ENGINEERING: OCR – CAMBRIDGE TECHNICAL LEVEL 3

Year 12

What are the aims and intentions of this curriculum?

Cambridge Technical Engineering level 5 is practical, accessible, fun to teach and exciting to learn, it inspire students to develop real-world skills to prepare them for their future. Additionally, the course develops students so they are able to identify market opportunities and solve problems, which contribute to the development of mathematical and scientific new products and systems. This is a vocational qualifications designed with the workplace in mind and provide a high-quality alternative to A Levels. This qualification is about educating students in the knowledge and skills required for employment and for the community as a whole. It is also about developing the behaviours and attributes needed to progress and succeed in education and in work. It is for learners over the age of 16 who wish to specialise or progress into a specific sector or occupational group, through advanced/higher apprenticeships, further study or employment. This course seeks to develop your knowledge, understanding and skills required in industry. This course compliments Maths, Science, Physics, Business studies and creative subjects.

Term	Topics	Knowledge and key terms	Skills developed	Assessment
Autumn 1	Algebra Fundamentals Polynomials Algebra and Functions Algebra and Functions	Refresher of common algebraic techniques learnt at GCSE including multiplication by a constant, binomial expressions, removing a common factor, factorisation and using a lowest common multiple (see exemplification in unit specification 1.1). Laws of Indices, Surds, Multiplying Out Brackets, Taking Out Common Factors, Algebraic Fractions, Simplifying Expressions. Functions and Mappings, Composite Functions, Inverse Functions, Modulus, Transformations of Graphs. Simplifying Expressions, Algebraic Division, Partial Fractions	The application of algebra relevant to engineering problems Application of algebra in engineering includes: Multiplication by constant, binomial expressions, removing a common factor, factorisation, use of the lowest common multiple (LCM). Simplification of polynomials by factorising a cubic, algebraic division, remainder and factor theorems	Summative assessment. Class activities Past paper questions.

Autumn 2	Sequences and Series Inequalities and Simultaneous Equations Quadratic Equations Coordinate Geometry and Graphs Logs and Exponentials Exponentials and Logarithms	Sequences, Arithmetic Progressions, Arithmetic Series and Sigma Notation, Geometric Progressions, Sequence and Series Problems, Binomial Expansion. Linear Inequalities, Quadratic Inequalities, Simultaneous Equations, Simultaneous Equations with Quadratics, Geometric Interpretation. Sketching Quadratic Graphs, Factorising a Quadratic, Completing the Square, The Quadratic Formula, and The Discriminant. Coordinate Geometry, Equations of Straight Lines, Curve Sketching, Graph Transformations, Circle. Logs, Exponentials and Logs. ex , In x and Graphs, Using ex and In x – Solving Equations.	Develop and use method to simplify and solve equations, transpose formulae containing two like terms, roots and powers. Solving linear simultaneous equations with two unknowns by graphical interpretation and algebraic methods. Methods used to solve quadratic equations by quadratic graphs, factorisation, completing the squares and using the formula: x = –b ± b2 – 4ac 2a. Use geometry and graphs in the context of engineering problems How to use co-ordinate geometry such as straight line equations (equation of a line through two points, gradient of parallel and perpendicular lines, mid-point of a line, distance between two points, composite and inverse functions Understand curve sketching such as graphs of y = kxn and graphical solution of cubic functions Know how to apply graphical transformations such as translation by addition and multiplication. Understand exponentials and logarithms related to engineering problems including y = eax, y = e-ax, ey = x, ln x = y and to use inverse function and log laws.	Summative assessment. Class activities Past paper questions.
Spring 1	Circles and Trigonometry	Arc Length and Sector Area, The Trig Formulas, Using the Sine and Cosine Rules, Graphs of Trig Functions, Transformed Trig Graphs, Solving Trig Equations in a Given Intervals.	Use trigonometry in engineering problems such as angles and radians (x radians = 1800x/π degrees: x degrees = πx/180 radians).	Summative assessment. Class activities

