



CAMBRIDGE TECHNICALS IN ENGINEERING

LEVEL 3 UNIT 2 – SCIENCE FOR ENGINEERING

DELIVERY GUIDE

Version 2

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INTRODUCTION

This Delivery Guide has been developed to provide practitioners with a variety of creative and practical ideas to support the delivery of this qualification. The Guide is a collection of lesson ideas with associated activities, which you may find helpful as you plan your lessons.

OCR has collaborated with current practitioners to ensure that the ideas put forward in this Delivery Guide are practical, realistic and dynamic. The Guide is structured by learning outcome so you can see how each activity helps you cover the requirements of this unit.

We appreciate that practitioners are knowledgeable in relation to what works for them and their learners. Therefore, the resources we have produced should not restrict or impact on practitioners' creativity to deliver excellent learning opportunities.

Whether you are an experienced practitioner or new to the sector, we hope you find something in this guide which will help you to deliver excellent learning opportunities.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resourcesfeedback@ocr.org.uk.

Unit aim

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.

By completing this unit learners will:

- understand applications of SI units and measurement
- understand fundamental scientific principles of mechanical engineering
- understand fundamental scientific principles of electrical and electronic engineering
- understand properties of materials
- know the basic principles of fluid mechanics
- know the basic principles of thermal physics

Unit 2 Science for Engineering	
LO1	Understand applications of SI units and measurement
LO2	Understand fundamental scientific principles of mechanical engineering
LO3	Understand fundamental scientific principles of electrical and electronic engineering
LO4	Understand properties of materials
LO5	Know the basic principles of fluid mechanics
LO6	Know the basic principles of thermal physics

Opportunities for English and maths skills development

We believe that being able to make good progress in English and maths is essential to learners in both of these contexts and on a range of learning programmes. To help you enable your learners to progress in these subjects, we have signposted opportunities for English and maths skills practice within this resource. These suggestions are for guidance only. They are not designed to replace your own subject knowledge and expertise in deciding what is most appropriate for your learners.



English



Maths

Please note

The timings for the suggested activities in this Delivery Guide **DO NOT** relate to the Guided Learning Hours (GLHs) for each unit.

Assessment guidance can be found within the Unit document available from www.ocr.org.uk.

The latest version of this Delivery Guide can be downloaded from the OCR website.

KEY TERMS

UNIT 2 – SCIENCE FOR ENGINEERING

Explanations of the key terms used within this unit, in the context of this unit

Key term	Explanation
Absolute error	Absolute error is the uncertainty in a measurement, which is expressed using the relevant units.
Absolute pressure	Absolute pressure = gauge pressure + atmospheric pressure.
Acceleration	Acceleration is a vector quantity that is defined as the rate at which an object changes its velocity.
Accuracy	Accuracy is how close a measured value is to the actual (true) value.
Archimedes' principle	Archimedes' principle – an up-thrust force in newtons acting on an immersed object is equal to the weight of fluid displaced.
	Up-thrust force F (N) = $Vg\rho$ where V is volume of fluid displaced, ρ is the density of the liquid and g is acceleration due to gravity.
Boyle's Law	Boyle's Law states that for a fixed mass of gas at constant temperature the pressure is inversely proportional to the volume.
	$pV = C$ where p is the pressure of the gas, V is the volume of the gas and C is a constant.
Calibration	Calibration is the process of checking an instrument or tool so that it does something correctly.
Capacitance	Capacitance is the property of a conductor to store an electric charge.
	One farad is the capacitance of a conductor which is at a potential of 1 volt when it carries a charge of 1 coulomb.
	$C = Q/V$ $Wc = \frac{1}{2}QV$
Capacitors – charging and discharging	The time constant for a series capacitor/resistor combination is given by $\tau = RC$
	When charging, capacitor voltage is described by the equation: $V_c = V_0 e^{-t/RC}$, where the potential difference (p.d.) at time t is V_c and at $t = 0$, the p.d. is V_0 . Similar defining equations exist for charging current and discharging voltage and current.
Charge and Coulomb	The coulomb C is the SI derived unit of electric charge. It is the charge that crosses a section of the circuit in 1 second when a current of 1 ampere flows.
	$Q = It$, where t is the time (for Q to be in coulombs, I in amperes t in seconds).

