SEC SYLLABUS (2020)

DESIGN AND TECHNOLOGY **SEC 33**

SYLLABUS

DESIGN AND TECHNOLOGY SEC33 (Not available in September)
Syllabus Paper I: Iterative Project + Paper II: 2 hrs

1. Introduction

Design and Technology is a multidisciplinary subject that calls on students to become entrepreneurial, creative and problem solvers through a design and make methodology and the application of relevant technology education. The applied academic, yet, practical nature of Design and Technology [D&T] provides a distinctive constructivist approach to learning, which caters for a wide spectrum of student learning styles.

The syllabus expands significantly in the **Design Aspect** with a deep focus on innovation, research and entrepreneurial skills and attitudes and established design thinking methodologies as a learning vehicle for critical thinking, enquiry skills, creativity and self-development.

The **Technology Aspect** is dynamic and reflects the fast changing needs of a modern digital society, which strives for both experiential and technological innovation. The areas of study in technology for this syllabus are designed to foster a multidisciplinary approach by streamlining strands that can be delivered simultaneously, thus focusing on *Materials and Making, Systems and Control* and *Design Graphics.* These are not only very relevant in every aspect of product innovation and engineering, but also inductive of a holistic approach towards technology. These areas shall be considered as a single Technology Aspect and students will work within these strands in parallel, allowing for cross disciplinary projects to be tackled by the students as a means of learning by designing and doing. Individually, the areas covered in both Design Aspect and Technology Aspect are defined as follows:

Design Aspect

- ***Design****, Entrepreneurship and Innovation.*
- ***Data*** *collection and Interpretation*
- ***Critique****, Implications and Evaluation*

Technology Aspect

- ***Materials*** *and Making*
- ***Systems*** *and Control*
- ***Graphics****, Communication and Digitisation*

Note: Throughout this document the strands shall be referred to in short, by their first term (as shown in **bold**).

The above Design and Technology areas are intended to be delivered in a spiral approach, focusing on individual or combined Technology Aspects through applied design projects.

2. General Aims

The syllabus aims to give students the opportunity to develop their abilities in the area of Design and Technology through:

i. activities involving the designing and making of quality products, whether new or modified from existing items, to meet specific purposes by addressing the needs, wants and values of the intended users;
ii. the opportunity to combine different areas of technology, applying knowledge in a required context;
iii. the recognition that striving for design innovation leads to personal, social and commercial development;
iv. the selection of appropriate resources and processes according to design problem;
v. working safely, correctly, effectively and efficiently;
vi. the analysis and evaluation of their own work and the work of others;
vii. the recognition of social, moral, economic, environmental, and health and safety issues, including the market influences that may be applied;
viii. communicating effectively with the different audiences and to take account of the values of those audiences and market influences through reasoned judgements;
ix. the encouragement of the entrepreneurial and personal qualities which are necessary to take a problem from an initial proposal stage to a Final Design Project.

3. Assessment Objectives

The objectives of the assessment are to evaluate the candidate's knowledge, skills and competences in Design and Technology at SEC level. The assessment is divided in two sections of equal weighting: (i) iterative project, and (ii) written summative examination.
The Design Aspect will be primarily assessed through an applied iterative project, where the learner demonstrates the abilities for iteration and creative thinking. The Iterative Project will be developed and presented by each learner and assessed for both the Design Aspect and Technology Aspect in context.

The written summative examination will assess the candidate's knowledge, skills and competencies on Design and Technology Aspects.

4. Scheme of Assessment

The SEC Design and Technology assessment consists of:

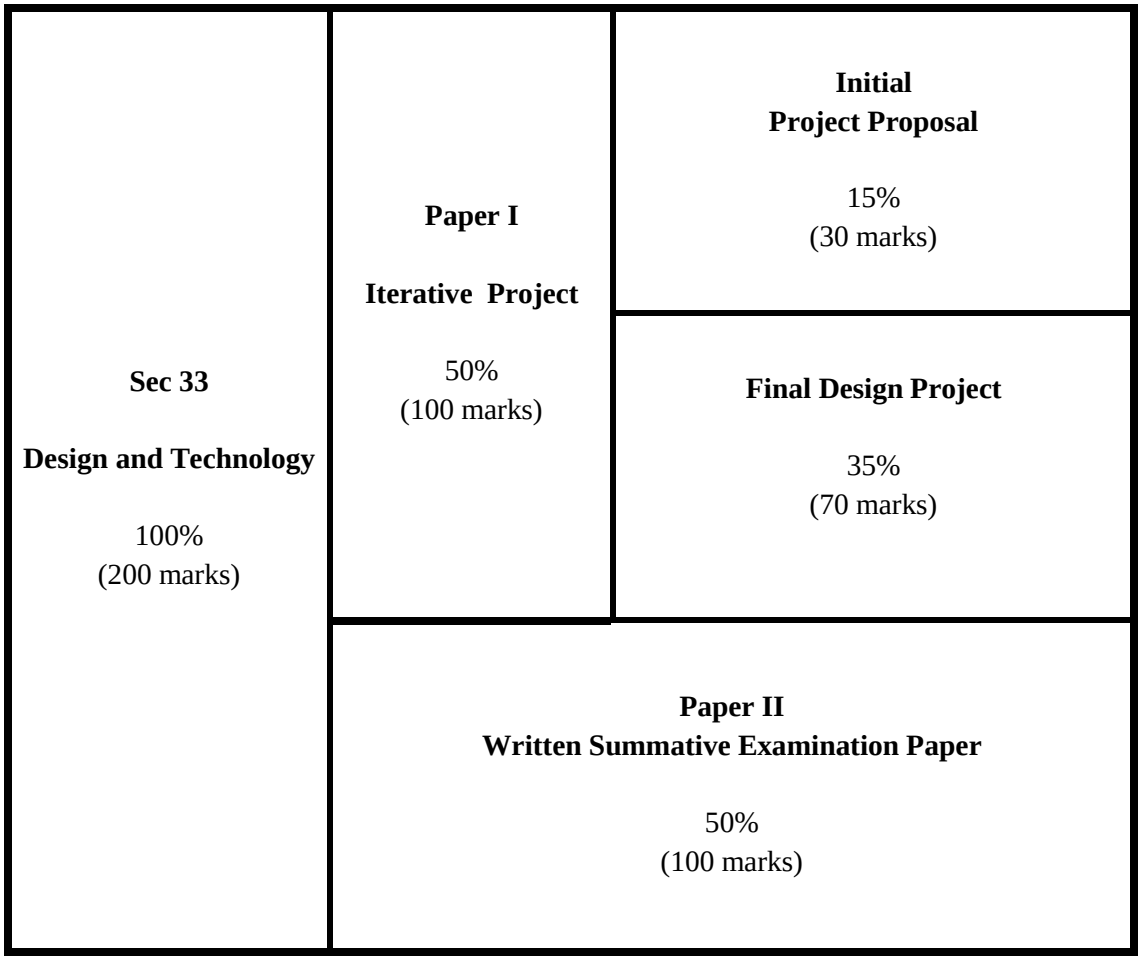
Paper I: Iterative Project (50%)