	Trigonometry Differentiation	Sin^{-1}, Cos^{-1} and Tan^{-1} ,Secant, Cosecant and Cotangent, Using Trigonometric Identities, The Addition Formulas, The Double Angle Formulas, The R Addition Formulas. Differentiation, Finding Tangents and Normals, Stationary Points, Increasing and Decreasing Functions, Curve Sketching. Chain Rule, Differentiation of ex and In x, Product Rule, Quotient Rule, Relating Rates of Change. Differentiation of Sin, Cos and Tan, with Parametric Equations, Implicit Differentiation.	Solve problems with arcs, circles and sectors using formula for length of an arc, circle, area and use (x – a)2 + (y – b)2 = r2 Solve problems for right-angled and non-right triangles, use Pythagoras' Theorem and sine, cosine and tangent rule and understand common trigonometric identities such as sin 60° = (√3)/2, cos 60° = ½, tan 60° = √3. Understand calculus relevant to engineering problems involving differentiation such as determine gradients to a simple curve, algebraic functions, max/min turning points, differentiate trigonometric functions of the form and differential properties of exponential and logarithmic functions.	Past paper questions.
Spring 2	Integration	The Trapezium Rule, Areas Between Curves. Integration of ex and 1/x, Volumes of Revolution, Numerical Methods, Location of Roots, Iterative Methods, Numerical Integration. C4 Integration of Sin and Cos, of f′(x)/f(x), Using the Chain Rule Backwards, Using Trig Identities, Integration by Substitution and by Parts, Differential Equations.	Solve problems involving indefinite integration using the rule to integrate simple algebraic functions i.e. y = a xn, ∫ axn dx = (xn + 1)/n + 1 + constant C, integrate functions of the form, integrate sine and cosine function. Problem solving involving definite integrals such as definite integral, integrate functions of the form, notation a∫ b fx = [F)x)]b a = F(b) – F(a) and the interpretation of a definite integral.	Summative assessment. Class activities Past paper questions.

	Representation of Data. Probability	Histograms, Stem and Leaf Diagrams, Mean, Median and Mode, Interquartile Range, Cumulative Frequency Graphs, Standard Deviation, Variation and Outliers, Coding, Comparing Distributions. Random Events and Venn Diagrams, Tree Diagrams, Conditional Probability, Independent Events, Arrangements and Selections.	Be able to apply statistics and probability in the context of engineering problems the terms “data handling” and “sampling” problem solving involving histograms, frequency polygons and cumulative frequency curves.	
Summer 1	Revision on all topics covered. Past papers			Class activities Past paper questions.
Summer 2	Exam	June 2024		

Unit 2

Term	Topics	Knowledge and key terms	Skills developed	Assessment
Autumn 1	SI units Measurement terms Part 1; accuracy, error, calibration and correction. Measurement terms Part 2; relative and absolute error formulae. Standard deviation and standard error of the mean. Using measuring instruments.	Introduce SI units, and the seven base units: metre, kilogram, second, ampere, kelvin, candela, mole. Simple quiz sheet to match unit to physical quantity represented. Introduce SI derived units; introduce SI derived quantities. Examples for learners to work through. Introduce definitions of measurement terms from unit specification (1.2); illustrate with examples of their application where possible. Develop worksheet where learner's complete or match definitions; use numerical examples to illustrate terms. Practical examples using measuring instruments might be possible, particularly to illustrate calibration. Introduction to the use of measuring instruments; developing into types of measuring instruments using the categories in the exemplification in unit specification.	Understand applications of SI units and measurement, the formulae for relative and absolute error, absolute and relative correction. Calculate the standard deviation and the standard error of the mean.	Summative assessment. Class activities/worksheets Past paper questions.
Autumn 2	Scalars and vectors, force, work. Forces and motion; displacement, speed, velocity and acceleration. Kinematics; distance, velocity, speed, acceleration, mass and density.	Recap (from previous work at level 2) on scalar and vector quantities. Displacement, distance travelled, speed, velocity and acceleration using graphical methods. Introduction of concepts of force (N) and weight (W).	Understand fundamental scientific principles of mechanical engineering Force and motion, scalar and vector quantities, resultant of two coplanar vectors (vector triangle), resolve perpendicular vectors. Understanding and applying kinematics, displacement, speed, velocity and acceleration, use of graphical methods to represent distance travelled, displacement, speed, velocity and	Summative assessment. Class activities/worksheets. Past paper questions.

	Dynamics Part 1; forces. Dynamics Part 2; work, power and energy.	Formulae for relating force, mass and acceleration; weight due to gravity. Use of formulae for moments of a force, and torque. Problems relating to force, weight, moments and torque. Introduction of concept of work done - Joule (J). Problems relating to work, power and energy. Problems relating to kinetic energy (KE) and gravitational potential energy (GPE). Use work done, KE, GPE and power equations (including rearrangement to find unknown).	acceleration. Speed – time graph, velocity gradient (displacement – time graph). Applying understanding of acceleration, gradient of a velocity – time graph. Uniformly accelerated motion in a straight line. Forces and Motion, the formula for force (F), definition of newton (N), application of the concept of weight as the effect of a gravitational field on mass, use of the formula for weight (W), centre of gravity.	
Spring 1	Electron flow, charge, current and potential difference; resistance and Ohm's law. Power (electrical), energy and efficiency. Resistivity. Electric fields, field strength and capacitance. Inductance	Atomic structure and electric current. Charge, potential difference and resistance. Series and parallel resistors in circuits; total resistance and total current. Illustration of power, energy and efficiency. Use of power (P), energy (W) formula. Use of resistivity formula. Resistivity of different material types, and materials of different cross-sectional area. Concepts of electric fields, electric field strength and capacitance. Introduce SI units and defining equation. Concept of inductance (L) and unit Henry (H). Show worked examples of use of defining formula for self-inductance.	Understanding coupled pairs of equal parallel forces, rotation, moment of a force and the torque of a couple, equilibrium and resultant force and resultant torque. Force, work and power Watts, the formula for energy or work done (W). Application of joules, the formula for work done (W), kinetic energy, gravitational potential energy, relationship between mechanical power, work done and time. Capacitance (C) farad (F), formula capacitance (C), energy (Wc) of a charged capacitor. Graph for a capacitor discharging through a resistor of (a) potential difference against time and (b) current against time. Capacitor time constant, discharge and charge (τ) Inductance (L) henry (H), formula for inductance (L), coil self-	Summative assessment. Class activities/worksheets. Past paper questions.

