Curriculum Mapping – KS5 - A level Design & Technology: Product Design

Intro: Learning about design and technology at A level strengthens learners' critical thinking and problem solving skills within a creative environment, enabling them to develop and make prototypes/products that solve real-world problems, considering their own and others' needs, wants, aspirations and values. OCR's A Level qualification requires learners to identify market needs and opportunities for new products, initiate and develop design solutions, and make and test prototypes/products. Learners should acquire subject knowledge in design and technology, including how a product can be developed through the stages of prototyping, realisation and commercial manufacture. This qualification will excite and engage learners with contemporary topics covering the breadth of this dynamic and evolving subject. It will create empathetic learners who have the ability to confidently critique products, situations and society in every walk of their lives now and in the future. OCR's A Level in Design and Technology enables learners to take every opportunity to integrate and apply their understanding and knowledge from other subject areas studied during Key Stage 4, with a particular focus on science and mathematics, and those subjects they are studying alongside AS and A Level Design and Technology

Course Specification Link: https://www.ocr.org.uk/Images/304609-specification-accredited-a-level-gce-design-and-technology-h404-h406.pdf

Yr 12 **Term 1, 2 & 3** (Subject staff deliver the content in a personalised order throughout year 12)	**Course Introduction** Throughout Term 1 & Term 2 students will work through a series of focused mini projects that incorporate a FPT (focused practical task) and a portfolio of evidence. **Mini Projects Overview** These have been designed and incorporated key aspects that teaches subject theory in key areas; develops practical skills; knowledge & understanding of processes; use of tools and equipment; health and safety; and quality control measures. Whilst the mini projects do not carry any marks towards the final A Level grade, they do follow the model expected within the Non-Examined Assessment Criteria as specified by the Examination Board. • **Mini Project 1: Resistant Materials - FPT: Pewter** **Transition Project** - Will begin prior to the end of Y11 with work an expectation that this is completed over the summer holidays. ***Learners will be taught to:*** ○ Follow the Explore, Create, Evaluate Process to build a real time portfolio of evidence as would be expected of the NEA, which will build on their ability to research, design leading to a 3D outcome. ○ Develop the use of Computer Aided Design utilising 2D and 3D drawing packages. ○ Use Computer Aided Manufacture facilities developing understanding and independent use of Laser Cutting / Engraving machines. ○ Produce moulds suitable for shaping, forming and casting of materials. ○ Produce a Die Mould utilising CAD CAM facilities. ○ Develop understanding and ability to cast metal safely using a production processes. ○ Develop proficiency in the use of workshop tools, equipment and machinery applying suitable safe working practices and risk assessments / control measures where appropriate. ○ Develop understanding and ability in hand production and finishing methods / techniques to arrive at a quality outcome including: ▪ Wasting ▪ Abrading ▪ Surface finishing ▪ Tool Use ▪ Standard industry practice ▪ Time Management ▪ Production Planning ○ Produce a photo diary documenting all stages of manufacture whilst evidencing Quality Control and Health & Safety application.	Learners will be taught the theory side of the course through dedicated 'theory period'. ***Learners will be taught:*** **5. Material and component considerations** • 5.1 What factors influence the selection of materials that are used in products? • 5.2 What materials should be selected when designing and manufacturing products and prototypes in product design? • 5.3 Why is it important to consider the properties/characteristics of materials when designing and manufacturing products? **6. Technical understanding** • 6.1 What considerations need to be made about the structural integrity of a design solution? • 6.2 How can products be designed to function effectively within their surroundings? • 6.3 What opportunities are there through using smart and modern technologies within products? **7. Manufacturing processes and techniques** • 7.1 How can materials and processes be used to make iterative models? • 7.2 How can materials and processes be used to make final prototypes? • 7.3 How can materials and processes be used to make commercial products? • 7.4 How is manufacturing organised and managed for different scales of production? • 7.5 How is the quality of products controlled through manufacture? **8. Viability of design solutions** • 8.1 How can designers assess whether a design solution meets its stakeholder requirements? • 8.2 How can product designers and manufacturers assess whether a design solution meets the criteria of technical specifications? • 8.3 How do designers and manufacturers determine whether design solutions are commercially viable? **9. Health and safety** • 9.1 How can safety be ensured when working with materials in a workshop environment? • 9.2 What are the implications of health and safety legislation on product manufacture? Use of mathematics within Design and Technology • **M1 - Confident use of number and percentages** ○ calculation of quantities of materials, components, costs and size with consideration of percentage profits and tolerances as appropriate. ○ substitute numerical values into and rearrange learnt formulae and expressions. ○ confident use of decimal and standard form • **M2 - Use of ratios** ○ understand and use ratios in the scaling of drawings and pattern grading ○ understand and apply fractions and percentages when analysing data, survey responses and user questionnaires given in tables and charts