KEY TERMS

Explanations of the key terms used within this unit, in the context of this unit

Key term	Explanation
Charles' Law	Charles' Law states that for a fixed mass of gas at constant pressure, the volume is directly proportional to the temperature. $V/T = C$ where V is the volume of the gas, T is temperature and C is a constant.
Combined Gas Law	The Combined Gas Law combines Boyle's Laws, Charles' Law and the Pressure Law into one equation. $(P_1 V_1) / T_1 = (P_2 V_2) / T_2$ The formula considers a fixed mass of gas at two different temperatures, volumes and pressures.
Displacement	Displacement is a vector quantity that refers to an object's overall change in position.
Drift current and electron flow in materials	Drift current is the electric current, or movement of charge carriers, which is due to an applied electric field. $I = nAve$, where n is the number of conduction electrons per unit volume, A the cross sectional area of the conductor, v the average drift velocity and e the charge on the electron.
Dynamics	Dynamics is a branch of mechanics concerned with the study of forces and torques and their effect on motion.
Elastic deformation of materials	Elastic deformation is deformation that disappears upon removal of the external forces causing the alteration and the stress associated with it.
Electric field strength	A uniform field is one in which the electric field is constant at every point. It can be approximated by placing two conducting plates parallel to each other and maintaining a voltage (potential difference) between them. $E = V/d$, for a potential difference V across plates of separation d .
Electron flow and current flow	An electric current is a flow of electric charge. In electric circuits this charge is often carried by moving electrons in a wire. By convention, electron flow is in the opposite direction to current flow in a circuit. Current is the rate of flow of charge. The SI derived unit of current is the ampere A. Electrical energy is the rate at which energy is transferred (or supplied) over a period of time. It is usually measured as kilowatt-hour (kWh). This is actually a measurement of average power consumption.
Equilibrium separation in materials	Equilibrium separation is the distance between the atoms at which the force on each atom is zero.
Error	Error is the difference between the actual value of a quantity and the value obtained by a measurement.
Force	The Newton is the SI derived unit of force. $F = ma$ where F is force in newtons, m is mass in kg and a is acceleration in ms^{-1}

KEY TERMS

Key terms used within this unit, explained in the context of this unit, give examples	
Key term	Explanation
Force-extension graph	A force-extension graph shows the extension of a material with an increasing applied load. It can be used to determine and predict the properties of the material.
Gauge pressure	Gauge Pressure – pressure indicated above that due to the atmosphere.
Gravitational potential energy	Gravitational Potential Energy is the energy an object possesses because of its position (usually height) in a gravitational field. Gravitational Potential Energy (GPE) = mgh The SI derived unit is the joule J .
Heat efficiency	Efficiency is usually the relationship between input and output energy to a system expressed as a percentage. Losses between input and output account for an efficiency which is usually less than 100%. Efficiency $\eta = (\text{Energy Output} / \text{Energy Input}) \times 100\%$
Hooke's Law	Hooke's law is a law stating that the stress on a solid substance is directly proportional to the strain produced, provided the stress is less than the elastic limit of the substance. It is characterised by the formula $F = Ke$ where F is force in newtons N , K is the spring constant in newtons per metre Nm^{-1} and e is extension in metres. The SI unit for Hooke's law is the newton N . Hooke's law applies to springs and continuous materials (e.g. steel) where it represents the linear region on a force-extension graph.
Ideal Gas Law	The ideal gas law is the equation of state of a hypothetical ideal gas. It is a good approximation to the behaviour of many gases under many conditions. $pV = nRT$ where p is pressure, V is volume, n is the amount of substance of gas (in moles), R is the Universal Gas Constant and T is temperature. R – the Universal Gas Constant has a value of approximately 8.3145 joules per kelvin per mole (J K mol⁻¹).
Inductance	A coil has a self-inductance (L) of 1 henry (H) if an e.m.f. of 1 volt (V) is induced in the coil when the current through the coil changes at the rate of 1 ampere per second. $L = \Phi N / I$ $W_L = \frac{1}{2} L I^2$
Internal energy	Internal energy is defined as the energy associated with the random, disordered motion of molecules.
Kinetic energy	Kinetic Energy is the energy that a body possesses by virtue of being in motion. Kinetic Energy (KE) = $\frac{1}{2} mv^2$ The SI derived unit is the joule J .
Laminar fluid flow	Laminar flow is the flow of a viscous fluid in which particles of the fluid move in parallel layers, each of which has a constant velocity but is in motion relative to its neighbouring layers.
Latent heat / Specific Latent Heat	Latent heat is the heat required to convert a solid into a liquid or vapour, or a liquid into a vapour, without change of temperature. $Q = mL$ where Q is the amount of energy released or absorbed during the change of phase, m is the mass of the substance and L is the latent heat capacity for the substance.

