geometric drawing	♦ Use drawing instruments to produce developments such as rectangular, or circular containers.	♦ mark out developments.
Presentation and reporting.	♦ Design sketching and drawing. ♦ Engineering drawings. ♦ Use of models. ♦ Reports and displays. ♦ Information and communication technology.	♦ use freehand sketching to communicate ideas. ♦ interpret working drawings and exploded views. ♦ use models to represent and demonstrate design ideas. ♦ compile and present a product design report using a range of media.
Framework for designing.	♦ *Research.* ♦ Briefs and specifications. ♦ Planning of solution. ♦ Prototype. ♦ Evaluation.	♦ *use a design process in problem solving.* ♦ design and make solutions to problems.

Drawing & Design — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory		
Product design.	♦ *Product.* ♦ *Case study.* ♦ *The designer in action.* ♦ *Evaluation as an ongoing process.*	♦ *describe the characteristics of the design process in the context of problem solving.*
Framework for designing.	♦ *Research (including electronic media).* ♦ Briefs and specifications. ♦ Planning of solution. ♦ Prototype. ♦ Evaluation.	♦ *explain the strategic steps in problem solving and creation of new designs.* ♦ test and evaluate product performance.
Presentation and reporting.	♦ Design sketching and drawing. ♦ Engineering drawings. ♦ Reports and displays. ♦ Information and communication technology.	♦ interpret working drawings and exploded views. ♦ compile and present a product design report using a range of media.

Computer Aided Processes (CAD/CAM) — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		

Drawing functions	• 3-D CAD Drawing.	• use CAD to:
		  • Create a basic profile.
		  • Generate a solid from a profile.
		  • Produce a dimensioned working drawing from the solid.
		  • Manipulate a solid model using zoom, pan and rotate commands
		  • Print or plot work to appropriate scales and orientations.

CAM Part program	• Define a profile.	• define a profile for CNC lathe to produce linear tool movements (parallel & angular) and part off to correct length.
CAM Simulation	• Use computer terminal to test program.	• run simulation of program on screen.

Computer Aided Processes (CAD/CAM) — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory		
Computer terminology	• Computer terminology.	• explain common computer terms. • explain the difference between operating & application software.
CAD hardware.	• Methods of inputting data. • Methods of outputting data.	• identify and state the function of the constituent components of a typical CAD workstation.
CAM Principles	• Principles of two axes programming. • Identification of Z and X axes. • Movements in the Z and X axes.	• explain the principle of cutting tool axis. • identify the Z and X axes on a CNC Lathe. • simulate the movement of the cutting tool towards and away from chuck and set at correct diameter.
CAM Co-ordinates	• Principles of using absolute co-ordinates.	• determine the absolute co-ordinates of a component to be produced.

Power & Energy — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		
Engines	♦ The four-stroke engine cycle.	♦ demonstrate the four-stroke engine cycle - restricted to single cylinder - spark ignition engines.
Electric Motors	♦ The principle of the electric motor.	♦ Use a model to demonstrate the principle of the electric motor. ♦ manufacture an Electro-magnet.
Cells and Batteries	♦ Current produced from electrolyte and two dissimilar metal plates.	♦ use copper, zinc and electrolyte to produce a simple cell. ♦ construct a simple cell from everyday materials to operate a LED.

Power & Energy — Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory		
Engines	♦ The four-stroke engine cycle.	♦ draw a schematic diagram of an internal combustion engine showing the main parts and how they operate. ♦ use sketches to explain the stages of the four stroke cycle.
Electric Motors	♦ The principle of the electric motor.	♦ explain how to construct an Electro-magnet. ♦ *sketch and identify the main parts of a DC motor.*
Cells and Batteries	♦ Current produced from electrolyte and two dissimilar metal plates.	♦ describe how copper, zinc and electrolyte could be used to produce a simple cell. ♦ describe how to construct a simple cell from everyday materials to operate a LED.
Energy	♦ Concept.	♦ describe the concept of energy as the capacity to do work. ♦ give examples of different forms of energy such as light, heat, electrical, potential and kinetic. ♦ list renewable energy sources.
	• Conservation.	♦ describe the conservation of energy, i.e., energy neither created, nor destroyed.
	• Conversion.	• give examples of energy conversion. ❑ Mechanical to heat. ❑ Electrical to mechanical. ❑ Chemical to mechanical. ❑ Mechanical to electrical.