Yr 12 Term 1, 2 & 3 (Subject staff deliver the content in a personalised order throughout year 12)	• **Mini Project 2: Computer Aided Design & Computer Aided Manufacture (CAD CAM) - FPT: Egg Cup** As with the transition project students will follow the Explore, Create, Evaluate Process to build a real time portfolio of evidence as would be expected of the NEA. This will build on their ability to research, design leading to a 3D outcome. ***Learners will be taught to:*** ○ Develop an understanding and need to undertake 1st hand research and investigation through hands on practical experiments, data gathering and research. ○ Investigate existing products and design practice. ○ Research into technical requirements and any associated legislation. ○ Investigate user wants and needs. ○ Generate initial ideas communicated graphically with associated annotation, evaluation and feedback from Primary Users and Stakeholders. ○ Produce technical specifications. ○ Develop Ideas through the use of 3D modelling software, developing skills and proficiencies of the available drawing tools. ○ Evidence developments and progress of CAD designs through real time diary and blogging of work undertaken to arrive at the final design solution. ○ Produce Parts, Components and Assemblies within 3D CAD to produce accurate and clearly communicated idea. ○ Apply CAD rendering to enhance realism and add contextual support components. ○ Produce industry standard drawings including orthographic projection, rendered isometric views, section views if and where required and associated annotation required to the pre-production of a prototype part. ○ Use Modern Technologies through the use of Computer Aided Manufacture facilities developing understanding and independent use of rapid prototyping utilising 3D printing. ○ Finish rapid prototyped parts to enhance quality and aesthetic appeal. ○ Apply formal product testing and evaluation through field testing, user and stakeholder feedback and full analysis of strengths, weaknesses against technical specifications and commercial viability. • **Mini Project 3: Graphic Design & Iterative Developments - FPT: Ergonomic Handle** Students are to analyse and develop the tin opener through existing product analysis, high quality 3D sketching and 3D card modelling. ***Learners will be taught to:*** ○ Investigate of existing products and design practice. ○ Research into technical requirements and any associated legislation. ○ Investigate of user wants and needs. ○ Generate initial ideas communicated graphically with associated annotation, evaluation and feedback from Primary Users and Stakeholders. ○ Develop Ideas through the use of 3D modelling software, developing skills and proficiencies of the available drawing tools.	○ calculate percentages e.g. with profit, waste saving calculations or comparing measurements. ● **M3 - Calculation of surface areas and/or volumes** ○ determining quantities of materials by surface area ○ calculate the overall surface area of different shapes, such as cuboids, cylinders and spheres to determine quantities of material and feasibility analysis ○ calculate the volume of different shapes, such as, cuboids, cylinders and spheres to determine suitability of objects and products ● **M4 - Use of trigonometry** ○ calculate the sides and angles of objects to determine structural integrity, marking out and direction of movement ● **M5 - Construction, use and/or analysis of graphs and charts** ○ representation of data used to inform design decisions and evaluation of outcomes ○ presentation of market data, user preferences, outcomes of market research as part of product design, fashion and textiles ○ interpret and extract appropriate data. ● **M6 - Use of coordinates and geometry** ○ use of datum points and geometry when setting out design drawings, when setting out patterns and within engineering drawings ○ present accurate 2D and 3D graphics to communicate design solutions. ● **M7 - Use of statistics and probability as a measure of likelihood** ○ interpretstatistical analyses to determine user needs and preferences ○ use data related to human scale and proportion to determine product scale and dimensions and sizes and dimensions of fashion products ○ understanding of dimensional variations in mass produced components ○ defects in batches and reliability linked to probabilities.

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<td>Yr 12
Term 1, 2 & 3

(Subject staff deliver the content in a personalised order throughout year 12)</td>
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Mini Project 4: Prototyping & Modelling - FPT: Fire Stick
Learners will be taught to:

Identify key dimensions from a given drawing.
Use modelling techniques to produce an accurate representation of the fire stick using modelling foam.
Develop knowledge of the characteristics of the modelling foam as well as techniques used during development of the model.

Mini Project 5: Resistant Materials - Practical Skills -
FPT: Dovetail Box
Learners will be taught to:

Reproduce given Parts within 3D CAD to produce accurate self-drawn parts that are within the original dimensions / tolerances given.
Produce Components and Assemblies to produce accurate and clearly communicated manufacture requirements which focuses on accuracy of dimension.
Apply CAD rendering to enhance realism and add contextual support components.
Produce industry standard drawings including orthographic projection, rendered isometric views, section views if and where required and associated annotation required to the pre-production of a prototype part.
Independently to use 3D CAD package. Transferable skills to own design work.
Develop ability to work from Engineering Drawings with accuracy and precision.
Develop ability in the accuracy of measuring and marking out work to produce high quality joints, parts and assemblies.
Develop the ability to apply quality control methods to improve the quality of 3D outcomes.
Develop proficiency in the use of workshop tools, equipment and machinery applying suitable safe working practices and risk assessments / control measures where appropriate.
Develop understanding and ability in hand production and finishing methods / techniques to arrive at a quality outcome including:

Wasting (hand and machine)
Production of high quality wood joints
Abrading (hand and machine)
Surface finishing
Tool Use (hand and machine)
Standard industry practice applied with high quality craftsmanship sought
Time Management
Production Planning

Produce a photo diary documenting all stages of manufacture whilst evidencing Quality Control and Health & Safety application.
Independently follow procedure and make adaptations to overcome issues faced.