KEY TERMS

Key terms used within this unit, explained in the context of this unit, give examples	
Key term	Explanation
Mechanical properties of materials	Characteristics that indicate the elastic or inelastic behaviour of a material under pressure or force, such as bending, brittleness, elongation, hardness, tensile strength etc.
Non-destructive testing	Non-destructive testing refers to a range of techniques used to determine the characteristics of a material that do not result in its destruction. Techniques include dye penetrant, ultrasonic, electromagnetic and radiographic testing.
Potential difference	The potential difference is the difference of electrical potential between two points. $V = W/Q$ where V is the potential difference in volts, W is the work done in joules J and Q is the charge in coulombs C . The SI derived unit of potential difference is the volt V .
Power (in electrical systems)	Electric power is the rate at which electric energy is transferred by an electric circuit. The SI unit of power is the watt W (one joule per second).
Power (in mechanical systems)	Power is the rate of doing work or converting energy from one form to another. $P = W/t$, where P is power, W is the work done in time t . The SI derived unit of power is the watt W .
Precision	Precision is how close measured values are to each other.
Pressure in a column of fluid	Pressure due to a column of liquid $p = h\rho g$ where p is pressure, h is height of column in metres m , g is the gravitational constant, ρ is the density of the liquid kg/m^3 The unit of pressure is the pascal Pa (or Nm^{-2}) Pressure in a column is often referred to as hydrostatic pressure.
Pressure Law	Pressure Law states that for a fixed mass of gas at constant volume, the pressure is directly proportional to the temperature. $p/T = C$ where p is the pressure, T is temperature and C is a constant.
Relative error	Relative error is a measure of the uncertainty of measurement compared to the size of the measurement.
Resistance and Ohm's law	Resistance is the opposition to current flow. The SI derived unit of resistance is the ohm Ω Ohm's law relates resistance to voltage and current flow in a circuit. $V = IR$, $I = V/R$ and $R = V/I$
Resistivity	Resistivity is a measure of the resisting power of a specified material to the flow of an electric current. The formula relating resistivity (ρ) to resistance (R), cross-sectional area (A) and length (l) is: $\rho = RA/l$ The SI unit of electrical resistivity is the ohm-metre ($\Omega\cdot m$).
Scalars and vectors	Scalar: a quantity, such as mass, length, or speed, that is completely specified by its magnitude and has no direction. Vector: a quantity having direction as well as magnitude, especially as determining the position of one point in space relative to another.

KEY TERMS

Key terms used within this unit, explained in the context of this unit, give examples	
Key term	Explanation
Sensible heat	When an object is heated, its temperature rises as heat is added. The increase in heat is called sensible heat. Similarly, when heat is removed from an object and its temperature falls, the heat removed is also called sensible heat. Heat that causes a change in temperature in an object is called sensible heat.
SI Units	<p>The International System of Units (abbreviated SI from French: Le Système International d'Unités) is the modern form of the metric system and is the world's most widely used system of measurement. It comprises seven base units (from which other units can be derived):</p> <p>The ampere (A) - unit of measurement of electric current.</p> <p>The kilogram (kg) - unit of measurement of mass.</p> <p>The metre (m) - unit of measurement of length.</p> <p>The second (s) - unit of measurement of time.</p> <p>The kelvin (K) - unit of measurement of thermodynamic temperature.</p> <p>The mole (mol) - unit of measurement of amount of substance.</p> <p>The candela (cd) - unit of measurement of luminous intensity.</p>
Specific heat capacity	Specific heat capacity is the heat required to raise the temperature of the unit mass of a given substance by a given amount (usually one degree).
Speed	Speed is a scalar quantity that refers to how fast an object is moving.
Standard deviation	Standard deviation is a quantity expressing by how much the members of a group differ from the mean value for the group.
Standard error of the mean	The standard error of the mean is an indication of how well the mean of a sample estimates the mean of a population.
Steady flow energy	<p>Power is the rate of doing work or converting energy from one form to another.</p> <p>The Steady Flow Energy Equation (SFEE) is used for open systems to determine the total energy flows. It assumes that the mass flow through the system is constant and that total energy input to the system is equal to total energy output. Steady flow energy is based on the principle of conservation of energy.</p> <p>$Q = (W_2 - W_1) + W$ where: Q is the heat energy supplied to the system, W_2 is energy leaving the system, W_1 is energy entering the system, W is work done by the system.</p>
Strain	<p>Strain is defined as 'deformation of a solid due to stress'.</p> <p>$\epsilon = \Delta L / l_0$ where ϵ is strain, ΔL is change in length in metres and l_0 is initial length in metres.</p> <p>As strain is metres divided by metres then it is dimensionless, although strain is sometimes determined as strain rate which has SI units 1/seconds or s⁻¹</p>

KEY TERMS

Key terms used within this unit, explained in the context of this unit, give examples