i. Initial Project Proposal
ii. Final Design Project

Paper II: Written Summative Examination Paper (50%)

4.1 Assessment Distribution

The overall assessment scheme is distributed as follows:



Students can only qualify for Grades 1 to 5 if they obtain at least **35%** of the mark allotted to each of Paper I and Paper II.

Paper II: Written Summative Examination Paper (50%)

Paper II consists of one examination paper (Paper IIA or Paper IIB) of two hours duration. Students are required to indicate on the registration form which option (A or B) of Paper II they would like to opt for. No change in the choice of paper will be allowed after the registration period.

Examination Papers IIA and IIB will comprise of a number of questions set in English that must be answered in English. Questions are to be answered within the spaces provided in the examination booklet.

Questions requiring the application of knowledge will normally refer to common situations and any calculations required will be simple and direct. When reference is made to particular situations or apparatus which might be unfamiliar to students, sufficient details will be given to explain the context. At the beginning of each paper a common, contextual situation will be provided. The contextual situation will be broad and questions within the paper may refer to it to provide context.

Paper IIA and Paper IIB will consist of three sections: Section A: Core Design and Technology Principles will carry 20% of the marks of the paper; Section B: Design Aspect will carry 25% of the marks of the paper; and Section C: Technology Aspect, which will carry 55% of the marks of the paper.

Section A is common to both Paper IIA and Paper IIB and will consist of 4 – 6 questions with a maximum of 20, overall, short and multiple choice, sub-questions. These questions will assess core principles in both the Design aspect and the Technology aspect of the syllabus.

Section B will consists of specialised Design aspect questions, which may refer to the contextual situation, or to a generic context, and cover synoptically the Design, the Data and the Critique strands (Design, Entrepreneurship and Innovation strand, the Data Collection and Interpretation strand and the Critique, Implications and Evaluation strand). This section will consist of 4-6 questions and divided into various sub questions. At least one question shall ask students to propose detailed design sketches of an idea they will develop against the given information.

Section C will consist of a number of questions about the Technology aspect of the syllabus. Students will be assessed synoptically in the strands of Materials and Making (15-25), Systems and Control (25-35 marks), and Graphics, Communication and Digitisation (5-10 marks). These questions may be presented within the specific strand or combined and may refer to the given contextual situation.

Questions in Paper IIA will be more demanding than those in Paper IIB

The use of non-programmable calculators is allowed. Standard notation and SI units will be used.

Paper I – Iterative Project

The MATSEC Examination Board will publish **ONE Project Theme with three situations** by the start of the scholastic year (Form 4). Students are required to choose ONE situation from those published and develop their iterative project accordingly. A situation consists of a given problem or need, in context, which the candidate needs to address in relation to the assessment criteria.

The chosen situation shall be developed as an **Initial Project Proposal** and submitted to the school by a deadline set by the said school not later than the end of the Form 4.Once submitted, the Initial Project Proposal shall be marked by the school, and the student must then proceed with the **Final Design Project**, taking into consideration feedback received. The Initial Project Proposal, as marked by the school, must be stored by the school and presented for MATSEC moderation as part of the complete Iterative Project on dates/s set by the MATSEC Board.

During Form 5, students will also present a complete Design folio and a finished artefact in fulfilment of part I.ii: **Final Design Project** of Paper I. The Final Design Project must be made available with the marked Initial Project Proposal to form the complete Iterative project (Paper 1) and made available for MATSEC moderation on date/s set by the MATSEC Board.

Iterative Project Marking Scheme

One grading criteria form, with detailed assessment criteria, is provided, including 2 sections. A section shows grading criteria for the Initial Project Proposal and a section for the Final Design Project. This is available separately on the MATSEC website.

The marking schemes address specific outcomes of the Iterative Project, marked to a minimum interval of 0.5 marks.

Iterative Project Guidelines

Part I. i. Initial Project Proposal

- Failure to submit the Initial Project Proposal by the stipulated date set by the school will result in the loss of all marks allocated for this part. Failure to submit on time does not preclude the candidate from completing the rest of Paper 1 and Paper 2.
- The assessed hard copy and digital copy need to be submitted to the school and stored by the school until the end of the moderation period.
- Formal feedback on the initial proposal, shall be provided by the D&T teacher, before the Form 4 summer recess.

Part I. ii. Final Design Project

- Students shall develop their Final Design Project based on the Initial Project Proposal.
- The selected *Project situation*, shall be deemed as final once submitted as part of the Initial Project Proposal.
- Any material produced during the proposal stage may be included in the Final Design Project documentation.
- Amendments and/ or improvements (upon proposed ideas) in the Final Design Project are allowed as long as these are within the same *Project situation*.
- Students shall present the Final Design Project in the form of a structured design folio, on A3 sheets, but not limited to the inclusion of additional presentation material, paper sizes or digital material as an appendix and a physical artefact as a prototype of the candidate's technological solution.
- Both design folio and artefact need to be stored at the school until the end of the moderation period.
- The design folio must contain the following: Front page with name & ID card number of candidate, school name, situation and project title. The document must also contain a (i) Contents page, and (ii) References. All pages must be numbered and bound.