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<td>Yr 12 - Term 3</td>
<td>Begin the process of the NEA component
Explore (AO1)
Learners will be taught to:

Undertake investigations to identify a breadth of highly challenging problems and opportunities for further consideration.
Consider market potential through the approaches taken.

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Yr 12 - Term 3	• Develop a clear and fully relevant design brief relative to the context offering scope for challenge and a focused identification of a primary user and other stakeholders. • Provide consideration of primary user and other stakeholders needs and wants, through a range of clearly defined and comprehensive requirements that offer scope to support the design process. • Research fully relevant information and sources of inspiration to perceptively and skilfully influence design iterations and thinking. • Provide consideration of relevant materials and possible technical requirements throughout the design process.	
Yr 13 **Term 1 & 2** (NEA Assessment worth 50 % of the final grade)	Continue the process of the NEA component **Create (AO2)** ***Learners will be taught to:*** • Generate relevant and innovative design approaches that lead to non-fixated ideas, offering outstanding scope for challenge and fully reflect and meet requirements. • Iterative development that are comprehensive and progressive, incorporating all technical requirements and fully respond to identified next-steps of development. • Produce clear design iterations, systematic and chronological, fully supported by real-time evidence. • Produce excellent informal graphical and modelling to communicate initial thinking. • Progress clearly and comprehensively from earlier developments and all of the identified opportunities and to meet all requirements. • Use a range of communication techniques that are excellent, effective and consistent in appropriately developing or communicating design concepts. • Produce a technical specification that has high levels of accuracy, outlines details that clearly communicate all requirements to a third party. • Produce a comprehensive and relevant plan, covering all requirements and safety considerations identified from the technical specification to effectively manage the making process. • Produce a final concept demonstrating high levels of accuracy. • Apply appropriate finishes to the outcome that will present well and provide impact to a stakeholder. • Use specialist techniques and processes that are effective and consistently appropriate to materials/components being used. • Use specialist tools and equipment to effectively and appropriately demonstrate excellent skills and knowledge. • Produce a final design that meets all of the technical specification and demonstrates excellent potential to become a marketable/industrial product. **Evaluate (AO3)** ***Learners will be taught to:*** • Analyse and evaluate primary and/or secondary sources of information from stakeholders, existing products and wider issues. • Evaluate throughout the design processes to identify problems and next-steps for future iterations to effectively and consistently support design progression. • Analyse and test the design solution to see if it is fit for purpose.	Learners will be taught the theory side of the course through dedicated ‘theory period’. ***Learners will be taught:*** **1. Identifying requirements** • 1.1 What can be learnt by exploring contexts that design solutions are intended for? • 1.2 What can be learnt by undertaking stakeholder analysis? • 1.3 How can usability be considered when designing prototypes? **2. Learning from existing products and practice** • 2.1 Why is it important to analyse and evaluate products as part of the design and manufacturing process? • 2.2 Why is it important to understand technological developments in product design? • 2.3 Why is it important to understand both past and present developments in product design? • 2.4 What can be learnt by examining lifecycles of products? **3. Implications of wider issues** • 3.1 What factors need to be considered whilst investigating design possibilities? • 3.2 What factors need to be considered when developing design solutions for manufacture? • 3.3 What factors need to be considered when manufacturing products? • 3.4 What factors need to be considered when distributing products to markets? • 3.5 How can skills and knowledge from other subject areas, including mathematics and science, inform decisions in product design? **4. Design thinking and communication** • 4.1 How do product designers use annotated 2D and 3D sketching and digital tools to graphically communicate ideas? • 4.2 How do industry professionals use digital design tools to support and communicate the exploration, innovation and development of design ideas? • 4.3 How do product designers use different approaches to design thinking to support the development of design ideas? • How to apply knowledge to past paper questions. **Examinations:** • Principles of product design (01) - 80 marks, 1 hour 30 minutes. Written paper equalling 26.7% of total A Level. • Problem solving in product design (02) - 70 marks, 1 hour 45 minutes. Written paper equalling 23.3% of total A Level

	• Evaluate the final prototype(s) in terms of strengths and weaknesses with comprehensive suggestions for modification and consideration of possible design optimisation presented.	
Yr 13 - Term 3	The NEA will be completed and submitted awarding 50% of the final grade, focus will turn solely to final preparations for the final examinations. This will apply theory and knowledge and understanding gained during the Mini projects and NEA alongside theory from the dedicated ongoing theory lessons.	