Key term	Explanation
Stress	<p>Stress is the load (force) per unit area that tends to deform the body on which it acts. Compressive stress tends to squeeze a body, tensile stress to stretch (extend) it, and shear stress to cut it.</p> <p>$\sigma = F/A$ where σ is stress, F is force in newtons and A is cross sectional area in m^2</p> <p>The SI unit of stress is newtons per metre squared Nm^{-2}</p>
Temperature and the kelvin scale	<p>A convenient operational definition of temperature is that it is a measure of the average translational kinetic energy associated with the disordered microscopic motion of atoms and molecules.</p> <p>The kinetic energy of the particles is proportional to the temperature of a gas if the temperature is measured using the kelvin scale.</p>
Turbulent fluid flow	Turbulent fluid flow is the motion of a fluid having local velocities and pressures that fluctuate randomly.
Velocity	Velocity is a vector quantity that refers to the rate at which an object changes its position.
Viscosity and ideal fluids	Viscosity is the state of being thick, sticky, and semi-fluid in consistency, due to internal friction. An Ideal fluid is one with assumed zero viscosity.
Weight	<p>Weight is the force with which a body is attracted to the Earth (or any other celestial body).</p> <p>$W = mg$, where g is the acceleration due to gravity. The SI derived unit of weight is the newton.</p>
Work (in mechanical systems)	<p>In mechanical systems, work is done when a force moves an object through a distance.</p> <p>$W = Fd$ (where W is work done, F is force in newtons and d is distance in metres). The SI derived unit of work is the newton-metre Nm or Joule J.</p>
Young's modulus	<p>Young's modulus is a measure of the stiffness of an elastic material and is a quantity used to characterise materials. It is defined as the ratio of the stress (force per unit area) along an axis to the strain (ratio of deformation over initial length) along that axis in the range of stress in which Hooke's law holds.</p> <p>The defining formula is: $E = FL_0 / A\Delta L$ where E is the Young's modulus, F is force in newtons N, L is original length in metres m, A is cross sectional area in m^2 and ΔL is change in length in metres m.</p> <p>The SI unit for Young's modulus is the pascal Pa equal to one newton per square metre Nm^{-2}.</p>

MISCONCEPTIONS/AREAS OF DIFFICULTY




Some common misconceptions and guidance on how they could be overcome

What is the misconception?	How can this be overcome?	Resources which could help
Difference between accuracy and precision	Learners often confuse the terms accuracy and precision in the context of measurements. Analogies and examples, such as the dartboard images in the resources link may be a way for learners to understand and remember the difference.	http://www.mathsisfun.com/accuracy-precision.html
Application of scalars and vectors	Learners often confuse scalar and vector quantities. Practical (real life) examples showing the application of scalars and vectors may prove useful in securing understanding. Teachers could develop a quiz where learners have to identify scalar and vector quantities.	http://www.khanacademy.org/science/physics/one-dimensional-motion
Application of the equations of motion	Understanding of the application of the equations of motion might be reinforced through solving practical problems involving displacement, speed, velocity and acceleration.	http://www.physicsclassroom.com/class/1DKin/Lesson-6/Kinematic-Equations
Difference between power, work and energy	Learners often confuse the meaning of the terms power, work and energy in mechanical and electrical systems. Reference might be made to domestic or industrial applications (e.g. a hairdryer that consumes 2000 watts describes the power consumed by the hairdryer. If the hairdryer is used for 1 hour, then it consumes 2000 watt-hours i.e. 2 kWh of energy). Similar examples might be developed for mechanical systems.	http://www.schoolphysics.co.uk/age16-19/Mechanics/Dynamics/text/Force_Work_Energy_Power_equations/index.html http://www.energylens.com/articles/kw-and-kwh
Phenomena of capacitance and inductance	The phenomena of capacitance and inductance might be explained using simple practical experiments. This could include charging and discharging of a capacitor, or demonstrating the energy stored in a coil (inductor).	http://www.schoolphysics.co.uk/age16-19/Electricity%20and%20magnetism/Electrostatics/text/Capacitor_energy_stored/index.html http://www.electronics-tutorials.ws/inductor/inductor.html
Interpretation of a force-extension graph	The understanding and interpretation of force-extension graphs might be reinforced if it is possible to perform tensile testing of materials. Alternatively real data could be used or web-based videos showing tensile testing. Learners could plot force-extension graphs for different materials, identifying key characteristics from the graph.	http://www.youtube.com/watch?v=D8U4G5kcpcM
Definition of stress and strain	It may be possible to demonstrate both stress and strain using practical experiments. Internet videos showing stress and strain measurement might also prove useful.	http://www.youtube.com/watch?v=0s5kBrk0d80