			inductance, energy (WL) stored in the magnetic field.	
Spring 2	Atoms, elastic deformation and forces; equilibrium and deformation. Basic material properties Drift, electron flow and current. Force-extension graphs; Hooke's law. Stress and strain; Young's modulus. Non-destructive and destructive testing.	Elastic deformation (separation of atoms in solid materials), forces between atoms and equilibrium separation. Concepts of electron flow in materials, and how this relates to the flow of electric current. Basic concepts of force-extension graphs, illustrating Hooke's law. Difference between elastic and plastic deformation, and key features of force-extension graphs for different materials. Stress and strain; relating to defining equations. Destructive and non-destructive techniques.	Understanding and applying scientific principles of electrical and electronic engineering. Understand elastic and plastic deformation of a material, calculate strain energy in a deformed material from a force – extension graph. Using ultimate tensile stress and force-extension graphs for typical brittle, ductile and polymeric materials showing that there is a difference for various materials Principles of fluid mechanics.	Summative assessment. Class activities/worksheets Past paper questions.
Summer 1	Fluids and pressure. Archimedes' principle. Fluid flow. Viscosity. Introduction to thermodynamics. Boyle's, Charles' and the pressure law. Gas equations.	Introduction to fluids and pressure. Archimedes' principle. Fluid flow and types. Concept and definitions of viscosity. Experimentally the viscosity of different materials.	Understanding fluids at rest, gauge pressure, absolute pressure and that pressure exerted on any point on a surface in a fluid is always at right angles to the surface while pressure at any point in a fluid is the same in all directions at that point. Application and definition of Archimedes' principle, fluid flow, ideal fluid, streamline or laminar turbulent flow, boundary layers and viscosity. Know the basic principles of thermal physics, 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.	Class activities/worksheets Past paper questions.

	Energy flow. Revision	Introduction to thermodynamics; internal energy in a system, and what is meant by the thermodynamic scale. Introduction to specific and latent heat capacity using numerical examples, and the efficiency equation. Different types of gas laws. Combined gas law and the characteristic (ideal) gas equation using suitable numerical examples. Non-flow and steady-flow energy equations.	Specific heat capacity, formula heat energy or sensible heat (Q) and the efficiency equation. Sensible and latent heat application of formulae. Know 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. Understand Boyle's law, Charles' law, Pressure law, combined gas law, characteristic gas equation. Solve numerical problems using each of the gas laws, including transposition of the subject.	
Summer 2	Exam	June 2024		

Unit 3

Term	Topics	Knowledge and key terms	Skills developed	Assessment
Autumn 1	Understand systems of forces and types of loading on mechanical components.	Different types of loading that could be applied to a mechanical component: • direct forces • turning forces, i.e. • moments • torque • Shear forces Resolve a force into its orthogonal components. Systems of co-planar forces, i.e.: • concurrent forces • non-concurrent forces Diagrammatic representations of engineering problems using force diagram. How mechanical engineering situations can be represented by: • particle mechanics • rigid bodies Conditions of equilibrium for systems of Forces. How to determine the resultant of a set of coplanar 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	Understand systems of forces and types of loading on mechanical components, different types of loading that could be applied to a mechanical component including direct forces, turning forces (moments, torque, shear forces). Know the different types of loading identified, and how they can be applied to a mechanical component. Understand situations in which assumptions of particle and rigid body mechanics can be applied. Use and draw force diagrams to represent engineering problems to aid visualisation and analysis. Learners should be aware of horizontal and vertical equilibrium for systems of concurrent forces (particle mechanics), and horizontal, vertical and rotational equilibrium for non-concurrent forces (rigid body mechanics). For systems of non-concurrent forces the learner must be able to define the resultant or equilibrant both in terms of : 1. magnitude and line of action (point and direction) 2. Magnitude and direction, and moment acting at a specific point. Learners should know appropriate units for stress and Young's modulus and be able to use	Summative assessment. Class activities/worksheets Past paper questions.