Electronics		Core
Topic	**Treatment of Topic** **Students will learn about..**	**Learning Outcomes** **Students will be able to..**
Practical		
Electronic circuits	• Use resistors, diodes, LED's *and NPN transistors* to produce circuits. • *Light Dependent Resistors, variable resistors or thermistors.* • Circuit soldering and de-soldering.	• build circuits using a selection of the named components. • *use Light Dependent Resistors, variable resistors or thermistors in a circuit.* • use the electric soldering iron for electronic circuits and repairs.
Transistor Circuits	• *Using the transistor as a switch.*	• *produce circuits to include a transistor.*
Measurement	• *Use multi-meter to measure voltage and resistance.*	• *use a multi-meter to measure DC voltage in a circuit.* • *use a multi-meter to measure resistance of known and unknown resistors.*
Support Theory		
Electronic Units	• Volts, Amps, Ohms.	• define Volts, Amps, Ohms and differentiate between the different terms.
	• *Ohms law.*	• *Define Ohms law and perform calculations to determine current, voltage, or resistance when two elements are known.*
Sensitive circuits.	• *The use of components such as the LDR's, thermistors and variable resistors as sensors in transistorised circuits.*	• *explain the main characteristics of variable resistors, LDR's and thermistors.* • *specify one application for each component.* • *draw circuit diagram with components in place.*

Mechanisms		**Core**
Topic	**Treatment of Topic** **Students will learn about..**	**Learning Outcomes** **Students will be able to..**
Practical		
Levers	• The three classes of levers.	♦ demonstrate the three classes of levers using pre-prepared kits. ♦ identify lever types and apply systems using the lever to gain mechanical advantage.
Pulleys & belt drives	♦ Belt drive systems.	♦ show the concept of transmitting motion from one shaft to another using ready-made pulleys, axles and belts.
Gears and gearing	♦ Creating a simple gear train.	♦ create a simple gear train to show how power is transmitted through gears using suitable kits.
	♦ *Creating a compound gear train..*	♦ *demonstrate a compound gear train using a suitable kit.* ♦ *demonstrate the difference between simple and compound gear trains using suitable kits*.

Mechanisms		Core
Topic	**Treatment of Topic** **Students will learn about..**	**Learning Outcomes** **Students will be able to..**
Support Theory		
Force.	• Defining a force.	• explain the term force.
Levers	• Principle of the lever. • How a lever amplifies force. • *Mechanical advantage.*	• give example of systems using levers. • *calculate mechanical advantage.*
Pulleys & belt drives	• Types of pulleys and belts, flat, vee and toothed. • Advantages of different type of pulleys systems for lifting,	• give example of belt drives. • explain the advantages and disadvantages of the different type of drives and pulleys.
Gears and gearing	• *Calculation of simple gear ratios.*	• *calculate simple & compound gear ratios.*

Pneumatics	Core

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		
Pneumatic Circuit	♦ A pneumatic circuit that includes a single/double-acting cylinder.	♦ Demonstrate a pneumatic circuit that includes a single/double-acting cylinder ♦ show how to connect air supply to a circuit.
Valves	♦ A three-port valve.	♦ Demonstrate the use of a three-port valve.
Support Theory		
Terminology & symbols	♦ Terminology and symbols used in pneumatics.	♦ identify single/double acting cylinder, 3-port valve, main & exhaust air as used in pneumatic circuits.
Supply & distribution	♦ Diagrams of pneumatic circuits. ♦ Control of single acting cylinder with 3-port valve. ♦ Control of double acting cylinder with two, 3-port valves.	♦ identify pneumatic circuits using the appropriate symbols. ♦ describe the use of a control valve in a pneumatic circuit. ♦ explain the importance of air pressure and safety checks. ♦ *draw and explain pneumatic circuits using appropriate symbols.*
Cylinders	▪ *The principle and operation of the single and double acting cylinder.*	♦ *explain the use of single and double acting cylinder in circuits.* ♦ *explain the difference between single and double acting cylinders.*

Options

Computer Aided Processes (CAD/CAM)
Control System
Decorative Metal Craft
Manufacturing Techniques & Technology
Materials Science