MISCONCEPTIONS/AREAS OF DIFFICULTY

Some common misconceptions and guidance on how they could be overcome		
What is the misconception?	How can this be overcome?	Resources which could help
Difference between laminar and turbulent fluid flow	Laminar and turbulent flow can be demonstrated with water flowing from a tap. This could be shown practically or using a web-based video.	http://www.youtube.com/watch?v=VoBc60iUq2
Relationship of temperature to the kelvin scale	Temperature relates to the amount of kinetic energy within a material or substance. It may be possible to demonstrate the effects of temperature on internal energy practically, or using web-based resources.	http://www.khanacademy.org/test-prep/mcat/physical-processes/gas-phase/v/absolute-temperature-and-the-kelvin-scale
The gas laws	It may be possible to demonstrate some or all of the gas laws using practical experiments. Alternatively, web-based videos might be used. The video link shows a simple demonstration of Boyle's Law.	http://www.youtube.com/watch?v=vSFVMJQ4J7U
Relationships between heat energy terms: specific, sensible and latent heat	Practical experiments could be performed to reinforce understanding of specific and latent heat. Alternatively web-based videos of experiments may prove useful. The video link shows latent heat of super-cooled water as it freezes.	http://www.youtube.com/watch?v=1PcnCWZP7I0
Energy flow theory: non-flow and steady flow energy	It may be possible to explain non-flow and steady flow of energy with reference to the first law of thermodynamics using suitable worked examples. A typical implementation can be seen in the Stirling Engine (a heat engine) which illustrates the principles of the first law of thermodynamics (i.e. conservation of energy).	http://www.animatedengines.com/vstirling.html




SUGGESTED ACTIVITIES

LO No:	1	
LO Title:	Understand applications of SI units and measurement	
Title of suggested activity	Suggested activities	Suggested timings
SI Units 	<p>Learners could be tasked to research the seven SI base units - metre for length, kilogram for mass, second for time, ampere for electric current, kelvin for temperature, candela for luminous intensity, mole for amount of substance.</p> <p>See ASE publication Signs, Symbols and Systematics (The ASE Companion to 16 – 19 Science, 2000).</p> <p>The National Physical Laboratory (NPL) website may prove a useful starting point and includes a series of videos illustrating each of the SI units http://www.npl.co.uk/reference/measurement-units/si-base-units/.</p> <p>Learners could further research SI derived units with special names and symbols, SI prefixes and SI derived quantities.</p> <p>Learners could present their findings in the form of a poster.</p>	2 hours
Measurement Terms Part 1 – accuracy, error, calibration and correction 	<p>Common measurement terms include: accuracy, accuracy class, absolute error, calibration, correction, error, intrinsic error, percentage error, precision, relative error, true value and uncertainty.</p> <p>Teachers could develop a quiz for learners to identify or explain each of these terms.</p> <p>Web-based resources may prove useful such as the following which explains accuracy and precision http://www.mathsisfun.com/accuracy-precision.html and the following which explains calibration http://www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/6098/Why-Calibrate-an-Instrument</p> <p>An alternative approach might be tasking learners to produce a poster or presentation explaining measurement terms.</p>	2 hours
Measurement Terms Part 2 – relative and absolute error formulae 	<p>Common error terms used in measurement include: relative error, absolute error, absolute correction and relative correction.</p> <p>The following web resource explains these terms and their associated calculation in detail http://www.mathsisfun.com/measure/error-measurement.html</p> <p>Teachers could demonstrate the solution of worked examples to learners, and provide learners with further practice problems to solve.</p>	3 hours




SUGGESTED ACTIVITIES

Title of suggested activity	Suggested activities	Suggested timings
<p>Standard Deviation and Standard Error of the Mean</p> 	<p>Standard deviation and standard mean of the error are often used in the context of taking measurements.</p> <p>Web-based resources might prove useful to explain these terms, or as part of self-study. The following video tutorials explain standard deviation http://www.youtube.com/watch?v=09kiX3p5Vek and standard error of the mean http://www.youtube.com/watch?v=BwYj69LAQOI</p> <p>Teachers could use further worked examples to illustrate these and task learners through developing a worksheet to solve practice questions.</p>	<p>2 hours</p>
<p>Using measuring instruments</p> 	<p>Teachers might begin by explaining how instruments can be used to perform measurements.</p> <p>The following NPL web resources explain mechanical measurements http://www.npl.co.uk/upload/pdf/beg-guide-measurement-mech-eng.pdf and electrical measurements http://www.npl.co.uk/upload/pdf/gpg-132-beg-guide-measurement-electronic-electrical-eng.pdf. Similar resources might be researched for materials, fluid and thermal measurements.</p> <p>Alternatively, learners could be tasked to undertake a research activity to identify and explain common measurements in the areas of mechanical engineering, electrical/electronic engineering, materials science, fluid mechanics and thermal physics.</p> <p>Understanding could be reinforced through undertaking practical activities (if access to suitable equipment is available) where learners perform measurement tasks.</p>	<p>2 hours</p>