		loaded components i.e.: • stress = force/cross-sectional area • strain = change in length/original length • use of Young's modulus (E) = stress/strain. Representation of material behaviour on a generic stress versus strain graph i.e.: • elastic deformation • the elastic limit • in-elastic and plastic deformation • ultimate stress • factor of safety How to apply formulae to calculate the shear stress in a component under shear loading i.e. • shear stress = shear force/shear area.	the formulae listed to carry out calculations for components in direct tension or compression. Learners must know the term of the modulus of elasticity (Young's modulus), and that this represents the stiffness of a material. Learners should understand how Factors of Safety (FOS) are used to calculate the allowable working stress of a material i.e. • allowable working stress = ultimate stress/FOS Learners should understand the terms shear stress and shear strain. Learners should be aware of components in single and double shear (e.g. a bolt).	
Autumn 2	Understand fundamental geometric properties.	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 nonsymmetrical 2D shapes i.e. • right-angled triangle • semi-circle The use of moment of area of uniform regular 2D shapes to find the position of the centroid of more complex uniform irregular shapes.	Understand fundamental geometric properties to include calculations of the area of irregular 2D shapes, the volume of a regular prism of known cross sectional area and length, the mass of a body of known volume and uniform density. Understand 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. Understand the position of the centroid of common non- symmetrical 2D shapes including right-angled triangle and semi-circle. The use of moment of area of uniform regular 2D shapes to find the position of the centroid of more complex uniform irregular shapes.	Summative assessment. Class activities/worksheets. Past paper questions.

Spring 1	Understand levers, pulleys and gearing.	Concepts of mechanical advantage (MA) and velocity ratio (VR) applied to: • levers • systems of pulleys • gears The three classes of lever i.e. • class one • class two • class three Different types of gears and gear systems, and their applications i.e.: • spur gears • compound spur gears • idler gears • chain driven sprockets • bevel gears • rack and pinion • wormgear and wormwheel 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 i.e.: • V-belts • flat belts • toothed belts Calculation of the MA and VR for the named belt drive systems above.	Learners should understand that MA and VR are inversely related so that an increase in output force (force amplification) or torque (torque amplification) is achieved at a cost of output speed. Levers (direct forces and linear movements) and gears or pulley systems (for torque and rotational movement) obey the same fundamental principles. Learners should be able to recognise different types of levers as part of simple mechanisms and identify the key features of fulcrum, input force (FI) and output force (FO). Learners must be able to carry out calculations to determine unknown forces, the mechanical advantage and/or velocity ratio for levers of given geometry (input velocity VI, output velocity VO). Learners should be able to identify different types of gear systems and suggest applications for which they are commonly used. Learners should be able to identify different types of pulley and belt systems and their advantages and disadvantages for common applications.	Summative assessment. Class activities/worksheets. Past paper questions.
Spring 2	Understand properties of beams.	Different types of beams and their support conditions. i.e.: • simply supported • cantilever	Learners should understand that uniformly distributed loads can be imposed loads e.g.	Summative assessment. Class activities/worksheets

		• continuous • encastre Different types of loading applied to beams i.e.: • point loads • uniformly distributed loads How to calculate, using conditions of static equilibrium, the reactions of beams. i.e.: • simply supported • cantilever 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.	pedestrians or dead loads from the weight of the beam. Understand properties of beams and different types of beams and their support conditions including simply supported, cantilever and continuous. Understand different types of loading applied to beams including point loads and uniformly distributed loads and how to calculate, using conditions of static equilibrium, the reactions of beams including simply supported and cantilever. Know how to calculate the bending moment at any point in simply supported or cantilever beams with point loading and how to draw a bending moment diagram for a simply supported or cantilever beam with point loading.	Past paper questions.
Summer 1	Understand 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 i.e.: The principle of conservation of energy and how to apply this principle to problems	Understand principles of dynamic systems How to apply Newton's Laws of Motion in a mechanical engineering context and the constant acceleration formulae to problems set in a mechanical engineering context. Understand the principle of conservation of energy and how to apply this principle to problems involving kinetic and gravitational potential energy. Understand the relationship between work done on a body and the change in energy of that	Summative assessment Class activities/worksheets Past paper questions.

		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 i.e.: • gravitational potential energy • kinetic energy • work done = force x distance Use of the equations for power to solve problems set in a mechanical engineering context i.e.: • instantaneous power = force x velocity • Average power = work done/time. 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 experiencing elastic collisions.	body and the application of equations for energy and work done to problems set in a mechanical engineering context to include gravitational potential energy.	
Summer 2	Exam	June 2024		