Computer Aided Processes (CAD/CAM) — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		
Design	• The use of CAD in design.	• apply CAD techniques and skills in solving design problems.
Drawing functions	• Additional commands.	• use CAD to: ❑ Create profiles in different work planes. ❑ Generate composite solid models.
Dimensioning	• Adding dimensions to modify a 3-D model.	• accurately modify 3-D models.
Drawing Generation	• *Generating drawings of parts and assemblies.* • *Basic animation of assemblies.*	• *generate drawings that are fully associative with the solid model.* ❑ Elevation, Plan and End Elevation. ❑ Sectioned Views. ❑ Isometric View.
Printing or plotting	• Page/sheet layout. Printing or plotting to various scales and orientations.	• print or plot work to appropriate scales.
Computer Aided Machining (CAM)	• Use CNC lathe to machine component.	• set up CNC lathe prior to machining. • load appropriate cutting tool, or tools . • *set tool offsets.* • perform safety check before machining. • produce pre-programmed component.

Computer Aided Processes (CAD/CAM) — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory		
Drawing functions	• Drawing commands. • Generating solid models from a profile.	• describe appropriate CAD commands used in the creation of profiles. • describe the process of generating a solid model from a profile.
Dimensioning	• *Adding dimensions to modify solid models.*	• *explain how the application of dimensioning can modify a solid model.* • *explain that changes in either the solid model or generated drawings are associative.*
Printing or plotting	• Page / sheet layout. Printing or plotting to various scales and orientation.	• explain how to print or plot drawings.
Drive system for CAM	• *The principle of stepper motor operation and their use in CNC machining.* • *The principle of photo-electric encoders and their use in CNC machining.* • CAM applications in industry.	• *describe how stepper motors operate and explain their use in controlling spindle speeds and slide movements.* • *identify where and why photo-electric encoders are used in CNC machining.* • List CAM applications in industry.
Applications of CAM	• Advantages and disadvantages of CNC systems.	• describe applications of CNC processes. • list the advantages and disadvantages of CNC processes.

Decorative Metal Craft — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		
Design	♦ The use of decorative design in enhancing the appearance of artefacts.	▪ use decorative design techniques in completing project briefs.
Geometric Drawing	♦ Development of prisms and pyramids. ♦ *Development of truncated prisms and pyramids.* ♦ Polygons. ♦ Ellipse. ♦ Parabola.	♦ produce developments of prisms and pyramids. ♦ *produce developments of truncated prisms and pyramids.* ♦ construct polygons. ♦ construct an ellipse. ♦ construct a parabola in a rectangle.
Beaten metalwork	♦ Hollowing, Raising, Planishing. ♦ *Sinking, Repoussé, Chasing*,	♦ employ these techniques in the manufacture of a bowl/*dish/plate/goblet /cup.*
Jewellery work	♦ Piercing in copper. ♦ Manufacture of Jewellery.	♦ use a piercing saw. ♦ manufacture of chains, rings, necklaces, bracelets, pendants and brooches.
Enamelling	♦ Surface preparation and fluxes. ♦ Firing - torch, kiln, temperature control.	♦ use the enamelling technique including *champlevé enamelling* in the manufacture of decorative artefacts.
Etching	♦ Acids and resists for *brass, copper* and aluminium. ♦ Producing an etched design on *a brass, copper* or aluminium artefact.	♦ use the corrosive and protective effects of acids and resists to produce designs on metals.

Decorative Metal Craft — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical (continued)		
Surface Treatment	• *Oxidation.* • Anodising.	• *use the process of chemical corrosion and oxidation to produce decorative finishes on metals.* • *anodise aluminium.*
Surface finishing	• Polishing. • Mottling. • Lacquers.	• produce different surface finishes for decorative, or protective purposes.
Edge finishing	• Beaded edge, wired edge, folded seam.	• produce the edges indicated.
Hot and cold forming	• Drawing down. • Turning an eye. • Twisting. • Scrollwork. • Riveting.	• manufacture artefacts incorporating the techniques mentioned.
Joining Processes	• Silver Soldering. • Brazing. • Manual Arc, and Inert Gas welding.	• prepare surfaces for soldering, brazing and welding. • join materials using silver soldering, brazing and welding.
Casting	• Casting of low melting point alloy with supplied, or prepared silicon moulds. • Casting of polymers.	• cast metal components. • cast polymer components.