SUGGESTED ACTIVITIES

LO No:	2	
LO Title:	Understand fundamental scientific principles of mechanical engineering	
Title of suggested activity	Suggested activities	Suggested timings
Generators, alternating current and voltage 	<p>Learners may already be familiar with the concept of scalars and vectors from previous work in mathematics.</p> <p>Teachers could develop worked mechanical examples demonstrating scalar and vector quantities.</p> <p>Examples should include how to determine the resultant of two coplanar vectors by using a vector triangle, how to calculate the resultant of two perpendicular vectors and how to resolve a vector into two perpendicular vectors.</p> <p>Learners could be tasked to solve practice questions involving vectors – which might be solved both graphically using scale drawings and mathematically.</p> <p>Web-based resources might be used to support learning, with the following explaining scalars and vectors http://www.physicsclassroom.com/class/1DKin/Lesson-1/Introduction</p>	1 hour
Displacement, speed, velocity and acceleration 	<p>Teachers might use simple analogies (e.g. a car journey, movement of an elevator or the flight path of an aircraft) to define and illustrate distance travelled, displacement, speed, velocity and acceleration.</p> <p>Learners could be presented with problem descriptions, which they are required to represent graphically in terms of distance travelled, displacement, speed, velocity, acceleration. Speed, velocity and acceleration might be represented against time.</p> <p>The following web resource explains each of these terms with animations and worked examples http://www.physicsclassroom.com/class/1DKin/Lesson-1/Introduction</p>	2 hours
Kinematics Part 1 – distance, velocity and speed 	<p>Learners could extend their knowledge by using graphical methods to determine distance, velocity and speed .i.e.</p> <ul style="list-style-type: none"> • distance travelled by calculating the area under a speed – time graph • velocity by using the gradient of a displacement – time graph • speed by using the gradient of a distance – time graph. <p>Determination of distance, velocity and speed might be related back to examples using graphical representation techniques learners have developed previously.</p> <p>Teachers might demonstrate the solution of problems using numerical methods (to determine area or gradient) and also show how to obtain values mathematically.</p> <p>The following web resource explains the characteristic kinematic equations of motion http://www.physicsclassroom.com/class/1DKin/Lesson-6/Kinematic-Equations</p> <p>A worksheet could be developed with problems for learners to solve.</p>	2 hours




SUGGESTED ACTIVITIES

Title of suggested activity	Suggested activities	Suggested timings
Kinematics Part 1 – acceleration and mass 	<p>To teach kinematics teachers could introduce learners to acceleration and the effects of mass. Learners could solve problems relating to acceleration by using the gradient of a velocity – time graph. Teachers could explain the equations which represent uniformly accelerated motion in a straight line. The following web resources contains video examples and video tutorials explaining acceleration http://academicianship/science/physics/one-dimensional-motion</p> <p>Teachers could further develop kinematic theory by presenting problems including mass, i.e. that mass is the property of a body which resists change in motion.</p> <p>Mass could be related to density and the application of different engineering materials.</p> <p>Learners could be presented with problems relating to acceleration and mass e.g. to select appropriate density and mass of materials to achieve specific acceleration.</p>	2 hours
Dynamics 	<p>Teachers could be.g.in by introducing learners to the concept of force and weight. Learners might already be familiar with these concepts.</p> <p>Web-based resources might prove useful with the following providing revision on weight, mass and gravity http://www.bbc.co.uk/bitesize/ks3/science/energy_electricity_forces/forces/revision/3/</p> <p>Teachers could extend this by introducing centre of gravity, couples, moments (rotation) and equilibrium. Again, web-based resources could prove useful with the following video tutorials explaining centre of gravity and rotation http://www.khanacademy.org/science/physics/torque-angular-momentum/torque-tutorial/v/center-of-mass</p> <p>It may be possible to demonstrate some concepts practically if access to equipment is available e.g. force and weight, turning moments (torque) etc.</p>	2 hours
Work and power 	<p>Learners could be tasked to research work and power including : joules and use of the formula for work done; kinetic energy, gravitational potential energy; the relationship between mechanical power, work done and time; watts and use of the formula for energy or work done.</p> <p>Web-based resources may prove useful with the following showing the equations for force, work energy and power http://www.schoolphysics.co.uk/age16-19/Mechanics/Dynamics/text/Force_Work_Energy_Power_equations/index.html</p> <p>Learners could present their findings in the form of a presentation or poster.</p> <p>It may be possible to perform simple experiments relating to work and power if access to suitable equipment is available.</p> <p>Teachers might develop a worksheet with problems for learners to solve.</p>	2 hours