Curriculum Mapping – KS5 - OCR Technical: Engineering

Intro: The Level 2 Cambridge Technicals in Engineering qualifications will allow students to take units that are specific to areas within the Engineering industry. These qualifications are designed to take students straight into employment, or an apprenticeship, or onto further study via a Level 3 Tech Level. Students would take these qualifications to develop a set of skills and knowledge required by the Engineering industry.
The Diploma allows students to learn about specific sectors such as Design Engineering, Production Engineering or Systems Engineering.

Course Brochure Link: https://www.ocr.org.uk/Images/266328-cambridge-technicals-engineering-summary-brochure.pdf

Yr 12	**Component 1**	**Unit 1 Maths For Engineering** Mathematics is one of the fundamental tools of the engineer. It underpins every branch of engineering and the calculations involved are needed to apply almost every engineering skill. This unit will develop learners' knowledge and understanding of the mathematical techniques commonly used to solve a range of engineering problems. ***Learners will be taught:*** ● algebra relevant to engineering problems ○ application of algebra ○ simplification of polynomials ○ how to simplify and solve equations ○ how to solve linear simultaneous ○ equations with two unknowns ○ how to solve quadratic equations ● the use of geometry and graphs in the context of engineering problems ○ how to use co-ordinate geometry ○ graphical transformations ● exponentials and logarithms related to engineering problems ○ problem solving using exponentials and logarithms ○ how to use inverse function and log laws ● the use of trigonometry in the context of engineering problems ○ angles and radians ○ problem solving with arcs, circles and sectors ○ problem solving involving right-angled triangles ○ problem solving involving non-right angled triangles ○ common trigonometric values ○ common trigonometric identities ○ sine, cosine and tangent operations ● calculus relevant to engineering problems ○ problem solving involving differentiation ○ solve problems involving indefinite integration ○ problem solving involving definite integrals ● how statistics and probability are applied in the context of engineering problems ○ the terms "data handling" and "sampling" ○ problem solving involving histograms, frequency polygons and cumulative frequency curves ○ problem solving for a set of data ○ problem solving using probability ○ the addition law of probability and the multiplication law of probability
	Component 2	**Unit 2 Science for Engineering** Different branches of science underpin the teaching and learning of a number of engineering disciplines. In this unit we focus on the science which supports mechanical engineering, electrical and electronic engineering, fluid dynamics, thermal physics and material science for engineering. This unit will develop the learner's knowledge and understanding of principles of engineering science and consider how these can be applied to a range of engineering situations. ***Learners will be taught to:*** ● understand applications of SI units and measurement ○ SI units ○ definitions of measurement and terms related to measurement ○ the formulae for relative error, absolute error, absolute correction and relative correction ○ how to calculate the standard deviation and the standard error of the mean ○ how to use instruments for taking measurements ● understand fundamental scientific principles of mechanical engineering ○ force and motion ○ Kinematics ○ Dynamics ○ force, work and power ● understand fundamental scientific principles of electrical and electronic engineering ○ atomic structure and electric current ○ the term Coulomb and use of the formula for charge ○ electron flow and current flow in conductors, semi-conductors and insulators ○ potential difference (V) relating to energy and charge, power and current ○ current-potential difference characteristics for a metallic conductor at constant temperature, a filament lamp and a semiconductor diode ○ resistance and Ohm's law for resistive circuits ○ how to calculate the total resistance and total current for a circuit that is a combination of resistors connected in series and parallel ○ use of the formulae for electrical power (P) and energy (W) ○ that the kilowatt-hour is a unit of energy