5. Private Candidates

Private candidates are required to submit their Iterative Project to the MATSEC Board by the date specified by the MATSEC Board. The Initial Project Proposal and Final Design Project must be submitted together. Private candidates will be called for an interview on a date set by the MATSEC Board.

6. Grade Criteria

Students sitting for Paper IIA or IIB and for the Iterative Project (Paper I) may qualify for Grades 1, 2, 3, 4 or 5, when a minimum of 35% is achieved in each paper. The results of students who do not obtain at least a Grade 5 in Paper IIA shall remain Unclassified (U).

Students who obtain **35% or more in the Iterative Project** may carry it forward to the following year and sit for the written paper the following year.

7. Content

In section 7.2, an overview list of content Strands is provided as a glimpse of all 6 strands. In 7.3 sub strands are broadly described. These overview descriptors are useful for planning activities in the subject. These are expanded in further detail in section 7.4, Detailed strand Outcomes. Some detailed strand outcomes are further explained with text in brackets.
Please note that in section 7.4 detailed strands are labelled with a heading table. This includes the Aspect name, strand number, strand name in short (presented in capital letters) and the full strand name. e.g.:

Aspect	**Design Aspect**		
Strand	**1**	**DESIGN**	**Design, Entrepreneurship and Innovation**

Section 7.5 shows content range tables, which specify the range of content being referred to in the detailed strand outcomes.

7.1 Terminology (note relevant for evidence in Iterative Project only)

Examples (e.g.), when made available, need to be considered as a guideline but at least one of these examples needs to be delivered as evidence in the iterative project. When the term 'e.g.' is not used, all the provided list of deliverables must be done.

7.2 Strand overview:

1.	**DESIGN**	**2.**	**DATA**	**3.**	**CRITIQUE**
1.1	Explore the Design Context	2.1	Enquiry skills	3.1	Society (economy, industry, ethnic groups)
1.2	Use Design Methods	2.2	Data recording	3.2	Environment and resources
1.3	Design Communication	2.3	Analysis	3.3	Peer interaction
1.4	Design Value and Entrepreneurship	2.4	Communicating and sharing data	3.4	Evaluation
		2.5	Data implications	3.5	Value

4.	**MATERIALS**	**5.**	**SYSTEMS**	**6.**	**GRAPHICS**
4.1	Materials and Standard Forms	5.1	Systems design	6.1	Elements of Design
4.2	Workshop and Industrial Processes	5.2	Discrete Electronic/Mechanical components	6.2	2D Graphics
4.3	Tools and Machinery	5.3	Microcontroller Systems	6.3	3D Graphics
4.4	Health and Safety with Tools and Machinery	5.4	Assembly, skills and application	6.4	Digitisation and CAD/ CAM
4.5	Artefacts	5.5	Health and Safety	6.5	Idea Communication and Publication

7.3 Sub-Strand Overview

Code	Sub strand	*Description*
1.	**Design Aspect**	**DESIGN - Design, Entrepreneurship and Innovation**
1.1	**Explore the Design Context**	*Exploring various parts of a problem, unforeseen aspects, opportunities and needs, empathy, leading to a list of specifications useful to validate ideas.*
1.2	**Use Design Methods**	*Cope with a problem in a structured way sharing the process of idea exploration, idea generation and moving on with testing prototypes and iterating towards a planned and developed solution.*
1.3	**Design Communication**	*Use design documentation as a tool to further develop my iterative project and enhance communication during and after the realisation of a solution.*
1.4	**Design Value and Entrepreneurship**	*Addressing user needs, taking initiative in creating new value for users, and ways to communicate or promote a complete solution.*

2.	**Design Aspect**	**DATA - Data Collection and interpretation**
2.1	**Enquiry skills**	*Employ research techniques to define what needs to be discovered.*
2.2	**Data recording**	*Collection and organisation of data from appropriate market sources.*
2.3	**Analysis**	*Making sense of raw data and relevant information in order to specify design decisions*
2.4	**Communicating and sharing data**	*Documenting data as a means to inform the design and involve stakeholders.*
2.5	**Data implications**	*Ensuring correct use and presentation of derived and created data within given tolerances, governing standards and regulations.*

3.	**Design Aspect**	**CRITIQUE - Critique and Evaluation**
3.1	**Society (economy, industry, ethnic groups)**	*Consideration of how social and economic factors have effected design choices and vice versa*
3.2	**Environment and resources**	*Evaluating how resources, waste, energy and production may or have affected the design and the environment*
3.3	**Peer interaction**	*Evaluating the effect of peer interaction and critique*
3.4	**Evaluation**	*Evaluating the effectiveness of a solution and the design methods used*
3.5	**Value**	*The effect of design and entrepreneurship towards personal growth and society*

Code	Sub strand	*Description*
4.	**Technology Aspect**	**MATERIALS – Materials and Making**
4.1	**Materials and Standard Forms**	*Classify, Identify and define materials, their standard forms and properties according to intended use and known handling hazards*
4.2	**Workshop and Industrial Processes**	*Describe fabrication processes available at school in comparison with a broad view of industry level fabrication and production scales.*
4.3	**Tools and Machinery**	*Identify, select and describe listed components, tools and machinery against intended use.*
4.4	**Health and Safety with Tools and Machinery**	*Safely operate, Record, Identify, reduce and assess H&S risks involved in operating, listed tools and machinery under supervision.*
4.5	**Artefacts**	*Construction and finishing of parts and whole of a quality artefact or prototype that satisfies the needs of the design brief.*