Decorative Metal Craft — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory		
Casting	• Casting techniques.	• describe the techniques of, investment and silicone casting.
Jewellery Techniques	• *Stone setting.* • Polishing.	• *describe how stones are set and secured in decorative craft-work and jewellery.* • describe how metals and stones are polished.
Enamelling	• Types of enamel. • Forms of supply - powder, rod, etc. • Surface preparation, fluxes. • Firing by torch and kiln. • Applications of enamel.	• *identify the source of pigments.* • describe enamelling techniques used in the manufacture of decorative artefacts. • describe how enamels are applied using the following techniques: - ❑ Free dusting. ❑ Stencilling ❑ *Champlevé* ❑ Paste • *list methods of temperature control.*
Etching	• Acids and resists for *brass, copper* and aluminium	• explain how acids and resists are used to produce a design.

Decorative Metal Craft — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory (continued)		
Decorative Finishes	• Planishing, mottling and surface texturing. • *Anodising*, lacquering.	• explain how these surface finishes are achieved. • describe how to produce different surface finishes on artefacts. • *describe the chemical process of anodising.*
Edge Finishing	• Beaded edge, wired edge and folded seam.	• describe how to produce these edges.
Hot and Cold Forming	• Drawing down. • Turning an eye. • Twisting. • Scrollwork. • Riveting – Snap and Countersunk head.	• describe the principles of each of the processes and techniques listed.
Joining Processes	• Rivets. • Preparation of surfaces and use of fluxes. • Silver soldering • Brazing. • Manual Arc and *Inert Gas Welding.*	• describe the principles of each of the processes and techniques listed.
Celtic Metalwork	• Study of the techniques used in the manufacture of the 8^{th}. century Ardagh Chalice, 10^{th}. century Thistle brooch and a bronze age spear head.	• describe the skills and techniques employed by Celtic Metalworkers in the manufacture of the named items.

Energy Power & Control — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		
Design	• The use of control devices in solving design problems.	• identify and apply control devices in solving design problems.
Energy	• A working generator.	• construct a working generator.
Control device	• *Constructing a model unit incorporating a control device.*	• *construct a control loop to control pneumatic and electronic systems.*
Computer Interfacing	• Computer interfacing.	• Use a computer to power or control a device.
Support Theory		
Energy	• Methods of storing energy, fossil fuels. • The Joule as a unit of energy. • Conversion of energy (Electrical to Heat) Electrical energy = Watts x Time Heat energy = Change in temp x Specific heat capacity x mass.	• list the various types of energy. • calculate the amount of electrical energy required to raise the temperature of a quantity of water by a given amount.
	• Calorific value.	• explain the difference between fuels of high calorific value and low calorific value.
Work	• Work = Force x Distance.	• define work as moving a force over a distance.

Energy Power & Control — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory (continued)		
Power	• *Mechanical power =* $\frac{\text{Force (N) x distance (m)}}{\text{time (s)}}$ = Nm / s = J / S = Watts.	• *define power as the rate of doing work, unit of power as the:* *Watt = Joule / sec = Nm / sec.*
	• *Electrical Power = volts x amps.*	• *define electrical and mechanical power.* • *manipulate formula to perform calculations.*
	• *Engines.*	• *describe the engine as an energy converter.*
	• *Electrical generator.*	• *sketch an electrical generator.* • *explain the principle of the electrical generator.*
Efficiency of systems	• *Efficiency of systems expressed as: -* $\frac{\text{Useful energy, or work output}}{\text{Energy input}}$	• *calculate efficiency from given data with answer given as a percentage.* • *list the reasons why energy output is less than energy input in various energy conversion systems.*

Energy Power & Control — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory (continued)		
Control	• Elements of a control system.	• *describe a control loop incorporating input, processing and output.* • list methods of input, processing and output in a system.
	• Transducers, sensors and actuators.	• explain the principle of operation of transducers, sensors and actuators. • specify transducers sensors and actuators to suit specified applications.
	• Feedback.	• explain the meaning of feedback as applied to control systems.
	• Mechanical control.	• explain the use of weights in pressure control, governors in machines, and centrifugal clutches and brakes.
	• Electronic control.	• describe the function of infra-red sensors, amplification and integrated circuits.
	• Computer control.	• describe the use of some form of computer interface control.
	• Pneumatic control.	• explain how the five port valve operates. • list common applications of the five port valve.
	• Design	• combine the different control systems in solving design problems