Yr 12	**Component 2**	○ that the efficiency of a system is the ratio of work output to work input ○ the term resistivity and use of the formula for resistivity (ρ) ○ the term temperature coefficient of resistance ○ use of graphs to show the variation with temperature of a pure resistor and of a negative temperature coefficient thermistor ○ use of the formula for the magnitude of the uniform electric field strength (E) between charged parallel plates ○ the terms capacitance (C) and farad (F) ○ the relationship between capacitance and energy stored in a capacitor ○ how to draw a graph for a capacitor discharging ○ through a resistor of (a) potential difference against time and (b) current against time ○ the significance of a time constant for the discharge of a capacitor and use of the formula for time constant (τ) ○ use of the formula for the discharge of a capacitor ○ the terms inductance (L) and the unit of inductance - henry (H) ○ use of the formula for the self-inductance (L) of a coil and the formula for energy (L W) stored in the magnetic field of a coil ● understand properties of materials ○ elastic deformation, in terms of the separation of atoms in a solid material ○ that the resultant force between two atoms in a crystal is the vector sum of an attractive force and a repulsive force ○ basic material properties ○ what is meant by the term equilibrium separation ○ plastic deformation ○ the difference between the drift velocity and root mean square (r.m.s) speed of an electron which forms part of an electric current in a solid ○ application of the formula for current (I) ○ that deformation is caused by a tensile or compressive force Hooke's law ○ what is meant by the terms elastic limit, stress, strain and Young's modulus ○ the difference between elastic and plastic deformation of a material ○ how to calculate the strain energy in a deformed material from a force – extension graph ○ the term ultimate tensile stress ○ how to draw force-extension graphs for typical brittle, ductile and polymeric materials showing that there is a difference for various materials ○ what is meant by the terms non-destructive testing and destructive testing ● know the basic principles of fluid mechanics ○ fluids at rest ○ the terms pressure, gauge pressure and absolute pressure ○ pressure exerted on any point on a surface in a fluid is always at right angles to the surface ○ pressure at any point in a fluid is the same in all directions at that point ○ pressure due to a column of liquid ○ Archimedes' principle ○ fluid flow - ideal fluid, streamline or laminar, turbulent flow and boundary layers ○ definition of viscosity ● know the basic principles of thermal physics ○ the non-flow energy equation ○ the steady flow energy equation ○ that the internal energy of a system is the sum of a random distribution of kinetic and potential energy concerned with the molecules of the system ○ what is meant by the term thermodynamic scale and state that on the Kelvin scale, absolute zero is the temperature at which all substances have a minimum internal energy ○ Boyle's law and its equation ○ Charles' law and its equation ○ Pressure law and its equation ○ combined gas law and its equation ○ ideal and characteristic gas equations ○ the term specific heat capacity and the equation for heat energy or sensible heat (Q) ○ the efficiency equation ○ what is meant by the terms sensible heat and latent heat ○ application of sensible and latent heat formulae
	Component 3	**Unit 18 Lean And Quality** Striking an effective balance between efficiency of production and quality of product without compromising either is fundamental to the commercial success of engineering companies. The aim of this unit is for learners to develop their understanding of the principles behind lean manufacturing and apply their understanding to a manufacturing context in terms of improving quality, eliminating waste and improving productivity. They will also learn about a wide range of quality control, assurance and management techniques including mathematical analysis of quality data to identify trends and recommend subsequent improvements to processes or procedures. Learners will apply the knowledge and understanding gained to the development production plans, factory layouts and manufacturing processes. ***Learners will be taught to:*** ● understand lean manufacturing ○ lean principles ○ lean wastes ○ lean tools and techniques ● understand approaches used to ensure quality in manufacturing ○ quality control ○ quality assurance ○ total quality management (TQM)

Yr 12	**Component 3**	○ statistical process control ● be able to apply lean manufacturing and approaches used to ensure quality ○ identification of lean wastes in manufacturing situations ○ suggested improvements to a manufacturing process ○ industrial best practice ○ measuring performance improvements ● be able to plan manufacturing production using lean and quality principles and approaches ○ production planning ○ influencing factors ○ planning to include lean and quality ○ manipulation of takt time and cycle time ○ use of JIT and Kanban ○ implementation of quality and inspection techniques ○ automated and manual processes ○ factory or production layout ○ minimising the lean wastes ○ cellular and linear production ○ made to order (MTO) or made to replenish (MTR) variations in layout
	Component 4	**Unit 6 Circuit Simulation and Manufacture** For electrical and electronic devices to function, they depend on their circuits operating normally. Circuit simulation and safe, effective manufacture of circuit boards is therefore a key function within electrical engineering companies. The aim of this unit is for learners to develop the ability to make working printed circuit boards (PCBs). Learners will develop the ability to use computer aided design (CAD) software to design and simulate electronic circuits, and then to design PCBs. They will go on to be able to safely manufacture and construct PCBs. Learners will also develop their fault-finding techniques for PCBs, to test and rectify, where possible, faults on circuits. They will also gain knowledge on the commercial manufacture of circuits, including manufacturing process methods and quality assurance techniques. ***Learners will be taught to:*** ● be able to use Computer Aided Design (CAD) for circuit design and simulation ○ circuit schematic diagram drawing using CAD software ○ circuit simulation and test using CAD software ● be able to use Computer Aided Design (CAD) to design printed circuit boards (PCBs) ○ printed circuit board (PCB) layout production to include both track and component views ● be able to manufacture and construct electronic circuits safely ○ safe manufacture of PCBs ○ circuit construction following circuit diagrams ○ safe circuit construction using appropriate methods ○ correct order for circuit construction ○ connecting between boards and final assembly techniques ● be able to test and perform fault-finding on electronic circuits ○ visual inspection techniques for testing electronic circuits ○ appropriate testing and fault-finding techniques ○ use of physical test equipment ○ techniques for design verification through comparison with simulation data ○ fault rectification ● understand commercial circuit manufacture ○ application of discrete, through hole and surface mount component types ○ benefits and drawbacks to the manufacturer of using surface mount components and using alternatives ○ applications and reasons for using multiple layer PCBs ○ manufacturing processes used within commercial circuit construction ○ quality assurance methods used during commercial printed circuit board (PCB) production
	Component 5	**Unit 10 Computer Aided Design** Computer aided design (CAD) has been used across the world for many years in many diverse industries to design products, including both mechanical and electrical component and product design. A variety of software packages are used to perform this commercially. The aim of this unit is for learners to develop the ability to be able to produce 3D models using CAD, and to go onto create 3D assemblies of components within a CAD system. To underpin this, learners will develop the skill of producing 2D CAD engineering drawings to appropriate standards, and will develop knowledge and understanding of the use of simulation tools within commercial CAD systems. ***Learners will be taught to:*** ● be able to produce 3D models using Computer Aided Design (CAD) ○ how to use solid modelling tools to produce ○ how to use advanced solid modelling tools ● be able to create 3D assemblies of components within a CAD system ○ aspects of assembly ○ automatic population of assemblies based on geometry ● be able to produce 2D CAD engineering drawings ○ how to use formats and templates ○ how to use projection and units ○ how to apply dimensioning and annotations ○ assembly drawings ○ drawing standards ● understand the use of simulation tools within CAD systems ○ types of simulation ○ Manufacturability ○ Finite Element Analysis (FEA) ○ Computational Fluid Dynamics (CFD)