5.	**Technology Aspect**	**SYSTEMS - Systems and Control**
5.1	**Systems design**	*Identification, Organising, planning and describing electronic, mechanical and other systems, their functions and behaviour.*
5.2	**Discrete Electronic/Mechanical components**	*Selecting and describing the function of discreet mechanical, electronic and structural components.*
5.3	**Microcontroller Systems**	*Application of basic microcontroller systems, with awareness of their advantages, inputs and outputs, operation and programming through a graphic interface software.*
5.4	**Assembly, skills and application**	*Application of skills in using tools and equipment for systems and control domains, including the identification, selection, description, measurement, planning, construction, assembly, testing and operation.*
5.5	**Health and Safety**	*Identification and awareness Health and Safety hazards and their risk assessment in working with electronic fabrication.*

6.	**Technology Aspect**	**GRAPHICS - Graphics, Communication and Digitisation**
6.1	**Elements of Design**	*Selection, and application of graphic media, tools and techniques including illustration, enhancement and finishing of products and prototypes with awareness of basic aesthetics and design elements.*
6.2	**2D Graphics**	*Application of 2D graphic techniques including marking out, freehand sketching, geometrical construction, illustrations, orthographic working drawings, and surface geometry, etc.*
6.3	**3D Graphics**	*Application of 3D graphic techniques including 3D freehand sketching, 3D pictorial projections, 3D visualisation, etc.*
6.4	**Digitisation and CAD/ CAM**	*Application and awareness of digital graphics for 2D and 3D designs and media, their manipulation, modelling, design and production using CAD CAM and digitisation tools including additive manufacturing.*
6.5	**Idea Communication and Publication**	*Communicating ideas, information and branding graphically and evaluate the effects of product presentation.*

7.4 Detailed Strand Outcomes

Aspect	**Design Aspect**		
Strand	**1**	**DESIGN**	**Design, Entrepreneurship and Innovation**

1.1 Exploring the Design Context

1.1.1 Gain insight about a situation.
(Learning about details of a problem and existing solutions)

1.1.2 Identify with different roles and stakeholders.
(Understanding the different needs of designers, clients, manufacturer, users and personas)

1.1.3 Derive specifications.
(From given information e.g.: situation)

1.1.4 Identify opportunities.
(Derive further specifications from explored values)

1.1.5 Reflect on ideas that lead to feasible solutions.
(Compare ideas with explored specifications and opportunities to identify the best solution to a problem)

1.2 Design Method

1.2.1 Generate a variety of creative and relevant design ideas.
(E.g.: Brainstorming, mind maps)

1.2.2 Use relevant data and knowledge to generate design solutions.
(Refer to Data Collection and Interpretation section.)

1.2.3 Record the stages of design.
(Present an organised design folio with a broad and iterative design process approach, Refer to table J)

1.2.4 Iterate between stages of design to refine solutions.
(Revisiting stages of design to refine approach. i.e. learning from failure, Refer to table J)

1.2.5 Plan the implementation of the product.
(E.g.: Gantt chart, system diagram)

1.3 Design Communication

1.3.1 Facilitate two-way communication with different stakeholders through the Initial Project Proposal.
(Provide clear design documentation that can be understood by specific stakeholders)

1.3.2 Communicate a finalised product.
(Describing and modelling a product, verbally, visually, graphically, physically and digitally)

1.4 Design Value and Entrepreneurship

1.4.1 Write a design brief that seeks new opportunities beyond a given iterative project situation.
(Addresses needs and values that were not identified in the given situation)

1.4.2 Propose a realistic, marketable and desirable solution.

1.4.3 Take new initiatives in promoting or enhancing the value of the Final Design Project.
(Integrating product branding techniques within the Final Design Project. Refer to 6.5.1)

Aspect	**Design Aspect**		
Strand	**2**	**DATA**	**Data collection and Interpretation**

2.1 Enquiry Skills

2.1.1 Develop the design brief based on the research carried out.
(Problem analysis, iterative design brief)

2.1.2 Devise appropriate research tools.
(e.g.: Questionnaire, Interview, [Product] Usability tests)

2.1.3 Devise scientific investigation.
(Design appropriate tests based on hypothesis and predictions.)

2.1.4 Apply the appropriate subject knowledge/data
(Refer to subject knowledge in Technology areas)

2.2 Data recording

2.2.1 Collect data from a minimum of three different sources.
(e.g.: users, internet, publications, experts, peers, surveys, test, project proposal feedback)

2.2.2 Use tools to record and organise data.
(E.g.: Spreadsheet, logbook, bulletin board, audio-visual, online & digital tools)

2.3 Analysis

2.3.1 Analyse data and knowledge in the context of the Final Design Project.
(Compare products, ideas and data with each other)

2.3.2 Interpret data and results to develop project design and specifications.
(Derive conclusive specifications, derive further research required)

2.4 Communicating and sharing data

2.4.1 Use tools to communicate data.
(Communicate data: e.g.: poster, product pitch, audio-visual presentation; tools: refer to sections 6 - Graphics)

2.4.2 Present the Initial Project Proposal and share with stakeholders, with a fair degree of clarity.
(E.g.: presentations, open days, notice boards, online platforms.)

2.5 Data implications

2.5.1 Reference data correctly, ethically and legally.
(E.g.: Data sources used, intellectual property references and personal data.)