SUGGESTED ACTIVITIES

LO No:	3	
LO Title:	Understand fundamental scientific principles of electrical and electronic engineering	
Title of suggested activity	Suggested activities	Suggested timings
Electron flow, charge, current and potential difference 	<p>Teachers might be.g.in this section on electrical and electronic engineering by looking at charge, electron and current flow and potential difference – introducing the term coulomb and electron flow in conductors, semiconductors and insulators. Potential difference might be related to energy and charge and also power and current.</p> <p>Web-based resources may prove useful with the following explaining conventional and electron flow http://www.allaboutcircuits.com/vol_1/chpt_1/7.html and potential difference http://www.physicsclassroom.com/class/circuits/Lesson-1/Electric-Potential-Difference</p> <p>Learners might be tasked to research and present findings for current-potential difference characteristics for different materials and devices including: a metallic conductor at constant temperature; a filament lamp; a semiconductor diode.</p>	2 hours
Resistance and Ohm's Law 	<p>Learners may already be familiar with the concept of electrical resistance and the application of Ohm's law to solving circuit problems.</p> <p>Learners could build upon knowledge of series and parallel resistor circuits, and also Ohm's law, to determine total resistance and current in circuits that are a combination of series and parallel resistors. Theory could be linked with practice, and learners might be able to calculate resistance and current and then prove this through practically building and testing circuits.</p> <p>Web resources may prove a useful source of information with the following explaining resistor circuits http://www.electronics-tutorials.ws/resistor/res_5.html</p>	1 hour
Power, energy and efficiency 	<p>Power, energy and efficiency could be related to everyday examples of domestic or industrial energy consumption.</p> <p>Teachers could explain and demonstrate application of the formulae for power and energy including that the kilowatt-hour is a unit of energy.</p> <p>System efficiencies could be determined i.e. ratio of work or power output to work or power input.</p> <p>Learners could be presented with problems to solve in order to reinforce understanding.</p> <p>The following web page explains energy and power (and their relationship), and may prove a useful starting point http://www.physicsclassroom.com/Class/circuits/u9l2d.cfm</p>	2 hours





SUGGESTED ACTIVITIES

LO No:	3	
LO Title:	Understand fundamental scientific principles of electrical and electronic engineering	
Title of suggested activity	Suggested activities	Suggested timings
Resistivity 	<p>Resistivity is a measure of the resisting power of a specified material to the flow of an electric current. It is affected by the nature of the material itself with resistance also being affected by length, cross-sectional area and temperature.</p> <p>Teachers could begin by explaining the concept of resistivity using examples of different materials, and introducing its relationship to resistance, cross sectional area and temperature.</p> <p>The following web page explains the relationship between resistivity and resistance http://resources.schoolscience.co.uk/CDA/16plus/copelech2pg1.html</p> <p>Learners could conduct research (or perform practical experiments) to determine variation in temperature with a pure resistor and with a negative temperature coefficient thermistor, and to present this graphically. The following website explains resistance variation with temperature http://www.electrical4u.com/electrical-resistance-and-laws-of-resistance/</p>	2 hours
Electric fields, field strength and capacitance 	<p>Electric fields, field strength and capacitance are important concepts in electrical theory. Teachers might begin by explaining uniform field strength, simple parallel plate capacitors and capacitance. Formulae for electric field strength, capacitance and energy of a charged capacitor could be presented along with worked calculations. Learners could be tasked to solve practice questions.</p> <p>The following web page explains energy in a charged capacitor http://www.schoolphysics.co.uk/age16-19/Electricity%20and%20magnetism/Electrostatics/text/Capacitor_energy_stored/index.html</p> <p>Charging and discharging of capacitors through a resistor could be demonstrated practically by a simple experiment – with the characteristic equations being explained (including time constant). Plotting of graphs of voltage against time and current against time (charging and discharging) could be done using software (e.g. a spreadsheet) thereby developing ICT skills. See Lesson Element Electric fields, field strength and capacitance – the RC circuit and time constant</p>	2 hours
Inductance 	<p>Inductance (self inductance) is a further important concept in electrical engineering.</p> <p>Teachers might begin by explaining the terms inductance (L) and henry (H), the formula for self-inductance of a coil and the formula for energy stored in the magnetic field of a coil.</p> <p>Learners could be tasked to solve problems using both formulae. A practical demonstration could be used to illustrate the energy stored in a coil (e.g. through the generation of a spark when discharged). The following web page explains inductance in more detail http://www.electronics-tutorials.ws/inductor/inductor.html</p>	2 hours