Manufacturing Techniques & Technology — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		
Design	• Framework for Design.	• apply design techniques to given briefs.
Manufacture	• Designing and manufacturing components/tasks/artefacts from a variety of materials, utilising approved techniques and processes.	• design and produce artefacts from a variety of materials. • interpret given drawings/instructions and produce components to requirements.
Lathe Turning	• Reaming.	• use the reamer to produce accurate machined holes.
	• Knurling and parting off.	• use the knurling tool to produce a serrated finish on components. • part off material to required lengths. • manufacture turned components.
	• *4-Jaw chuck/eccentric turning.*	• *turn a component to required diameter using off-centre turning in the 4-jaw chuck.*
	• Turning between centres.	• Set up and turn a component between centres. • distinguish between oblique and orthogonal cutting tools.
Grinding	• Regrinding of lathe tools to suit machining operations. (Demonstration only)	• observe the regrinding of a lathe tool.
	• The dressing of a pedestal/bench grind-wheel using a star wheel dresser. (Demonstration only)	• observe and appreciate the need for routine grind-wheel maintenance.
	• Tool rest adjustment of a pedestal/bench grind-wheel.	• adjust the tool rest.

Manufacturing Techniques & Technology — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical (continued)		
Soldering	• Silver Soldering. • Brazing.	• join light gauge metals using silver soldering or brazing.
Welding	• Oxy/acetylene welding.	• control the welding flame. • regulate the gas pressure. • fuse two or more metals using a gas flame and appropriate filler rod.
	• Manual Arc /Inert Gas welding.	• fuse metals using either manual arc or inert gas welding plant.
	• Thermal welding of plastics.	• weld plastics using hot air gun.
Heat Treatment	• *Normalising.*	• *normalise the structure of worked steel by cooling the steel in air and compare the pre and post state.*
	• Case hardening.	• increase the durability of the surface of low carbon steel by the pack carburising method.

Manufacturing Techniques & Technology — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory		

Lathe Turning	• Work holding:
	  • 4-jaw chuck.
	  • Revolving centre.
	  • Carrier and driving plate.
		• describe the 4-jaw chuck, revolving centre and turning between centres.

	• *Cutting tool forces.*	• *describe the oblique and orthogonal forces on the lathe cutting tool.*
	• Speed and feed.	• explain the relationship between feed, speed and power consumption.
Grinding	• Loading.	• explain the term loading.
	• Glazing.	• explain the term glazing.
	• Dressing, routine care and maintenance of pedestal/bench grind-wheels.	• explain the need for grind wheel maintenance. • describe the necessity for tool rest adjustment.
	• *Structure of grind-wheel:* *Grit, grade and bonding material.*	• *describe the structure of grind-wheels.*
Brazing	• The brazing process.	• describe the brazing process in the joining of light gauge materials.

Manufacturing Techniques & Technology — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory (continued)		

Welding	• Gas Welding: -
	  • Equipment.
	  • Nozzle and gas pressure.
	  • *Gas regulator.*
	  • Welding flames.
		• list the function of the individual parts of gas welding equipment.
		• describe the relationship between metal thickness, nozzle size and gas pressure.
		• *describe the function of the gas regulator.*
		• identify and describe the neutral, oxidising and carburising flames.

	• Manual Arc, CO2, *MAG and TAG welding*.	• describe the operation of the listed electric welding units. • *describe the MAG and TAG welding processes.*
	• Thermal welding of plastics.	• describe the principle of hot air welding of plastics.
Hot forming of metal	• Drop forging.	• describe the principle of drop forging. • *explain with reference to grain structure and advantage of forging over machining.*
	• Extrusion.	• describe the principle of hot extrusion.
	• Hot rolling.	• describe the principle of hot rolling. • give an advantage and disadvantage of hot rolling metals.