2.5.2 Document own Product Health & Safety data and Proper Care data.
(A minimum of 4 aspects, (2) in terms of Health and Safety e.g.: choking, age, toxicity; and (2) for Proper Care e.g.: storage, cleaning, disposal)

2.5.2 Use given tolerances as a parameter to select materials and components.
(Given tolerances in SI units of +-2mm for materials, generic resistor tolerances)

Aspect	**Design Aspect**		
Strand	**3**	**CRITIQUE**	**Critique, Implications and Evaluation**

3.1 Society (economy, industry, ethnic groups)

3.1.1 Consider the effects of design on the needs of different social groups.
(Social groups: income, status, ability, ethnic and minorities)

3.1.2 Discuss product economics.
(Awareness of economies of scale, scale of production, budgeting, market and industry)

3.2 Environment and resources

3.2.1 Evaluate the sustainable use of resources
(Reduce, reuse and recycle)

3.2.2 Evaluate the use of renewable sources of energy
(Wind, solar, hydroelectric, biofuels)

3.2.3 Evaluate methods to reduce waste.
(Circular economies, carbon footprint)

3.3 Peer interaction

3.3.1 Evaluate the critical contribution of peers within a task.
(Suggestions and Contributions by e.g.: Fellow students, relatives, friends, professionals)

3.4 Evaluation

3.4.1 Evaluate the final product and/or system against testing carried out.
(e.g.: specifications, quality checks, performance / user testing; refer to 2.1.3)

3.4.2 Communicate the iterative process of design
(e.g.: Discuss, visualise and explain how iteration was used in the design folio)

3.5 Value

3.5.1 Reflect on how engaging in design and entrepreneurship, affected personal growth.
(Self-esteem, self-image, self-confidence, working in a team, working independently, taking responsibilities)

3.5.2 Discuss the value of design, creativity and entrepreneurship to the development of human society.
(Describing how design solutions can benefit both consumers and entrepreneurs)

Aspect	**Technology Aspect**		
Strand	**4**	**MATERIALS**	**Materials and Making**

4.1 Materials and Standard Forms

4.1.1 Classify materials into sub categories
(Refer to t*able A)*

4.1.2 Identify available standard forms of supply for different materials
(Bar, sheet, board, pipe, wire, filament, plank, rod, mouldings, extrusions, pellets, powders)

4.1.3 Describe the definitions of material properties.
(Refer to table B)

4.1.4 Describe the reason for the selection of appropriate material/s and its form of supply for a specific use.

4.1.5 Identify Health and Safety hazards in handling different materials.
(Chemically hazardous materials e.g.: lead, adhesives; physically hazardous materials e.g.: sharp edges, heavy objects; Thermal hazards e.g.: heat-treated material, Thermo-formed plastics)

4.2 Workshop and Industrial Processes

4.2.1 Describe fabrication and manufacturing processes used in the school workshops and industry.
(Refer to table C, except for high risk)

4.2.2 Discuss how available school workshop processes relate to industrial processes, highlighting how these may facilitate or restrict production.
(Model making, prototyping processes, additive/subtractive manufacturing, One-off, Batch, Mass, Continuous production)

4.3 Fabrication, Tools and Machinery

4.3.1 Identify components from an Image.
(Refer to table D)

4.3.2 Describe the function of components.

4.3.3 Identify the tools and machinery from an image
(Refer to table E)

4.3.4 Describe the fabrication processes specific to particular tools and machinery.

4.3.5 Independently select the appropriate tools and machinery for a desired task.

4.3.6 Label main parts of tools and machinery.
(Cutting blade, handle, driver bits, chuck, roller, grinding wheel, disk, belt, motor, heating element, working surface, machine bed, vacuum chamber, feed handle/lever, tailstock, headstock, tool post, work support, depth gauge, inside/outside jaws, battery pack, power switch, terminals, heated bed, extruder head, shaft, foot press, needle assembly, hand-wheel, bobbin case, guard, dust bag.)

4.4 Health and Safety with Tools and Machinery

4.4.1 Operate the tools and machinery, selected for the Final Design Project, safely and appropriately, under supervision.
(Refer to table E, but limited to machinery selected in Final Design Project)

4.4.2 Record the list of tools used to fabricate the Final Design Project, including Health and Safety precautions taken.
(This includes equipment operated both by the students and authorised workshop personnel)

4.4.3 Identify Health and Safety hazards in terms of tools and machinery processes.
(E.g.: particles and projectiles during wasting with a sander, risk of electric shock)

4.4.4 Identify ways to reduce risks during fabrication processes.
(List of PPE e.g.: Head and Face, Hearing, Eye, Respiratory, protection, Work wear, Disposables, Safety Gloves and safety Footwear.; Good workshop practice e.g.: working in well ventilated areas, follow lab rules, avoid any accessories and loose clothing, keep tools and workshop organised.)

4.5 Artefacts

4.5.1 Construct parts of an artefact according given or own design,

4.5.2 Construct an artefact from own design taking care of joining and fastening different parts together taking in account maintenance and improvements.

4.5.3 Apply finishing processes to artefact parts and complete the Final Design Project.
(Refer to 'finishing' in table C and 'decoration' in table D)

4.5.4 Produce an artefact/product that satisfies the functional, usability, aesthetic and ergonomic needs in a developed design brief.

Aspect	**Technology Aspect**		
Strand	**5**	**SYSTEMS**	**Systems and Control**

5.1 Systems Design

5.1.1 Organise visually functions in terms of Inputs, Process, Output and one Feedback loop.
(E.g.: a kettle, making tea, washing machine, wind turbine, torch, refer to table F)

5.1.2 Describe the function of a system.
(Refer to table F)
System Diagram: *e.g.: Simplify processes graphically, arrows;*
Electronic systems: *e.g.: Sensor circuits that triggers an electronic output like a sound after sensing light,*
Mechanical systems: *e.g.: lifting of loads, changing linear movement into rotational movement,*
Structures: *e.g. using weight/mass, retain balance/stability, mimicking natural forms)*

5.1.3 Establish the behaviour of electronic systems.
(Understand functions and calculate values, refer to table F)

5.1.4 Establish the behaviour of mechanical systems.
(Understand functions and calculate values, refer to table F)

5.1.5 Identify structures from an image
(Refer to table F)

5.2 Discrete Electronic components / Mechanical components

5.2.1 Select discrete components from their classification, function, given data, visually, and graphically.
(Refer to table G; identify components, choose appropriate component)