Yr 12	**Component 6**	**Unit 17 Computer Aided Manufacture** Many companies which make products are reliant on computer systems to run the manufacturing processes involved. This is known as Computer Aided Manufacturing (CAM). The aim of this unit is for learners to understand how CAM systems are used within manufacturing and be able to program and use Computer Numerical Control (CNC) machines to produce components. They will also learn to produce components using additive manufacturing techniques. ***Learners will be taught to:*** ● understand how computers are used in manufacturing systems ○ use of computers in additive and subtractive manufacturing processes ○ CNC setting, operating, programming ○ automation in manufacturing ○ computer aided planning ○ advantages of using computers in manufacturing ● be able to produce CNC programs for the manufacture of components ○ manual CNC programming ○ use of CAM software ○ production and manufacture of parts ● be able to set-up and operate a CNC machine to produce components ○ machine set-up ○ machine operations ○ machining of components ● be able to produce components using additive manufacturing techniques ○ rapid prototyping ○ 3D printing using additive manufacturing techniques ○ parts for one-off prototyping functions ○ how additive manufacturing techniques are used ○ production of 3D components using additive manufacturing ○ production of 3D CAD data and conversion to STL file format
	Component 7	**Unit 19 Inspection and Testing** In ensuring that the business can meet the demands of its customers when manufacturing and supplying goods, suppliers must inspect and test these goods and products prior to completion, to guarantee their levels of quality. Dependent on the product type and process used to manufacture, there are a number of methods which can be used. The aim of this unit is for learners to develop an understanding of different methods of inspection and testing (including both destructive and non-destructive testing). They will learn how the use of these methods contributes to quality control, and how defects can form in manufacturing components, processes and materials in the first place. They will also learn about how automatic testing and inspection techniques are used in engineering. ***Learners will be taught to:*** ● understand how inspection and testing methods and processes improve quality control ○ how inspection and testing methods are used to minimise quality issues ○ how Statistical Process Control (SPC) is used to minimise quality issues ○ how SPC moving range charts are produced and used ○ how to schedule inspection and testing methods and processes to improve quality control ● understand how defects can occur in manufacturing materials, processes and components ○ the types of defects that can occur in materials, their causes and effects ○ the type of defects that occur in different manufacturing processes ○ in-service defects that can occur in different manufactured components ● understand how destructive testing methods are used for quality assurance in manufacturing ○ which type of material or component each destructive testing method is suitable for ○ the advantages and limitations of each destructive testing method ○ destructive testing methods ● understand how non-destructive testing methods are used for quality assurance in a manufacturing environment ○ which type of material or component each non-destructive testing method is suitable for ○ the advantages and limitations of each non-destructive testing method ○ non-destructive testing methods ● understand automatic inspection and testing techniques which are used in manufacturing ○ automatic inspection techniques ○ how automatic inspection techniques are used in quality assurance in manufacturing ○ the advantages and limitations of automatic inspection techniques ○ types of automatic testing techniques used in manufacturing (e.g. Automated Test Equipment (ATE) ○ how automatic testing techniques are used in manufacturing