Manufacturing Techniques & Technology — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory (continued)		
Shaping of Plastics	• Vacuum forming. • Blow moulding. • Extrusion. • *Compression forming.* • Injection moulding. • Calendaring.	• describe the named production methods in the shaping of plastics.
Heat Treatment	• Annealing of steel and copper.	• describe how the annealing process relieves stresses in copper and steel. • *describe how the annealing process affects re-crystallisation and grain structure.*
	• Normalising of steel.	• describe the normalising process. • *explain the difference between normalising and annealing.*
	• Case Hardening of mild steel.	• describe the pack carburising process. • explain the relationship between time, temperature and depth of case. • *discuss the advantages of manufacturing components from mild steel while achieving a hardened durable surface.*

Metrology	• Limits and Fits.	• explain how plug and gap gauges are using for batch testing.
		• explain the difference between: -
		  ◦ Clearance fit
		  ◦ Transition fit
		  ◦ Interference fit.

Materials Science — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Practical		
Design	• Properties and characteristics of materials to fulfil design criteria.	• use and select materials to fulfil design criteria.
Classification of Materials	• Identification of materials named in the syllabus as ferrous, non-ferrous, polymer, composite, or ceramic.	• distinguish materials as ferrous and non ferrous, polymer, composite and ceramic. • select appropriate materials within the context of design activities.
Structure of Materials	• Crystalline structure.	• assemble models to demonstrate crystalline structure of the unit cell:-- B.C.C., F.C.C., and C.P.H.
	• *Micro* and macro examination of pre-prepared samples of steels.	• visually examine pre-prepared samples of steel to examine grain size and grain boundaries • *use a microscope to examine pre-prepared samples of steel to identify grain size and grain boundaries.*
Corrosion	• Electrochemical series.	• perform practical test to determine the corrosive effects on different combinations of metals with respect to their relative positions in the electrochemical series.
	• *Sacrificial protection.*	• *setup sacrificial protection experiment to compare sacrificial protected metals and unprotected combinations.*

Materials Science — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory		
Structure of Materials	• Ionic bond. • Covalent bond. • Metallic bonds.	• describe the properties of materials resulting from ionic, covalent and metallic bonds with reference to their position in the periodic table.
	• Imperfection in crystallisation.	• describe imperfections in the crystal structures.
	• *Substitutional and interstitial solid solutions.*	• *explain substitutional and interstitial solid solutions.* • interpret and label equilibrium diagrams.
	• The allotropy of iron and the iron/carbon equilibrium diagram from 0% to 1.4% carbon and to 1000^0C. • Phases and critical points, *eutectoid*, upper and lower critical lines.	• extract information from iron / carbon equilibrium diagrams.

	• *The structure of steel.*
	  ◦ *Ferrite.*
	  ◦ *Pearlite.*
	  ◦ *Cementite.*
	  ◦ *Martensite.*
	  ◦ *Austenite.*
		• *identify, name and describe the structures listed.*

	• Classification of plastics: -
	  ◦ Thermoplastics.
	  ◦ Thermosetting plastics.
		• name, classify and give uses for: -
		PVC, Nylon, Polythene, Polystyrene, Phenol-Formaldehyde, Polyurethane, Polypropylene and Polyester Resin.
		• describe the structures of: -
		PVC, Nylon, Polythene, Polystyrene, Phenol-Formaldehyde, Polyurethane and Polyester Resin.

Materials Science — Option

Topic	Treatment of Topic Students will learn about..	Learning Outcomes Students will be able to..
Support Theory (continued)		
Materials testing.	• Destructive testing Brinell, Vickers, Rockwell, Izod, extensometer, and cyclic. • Non-destructive testing: X-ray, ultrasound, and dye.	• describe the individual tests to determine hardness, toughness, tensile strength, and fatigue. • *describe the merits of the individual tests to determine hardness, toughness, tensile strength, and fatigue.* • give an application for each of the tests.
Corrosion	• Electrochemical series: • Effects of corrosion on the environment. • Design.	• *give a brief description of the effects of corrosion on combinations of different metals arising from their position in the electrochemical series.* • explain how the environment will benefit by adhering to good design practice. • explain how good design is used to minimise corrosion.

Origin and production of materials	• Ore concentration.
	• Production of aluminium and copper.
	• Recovery and recycling.
		• *describe the following methods of ore-concentration (dressing): - floatation, magnetic, gravity and amalgamation.*
		• describe the production of aluminium from bauxite.
		• describe the production of copper from chalcopyrite.
		• describe the recycling process for:
		  ◦ Steel.
		  ◦ Aluminium.
		  ◦ Plastics.
		• list the advantages and disadvantages of recycling.
		• describe the environmental, economic and social implications of recycling.