5.2.2 Describe the function of discrete components.
(Refer to table G)

5.3 Microcontroller System

5.3.1 Describe the advantages and disadvantages of microcontroller systems when compared to discrete electronics.

5.3.2 Identify the input and output (digital/analogue) features of microcontrollers from the given datasheet.

5.3.3 Program a microcontroller device through the use of graphic interface software.
(A system using a minimum of one analogue/digital input, one delay, one analogue/digital output, repeat, and one additional mechanical input/output)

5.4 Assembly, Skills and Application

5.4.1 Identify electronics tools and machinery from an image.
(Refer to table H)

5.4.2 Describe the fabrication processes specific to particular electronic tools and machinery.
(Refer to table H)

5.4.3 Independently select the appropriate electronic tools and machinery for a given task.
(Refer to table H)

5.4.4 Operate the electronics tools and machinery, selected for the Final design project, safely and appropriately, under supervision.
(Refer to table H)

5.4.5 Measure the discrete components' parameters using measuring instruments and tools.
(E.g.: Parameters: voltage, resistance, continuity, dimensions; Instruments: Multi-meter, Vernier Callipers. Refer to table E, G and H)

5.4.6 Build working models to test parts of the Final Design Project.
(Minimum of 2 parts e.g.: mechanical, electronic)

5.4.7 Independently apply a minimum of three working mechanical systems for a given task.
(Refer to mechanical system in table F)

5.4.8 Translate between simple electronic schematic diagrams, pictorial circuits and physical circuits.
(Between 7 and 10 discrete components)

5.4.9 Independently develop a simple circuit to achieve a desired function.
(Between 7 and 10 discrete components)

5.4.10 Build a working model of a simple electronic circuit on a breadboard.
(Between 7 and 10 discrete components)

5.4.11 Prototype a custom electronic circuit board using CAD.
(Electronic circuit board: strip board, PCB; e.g.: CAD: DIYLC, Yenka, VeroDes, etc.)

5.4.12 Assemble permanently a basic circuit on prototyping boards from given pictorial information.
(Between 7 and 10 discrete components, stripboard, PCB, schematic drawing, pictorial diagram)

5.4.13 Select connectors and fasteners, appropriate to assemble electrical and mechanical components.
(Refer to fasteners in table D, breadboard, strip board, PCB)

5.5 Health and Safety

5.5.1 Identify Health and Safety hazards during electronic circuit fabrication.
(Refer to table H e.g.: fumes whilst soldering, projectiles during trimming component leads, risk of electric shock)

5.5.2 Identify ways to reduce risks during electronic circuit fabrication.
(List of PPE e.g.: Eye, Respiratory, protection, Work wear, Disposables, Safety Gloves and safety Footwear.; Good workshop practice e.g.: working in well ventilated areas, follow lab rules, avoid any accessories and loose clothing, keep tools and workshop organised)

Aspect	**Technology Aspect**		
Strand	**6**	**GRAPHICS**	**Graphics, Communication and Digitisation**

6.1 Elements of Design

6.1.1 Select appropriate graphic materials and graphic media/tools for developing and presenting design ideas.
(Graphic materials: refer to table A; Graphic media/tools: e.g.: pens, pencils, markers, paints, brushes, drafting aids, compasses, stationery)

6.1.2 Apply basic elements of design and annotations to enhance communication of the designs.
(Elements of design: Refer to table I; Annotations e.g.: neat use of fonts, text, titles)

6.1.3 Apply quality finishing techniques to illustrations, graphic products and prototypes.
(E.g.: Finishing Techniques: rendering, prints, vinyl cutting, paint effects; Illustration: all drawings; Graphic products: packaging, labels; Prototypes: additional graphic overlays, decals)

6.2 2D Graphics

6.2.1 Sketch 2D compound geometric shapes/diagrams.

6.2.2 Construct approximate 2D elevations of parts.

6.2.3 Mark accurate 2D parts for fabrication using marking out tools.
(Refer to Table E)

6.2.4 Construct regular polygons using Compass, protractor and set squares.

6.2.5 Draw dimensions appropriately.

6.2.6 Read and draw 2D working drawings in orthographic projection of 3D objects.
(Draw: Using Third angle projection the front, plan and end views in 3 view layouts with a fair degree of accuracy, using guides)

6.2.7 Design 2D surface geometry nets for basic 3D objects or 3D models, including flaps.
(Cube, cuboid, pyramid, cone, cylinder)

6.3 3D Graphics

6.3.1 Sketch 3D basic and compound geometric forms to a fair degree of accuracy.
(Cube, cuboid, pyramid, cone, cylinder)

6.3.2 Apply freehand 3D Pictorial projection techniques, proportionally.
(E.g.: isometric, oblique, single point perspective, two point perspective, exploded views)

6.4 Digitisation and CAD/ CAM

6.4.1 Manipulate Raster/bitmap images using Image manipulation software.
(Manipulation: resize, contrast, brightness, crop, deform; Formats: .jpeg, .bmp, .pdf; Software e.g.: Gimp, Photoshop, Paint, Picasa)

6.4.2 Produce accurate 2D drawings of parts of the Final Design Project, using Computer Aided Design [CAD] Software.
(Create and convey designs using software, e.g.: Vector, Autoshapes; CAD software e.g.: word processor, Sketchup, Autodesk AUTOCAD, Inkscape, Draftsight, Autodesk 123D Design, Autodesk Sketchbook; Formats e.g.: .svg, .pdf)

6.4.3 Produce accurate 3D digital models using CAD Software.
(Create and convey designs using software e.g.: Sketchup, Autodesk AUTOCAD, Autodesk 123D Design; Formats e.g.: .stl, .obj, .dxf, .dwg.)