Yr 13	**Component 8**	**Unit 3 Principles of Mechanical Engineering** All machines and structures are constructed using the principles of mechanical engineering. Machines are made up of components and mechanisms working in combination. Engineers need to understand the principles that govern the behaviour of these components and mechanisms. This unit explores these principles and how they are applied. ***Learners will be taught:*** ● systems of forces and types of loading on mechanical components ○ different types of loading that could be applied to a mechanical component ○ to resolve a force into its orthogonal components ○ systems of co-planar forces ○ diagrammatic representations of engineering problems using force diagram ○ how mechanical engineering situations can be represented by particle mechanics and rigid bodies ○ conditions of equilibrium for systems of forces ○ how to determine the resultant of a set of co-planar forces and hence determine the equilibrant of those forces ○ how materials respond to direct axial loading, both in tension and compression ○ the terms stress, strain and Young's modulus, and application of formulae to calculate direct stress and strain in axially loaded components ○ representation of material behaviour on a generic stress versus strain graph ○ how to apply formulae to calculate the shear stress in a component under shear loading ● the fundamental geometric properties relevant to mechanical engineering ○ calculation of the area of irregular 2D shapes ○ calculation of the volume of a regular prism of known cross sectional area and length ○ calculation of the mass of a body of known volume and uniform density ○ the significance of the centroid of a body as its centre of gravity/centre of mass ○ the use of axes of symmetry of a uniform 2D figure to find its centroid ○ the position of the centroid of common non-symmetrical 2D shapes ○ the use of moment of area of uniform regular 2D shapes to find the position of the centroid of more complex uniform irregular shapes ● levers, pulleys and gearing ○ concepts of mechanical advantage (MA) and velocity ratio (VR) applied to levers, systems of pulleys and gears ○ the three classes of lever ○ different types of gears and gear systems, and their applications ○ calculation of MA and VR for spur gears ○ calculation of MA and VR for simple compound spur gear systems ○ different types of pulley and belt drive systems and their applications ○ calculation of the MA and VR for the named belt drive systems ● the properties of beams ○ different types of beams and their support conditions ○ different types of loading applied to beams ○ how to calculate, using conditions of static equilibrium, the reactions of beams ○ how to calculate the bending moment at any point in simply supported or cantilever beams with point loading ○ how to draw a bending moment diagram for a simply supported or cantilever beam with point loading ● the principles of dynamic systems ○ how to apply Newton's Laws of Motion in a mechanical engineering context ○ how to apply the constant acceleration formulae to problems set in a mechanical engineering context ○ the principle of conservation of energy and how to apply this principle to problems involving kinetic and gravitational potential energy ○ the relationship between work done on a body and the change in energy of that body ○ application of equations for energy and work done to problems set in a mechanical engineering context ○ use of the equations for power to solve problems set in a mechanical engineering context ○ the action of a friction force between a body and a rough surface and how to apply the equation ○ to apply the principle of conservation of momentum to bodies
Yr 13	**Component 9**	**Unit 4 Principles of Electrical and Electronic Engineering** Electrical systems and electronic devices are present in almost every aspect of modern life – and it is electrical and electronic engineers who design, test and produce these systems and devices. This unit will develop learners' knowledge and understanding of the fundamental principles that underpin electrical and electronic engineering. ***Learners will be taught:*** ● fundamental electrical principles ○ application of the defining equations for resistance, power, energy, resistors connected in series and resistors connected in parallel ○ measurement of voltage, current and resistance in a circuit ○ circuit theory ● alternating voltage and current ○ what is meant by a simple generator ○ what is meant by an alternating current (AC) and generated electromotive force (e.m.f.) ○ diagrammatic representations of a sine wave ○ to determine frequency and amplitude of a sine wave ○ to determine the phase difference and phase angle in alternating quantities ○ circuit diagrams and phasor diagrams ○ application of the defining equation for reactance (X) and impedance (Z) ○ application of the defining equation for impedance ○ circuit diagrams and phasor diagrams where a pure resistance, inductance and capacitance is in series with an AC supply

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<td>Yr 13</td>
<td>Component 9</td>
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electric motors and generators

the difference between motors and generators
application of the defining equation for a motor and generator
the type of field winding and action of motors
application of the defining equations for motors and generators
DC motor starters to include a no-volt trip coil and an overload current trip coil
how the speed of a DC shunt motor and a series DC motor can be changed

power supplies and power system protection

the meaning of ac and dc
the capability of load regulation to maintain a constant voltage or current level on the output of a power supply regardless of changes in the supply load
how to draw a labelled block diagram of a stabilised power supply
power-system protection
how to explain, with the aid of labelled diagrams, how power supplies and electrical components

analogue electronics

the definition of an analogue circuit
how to explain with the aid of a labelled diagram the characteristics of an operational amplifier (op-amp)
how to draw a labelled diagram of an op-amp
characteristic properties of an ideal op-amp
application of the defining equation for gain in an inverting amplifier and non-inverting amplifier
state and apply the formula for a summing amplifier

digital electronics

the definition of a digital electronic circuit
how to draw a labelled diagram (symbol) and explain the function of the logic gates
how to construct truth tables
how to solve simple combinational logic problems
how to recognise simple Boolean expressions
how to explain with the aid of a circuit symbol the function of T type bi-stable flip-flop and D type bi-stable flip-flop
to explain the behaviour of a rising-edge triggered D flip-flop

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<td>Yr 13</td>
<td>Component 10</td>
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Unit 14 Automation control and robotics
Many companies use automation control devices to run manufacturing, production and other processes such as power generation. These machines require specialist engineers to design, manufacture, operate and maintain them. Industrial robots are also increasingly commonly used in automation control systems.
The aim of this unit is for learners to develop knowledge and understanding of automation control systems in industry. They will develop understanding of control system theory and how this is implemented in automation control systems.
They will develop an understanding of how sensors and actuators are used in automation control systems, about industrial network systems including industrial communication standards (e.g. controller area network (CAN) bus), and the role of maintenance for automation control systems.
They will also gain an understanding of the application of robotics in automation control systems, including aspects of robotic operation.
Learners will be taught to:

understand control system theory in engineering

open loop control systems
closed loop control systems
advantages and disadvantages of open loop and closed loop systems
functional representation of control systems using block diagrams
the relationship of input to output including steady state error
feedback and performance in closed loop systems
pulse width modulation and amplitude modulation as a means of control
advantages and disadvantages of analogue and digital control systems

understand the implementation of control in automated systems

the application of embedded control systems
the basic architecture of a PLC
Analogue-to-Digital and Digital-to-Analogue (A-D and D-A) converters and their use in industrial control systems

understand sensors and actuators used in automation control systems

the role of sensors and actuators in a control system
types of sensors
examples of sensors
applications of sensors for measurement
types of actuators
examples of actuators
applications of actuators which use different power sources

know about industrial network systems

requirements of industrial network systems
common industrial communication standards
application of human machine interfaces (HMI) and expert systems
network topologies
data transmission speed (baud rate)

know about maintenance in automation control systems

the need for maintenance in automation control systems
maintenance strategies in automation control systems
how machine parameters can be recorded over time
how Human Machine Interfaces (HMIs) can indicate maintenance issues
how statistical process control (SPC) is used to monitor process parameters
how expert systems can monitor, predict and report maintenance issues

understand the application of robotics in automation control systems

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<tr><td>Yr 13</td><td>Component 10</td><td>
characteristics of a robot
the difference between on-line and off-line robot programming
the interface of vision systems with robotics to perform tasks
aspects of robotic operation
application and operation of common types of industrial robot
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<tr><td>Yr 13</td><td>Component 11</td><td>Unit 15 Electrical. Mechanical, Hydraulic & Pneumatic Control
Automated machines used by industry are operated by systems of control, which include electrical, mechanical, hydraulic and pneumatic control – this requires engineers to have a sound understanding of the processes and theory which underpin the operation of these machines.
The aim of this unit is for learners to develop a foundation of knowledge and understanding of how these control systems work.
Learners will gain an understanding of mechanisms used in control systems, and how their design can deliver the desired motion and performance. They will be able to develop their knowledge of electric motor types commonly used in automation control, and how their construction relates to output characteristics.
They will gain an understanding of simple hydraulic control systems, including valves and actuators, and a basic understanding of fluid transmission. They will gain an understanding also of simple pneumatic control systems.
Learners will be taught to:

understand the mechanical elements of control systems
Motion
common mechanical elements for producing linear and rotary motion
Mechanisms
balance of rotating masses and effects of imbalance
power losses due to mechanical friction

understand the electrical elements of control systems
the role of electrical sensors and actuators in a control system
common types of electrical actuators
motor types
motor control
energy losses and reduced efficiency in electrical actuators
motor selection for given output requirements

understand simple hydraulic systems
power sources for hydraulic systems
valves and actuators for hydraulic systems
fluid transmission in hydraulic systems

understand simple pneumatic systems
compressors for pneumatic systems
valves and actuators for pneumatic systems
fluid transmission in pneumatic systems
recognise implications of moisture build up in pipe networks and need for drains

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<tr><td>Yr 13</td><td>Component 12</td><td>Unit 16 System and Programming
Industrial automation control systems are run by engineers who can program them to perform the tasks needed in industries such as manufacturing or power generation. These engineers need an understanding of programming methods and techniques in the specific context of industrial control systems.
The aim of this unit is for learners to develop an understanding of these programming techniques, and the ability to program Programmable Logic Controllers (PLCs) (including the principles of ladder logic programming), and other embedded devices for a control system.
They will also gain an understanding of commercial validation strategies for automation control programs, and the levels and types of testing carried out.
Learners will be taught to:

understand programming techniques
basic architectures of devices
use of logical instructions in programming
conversion of high level programming languages to machine code and then to binary/hexadecimal
Boolean algebra in logic programming
how to use flow charts to map logic flow
how to use modules to break down complex programs
how to use subroutines in programs
how to use comments for maintenance and debugging

be able to program embedded devices in a system
how embedded devices
practical applications for embedded devices
how to apply programming technique for an embedded device

be able to program Programmable Logic Controllers (PLCs)
historical development of ladder logic programming for PLCs
the structure of ladder logic
how to load and operate PLC programs
sequential cycling and speed of execution issues
how to use simulation software to model, test and validate PLC programs

understand commercial testing and validation strategies
limitations of software validation
structured approaches to testing of software in order to minimise defects (bugs)
the four accepted levels of testing
acceptance testing for software systems
metrics used to assess quality of software

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