6.4.4 Use CAD software with a range of Computer Numeric Control [CNC], Computer Aided Manufacturing [CAM] and other output devices.
(Minimum of 2 devices from e.g.: desktop printer, Projector; CNC and CAD/CAM: vinyl cutter, Embroidery machine, laser cutter, FDM 3D printer)

6.4.5 Digitise media with a range of input devices and software.
(E.g.: Digitisation: record, compile; Media: Images, illustrations, documents, audio, video; Input devices: Scanners, digital cameras, smart devices)

6.5 Idea Communication and Publication

6.5.1 Design a basic product branding scheme.
(Branding: Colour scheme, product name, logo)

6.5.2 Present data using infographic charts or organisational diagrams.
(E.g.: infographic charts: Histograms, bar charts, pie charts, spider charts, Gantt charts, flow charts; Organisational diagrams: mind maps, web diagrams, block diagrams)

6.5.3 Evaluate how graphics contribute to the development and presentation of the product.

7.5 Content Range Tables

Material Classification			
Type	**Origin**	**Class**	**Material name**
Metals	Mineral	Ferrous	Cast Iron, carbon steel, mild steel
		Non - ferrous	Aluminium, copper, gold
		Alloys	Stainless steel, brass, chrome vanadium (HSS), chromoly
Woods	Organic	Hardwoods	Oak, Walnut, Cherry, Mahogany, Teak
		Softwoods	Pine, Fir, Cedar, Deal
		Manufactured	Plywood, chipboard, MDF, block board; veneered boards, (plastic) laminated boards
Polymers	Petroleum	Thermoplastics	ABS, PET, HIPS, PVC, PMMA (Acrylic)
		Thermosetting	Vulcanised rubber, Bakelite, Melamine resin, Polyester resin (as in GRP),
Textiles	Organic	Cellulose base fibres	Cotton, flax (linen)
		Protein base fibres	Wool, silk
		Modified Cellulose	Rayon, Viscose
	Mineral	Mineral base fibres	Carbon fibre, fibreglass
	Petroleum	Polymer base fibres	Nylon, Acrylic, polyester, spandex
Graphic	Organic	Paper	Cartridge paper, tracing
		Boards	Corrugated board, cardboard, solid white board
	Mixed	Laminate boards	Foil lined, foam-board, packaging laminate (e.g.: Tetra Pak)
Smart Materials			Shape memory alloy (SMA), Thermo-chromic ink, Photo-chromic Ink, Magnetically controlled fluids, Nano-coated materials.
Composites			GRP (Glass reinforced polymer), CFRP (Carbon Fibre Reinforced Polymer), Kevlar, PVC coated Synthetic fibres (‘waterproof’ textiles)

Table A

Material Properties	
Aesthetic	Colour, texture, opacity, translucency, vein, effect (print)
Physical	Electrical conductivity, melting points, thermal conductivity, density
Mechanical	Hardness, elasticity, plasticity, malleability/ductility, toughness/brittleness, environmental degradation (durability), absorbency, flammability,

Table B

Fabrication Processes	
Wasting	Drilling, sawing, filing, grinding, sanding, and machining (e.g.: turning, facing) threading, tapping
Deforming	Thermoforming (vacuum forming, line bending, steam), laminating, metal jigs, hand modelling,
Cutting	Shearing
Reforming	Injection moulding, extrusion, sand casting
Joining and assembly	Soldering, brazing, welding, butt joint, lap joint, mitre joint, housing joint, dove tail joint, fabric seems (e.g.: plain seem, French seem),
Finishing	E.g. Galvanising, painting, polishing / buffing, plastic coating, fabric edge finishing, wax polish, varnish, oil, tie and dye, stencilling, block printing and silk screen printing.
Rapid prototyping	Additive layer manufacturing
Heat treatment	Annealing, hardening and tempering
Shaping Fibres	Pleating (e.g. fabrics), creasing and scoring (e.g.: card, paper)
Conversion of fibres to Fabric	Spinning, weaving (plain twill), knitting, bonding, laminating
Chemical processes applied to fabrics	Water proofing, flame proofing, moth proofing, stain resistance

Table C

Components	
Fasteners	Pop riveting, screws, nuts and bolts, nails, hinges, knock down joints, dowels and adhesives; buttons, toggles, hook and eye, zips, press fasteners(press studs), Velcro, laces and eyelets and clips/buckles.
Structural components	Threads, elastic bands, bias binding tape, bonding, beams, struts, ties, trusses
Decorative components	Borders, badges, decals, lace, braids, beads, fringes, embroidery, appliqué, motifs and sequins.

Table D

Tools and Machinery	
Hand tools	Hammers (cross pein, ball pein, claw), wooden mallets, nail pincers, combination pliers, back/Tenon saws, hand saw, coping saw, hack saw, screwdrivers, files / rasps, seam ripper, scissors, spanners and sockets, chisels, planer, hole cutters, taps and dies
Measuring & Marking out tools	Pencil, scriber, centre punch, dividers/callipers, tri square, tape measure, ruler, safety ruler, tailor's chalk, mortise gauge, sliding bevel, Vernier calliper, engineer's square, centre finder
Holding Tools	G- clamp, wood working vice, engineer's vice, Sash clamp, Jigs
Power tools and machinery	Cordless drills, pillar drills, scroll saw , strip wire heater, hot air blowers, dry or steam iron, orbital sander, hot glue gun, hand held power drills, dust collector, belt/disk sanding machines, vacuum former, sewing machine, CNC additive layer manufacturing machine, sewing machine. High Risk Tools and equipment (recommended to be operated only by supervising adults): Butane torch, bench sheers, engineering lathe, bench grinder, band saw, jigsaw saw, welding set, router, CNC equipment.

Table E

<table>
<tr><th colspan="4">Systems</th></tr>
<tr><th>Type</th><th>Function</th><th>Additional information</th><th>Formulae / terms</th></tr>
<tr><td>System design</td><td>Block diagram (open/closed-loop),</td><td>one feedback loop, various: input, process, output, feedback, single: Power arrow.</td><td>Use of arrows, connectors, block diagrams, flowcharts</td></tr>
<tr><td rowspan="8">Mechanical systems</td><td>Types of motion,</td><td>rotary, linear, reciprocating, oscillating</td><td>Use of arrows</td></tr>
<tr><td>Cams and followers</td><td>Pear, eccentric, snail;
Knife, flat and roller follower</td><td>Rise, fall, cycle, pause</td></tr>
<tr><td>Hydraulic/pneumatic</td><td>single/double acting piston, 2 cylinders in a system</td><td></td></tr>
<tr><td>Levers</td><td>class 1,2,3 levers</td><td rowspan="6">Fulcrum, load, effort

Mechanical advantage: Output force or load / input force or load, Length (load) / length efforts;

Velocity ratio: distance moved by effort / distance moved by load,
fixed pivot, moving pivot, slider
Clockwise and anticlockwise moments,

Fd=Fd, Equilibrium.
Efficiency:
Output/ input multiplied by 100%

R.P.M,
Driver, driven speed;
Input, output speeds;

Velocity ratio:
Driver/ Driven multiplied by RPM
Efficiency:
Output/ input multiplied by 100%</td></tr>
<tr><td>Linkage</td><td>Mechanical advantage,
Velocity ratios
e.g.: bell crank, reverse motion, parallel motion, efficiency</td></tr>
<tr><td>Pulleys and Belts</td><td>Mechanical advantage
Velocity ratios;
Belts: v-belt, toothed belt, flat belt</td></tr>
<tr><td>Gears</td><td>simple gear train, compound gear train, idler, rack and pinion, bevel gear, worm gear</td></tr>
<tr><td colspan="2">Chains and sprockets</td></tr>
<tr><td>Electronic systems</td><td>Capacitance,
Resistance,
Voltage and current.
Timing
Sensing
PIC microcontroller
Logic circuits.</td><td>Capacitor-resistor in series,
Resistors in series/ parallel, colour code.
Voltage and current in series/parallel
a.c./d.c. Power, Potential divider,
Time delay circuits,
Light/temperature sensing circuits,
PIC microcontroller board,
Logic: AND OR NOT NAND</td><td>T=RC,
V=IR,
P=IV,

Rt=R1+R2+R3,
$\frac{1}{Rt} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$
Vout = Vin ($\frac{R2}{R1+R2}$)</td></tr>
<tr><td>Structures</td><td colspan="2">Mass structure, Frame structure (beams, struts, ties, trusses), Shell structure, Natural structure</td><td>Tensile , compression</td></tr>
</table>

Table F

Discrete components		
Domain	**Classification**	**Component**
Electrical	**Connectors**	Wires, jumpers, ribbon cable, screw terminal connectors/blocks,
	Resistors	fixed, variable, potentiometers, pre-set
	Sensors	LDR, thermistor, pressure
	Capacitors	polarized, non-polarized
	Actuators	D.C. motors, relays (NO/NC, power rating, latching), solenoid, buzzer, siren, loud speaker
	Switches	SPST, SPDT, DPDT, momentary (NO/NC), tilt, latching, push, toggle, rocker, reed, rotary, micro,
	Power Sources	Primary / Secondary Batteries (AA, AAA, PP3), power supplies, button cell, solar cell
	Integrated circuits	Logic gates (AND, OR, NOT), NE555, voltage regulators; PIC
	Semiconductors	Diodes (biasing component, half wave, full wave rectifier), LEDs (size, colours, efficiency, 7 segment), operational amplifiers, transistors (NPN, PNP, Darlington pair)
Mechanical	**Cams and Followers**	Pear, eccentric, snail, flat and roller follower)
	Belts and Pulleys	v-belt, toothed belt, flat belt, cable
	Hydraulic/pneumatic	Single/double acting piston, 2 cylinders in a system
	Levers	Class 1,2,3
	Linkages	Bell crank, reverse motion, parallel motion,
	Gears and sprockets	Friction gear, cage gear, spur gear, pinion, idler, rack, bevel gear, worm gear, sprockets, chain

Table G

Electronics tools & Equipment	
Hand tools	side cutter, wire stripper (automatic manual), track cutter, desoldering pump
Measuring Instruments	Multimeter (voltage, current, continuity), power supply, Oscilloscope
Holding Tools	helping hand, soldering iron stand
Assembly and Prototyping	Signal Generator, soldering iron, UV box, breadboard, Etching tank

Table H

Elements of Design	
Line	Centre, hidden detail, folding line, construction line, bold, contour, outlines, construction, border, implied lines
Shape	Geometric, organic, dynamic, extruded profile, sectional cut, pattern.
Form	Solid, shell, geometric, organic.
Colour	Colour Categories (Primary, Intermediate, Complementary), Colour Harmonies (warm colours, cool colours, monochromatic),Colour variables(Hue, Saturation, lightness, vibrancy)
Space	Interior, exterior, focal point.
Texture	In illustrations: shade, shadow, matt, gloss, shiny, transparent. In real products: grainy, rough, smooth, sleek, translucent,

Table I

Iterative and Broad Design Process Organisation (key terminology and possible range)	
Exploration	E.g. Research, Problem analysis, facts, Existing solutions, stakeholders (users, clients, designers, owners, personas society), empathy, expert input, user data, market data, product data sheet, similar contexts, timeframe, budget. (not shown sequentially)
Designing	E.g. Documentation, Idea generation, sketching, system plan, specification list, chosen idea, iteration, idea detailing, idea summary, narrative and identity(mood board), idea modelling, idea presentation, initial proposal, idea feedback. (not shown sequentially)
Making	E.g. Iteration list, detailed cutting lists, required equipment list, Project Work plan, Working drawings, functional models, manufacturing procedures, finishing procedures, part testing, part assembly, full product testing, graphic finishing, packaging, usability guides. (not shown sequentially)
Evaluating	E.g. Test analysis, feedback analysis, self-evaluation, project evaluation, project marketing and communication, critique, documentation of future improvements. (not shown sequentially)

Table J

Note*: Table J shows a broad design process structure outlining the main instances of 'Exploration', 'Designing', 'Making' and 'Evaluating'. This gives a general guide of the format for structuring design documentation but variations are allowed due to the iterative nature of design. The same applies to any terms listed, which are examples and are not in any sequential order.*