SUGGESTED ACTIVITIES

LO No:	4	
LO Title:	Understand properties of materials	
Title of suggested activity	Suggested activities	Suggested timings
Atoms, elastic deformation and forces 	<p>Teachers might begin the topic area of materials science by considering and explaining materials at the atomic level. This could include elastic deformation in terms of the separation of atoms in a solid material, and vector forces in a crystal lattice.</p> <p>Alternatively, learners could be tasked with a research activity to explore these areas themselves and to present their findings. The following web-based resources may prove a useful starting point http://physicspractice.blogspot.co.uk/2009/02/elastic-behaviour-of-solids.html (elastic behaviour of solids), http://www.nuffieldfoundation.org/practical-physics/explaining-deformation-metal-solids (atomic attraction and repulsion).</p>	1 hour
Equilibrium and deformation 	<p>Learners might continue their learning and understanding of the atomic composition of materials by considering equilibrium separation and deformation.</p> <p>Plastic deformation might be researched in terms of slip, and the effects of dislocations in the material.</p> <p>Deformation caused by tensile and compressive force might also be researched. Learners might undertake directed research of equilibrium and deformation, presenting their findings. The following web-based resources might prove a useful starting point http://www.schoolphysics.co.uk/age16-19/Properties%20of%20matter/Elasticity/text/Intermolecular_forces/index.html (molecular separation and equilibrium) and http://www.phy.davidson.edu/StuHome/BeKinneman/metal/deformation.htm (elastic and plastic deformation of materials).</p>	1 hour
Basic material properties 	<p>The basic mechanical material properties include: ductility, brittleness, toughness, stiffness, resilience, endurance, hardness.</p> <p>Teachers may be able to demonstrate some or all of the material properties to learners. Alternatively, web-based video resources may prove useful to illustrate these – with the following showing malleability http://www.youtube.com/watch?v=OkuDM3hYutI</p> <p>Learners might be tasked to research material properties, highlighting their advantages and disadvantages. The following web page illustrates some material properties and may prove a useful starting point http://www.technologystudent.com/joints/matprop2.htm</p>	2 hours
Drift, electron flow and current 	<p>Teachers might begin by explaining to learners the concept of electron flow in materials, and how this relates to the flow of electric current.</p> <p>The following web-based resources explains drift velocity with worked examples of application of the current formula http://resources.schoolscience.co.uk/CDA/16plus/copelech2pg3.html</p> <p>Teachers might develop further worked examples and a learner worksheet with problems to solve.</p>	2 hours


SUGGESTED ACTIVITIES

Title of suggested activity	Suggested activities	Suggested timings
Force-extension graphs 	<p>A force-extension graph illustrates how a material deforms under a tensile or compressive force. Learners could research how to draw force-extension graphs for typical brittle, ductile and polymeric materials, showing their differences. Learners could identify key features of each graph such as regions of elastic and plastic deformation, and also the point between elastic and plastic regions (the yield point). See Lesson Element Force-extension graphs.</p> <p>If resources are available, learners might be able to undertake tensile testing of materials, or alternatively it may be possible to gain access to real data. An alternative might be to use web-based videos of experiments such as the following showing tensile testing http://www.youtube.com/watch?v=D8U4G5kpcM</p>	1 hour
Hooke's Law and Young's modulus 	<p>Learners might continue to develop their understanding of extension of materials due to a force by investigating Hooke's Law and Young's modulus.</p> <p>Hooke's Law specifies that the extension of a material is proportional to the force applied to it (up to a certain point – the yield point). Young's modulus describes the stiffness of a material. Learners should also identify elastic limit, stress, strain and the difference between elastic and plastic deformation of a material.</p> <p>Learners might be able to use data for a range of materials to correctly identify the occurrence of these key terms, and to determine Young's modulus for the material.</p> <p>Web-based resources may prove useful such as http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/forces/forceselasticityrev2.shtml (basic introduction to Hooke's Law) and http://www.youtube.com/watch?v=KxxTTf7kUTM (a video tutorial of Hooke's Law and Young's modulus).</p>	2 hours
Stress and Strain 	<p>Stress and strain are important concepts in understanding the property of a material.</p> <p>Stress-strain graphs can be used to describe and evaluate stress and strain in a material. Learners might be shown how to calculate the strain energy and determine the ultimate tensile strength in a deformed material using a stress-strain graph.</p> <p>The following web resources explains stress and strain including stress-strain graphs http://physicsnet.co.uk/a-level-physics-as-a2/materials/stress-strain/</p>	1 hour
Non-destructive and destructive testing 	<p>Testing of materials is often used to determine their physical properties, and also their serviceability. It is commonly performed using non-destructive testing and destructive testing techniques.</p> <p>Learners could be tasked to research non-destructive testing and destructive testing, explaining the advantages and disadvantages of both approaches.</p> <p>The British Institute of Non-destructive Testing (BINDT) provide a range of resources (including videos) illustrating materials testing and may prove a useful starting point http://www.bindt.org/videos/</p> <p>Findings could be presented as a presentation or as a poster.</p>	2 hours




SUGGESTED ACTIVITIES

LO No:	5	
LO Title:	Know the basic principles of fluid mechanics	
Title of suggested activity	Suggested activities	Suggested timings
Fluids and Pressure 	<p>Teachers might begin the topic area of fluid mechanics by explaining the properties of fluids at rest, including pressure in fluids. The pressure due to a column of liquid might then be explained. Learners could perform calculations involving pressure, and calculations involving pressure in a column of fluid.</p> <p>The following web-based resources explain pressure http://www.school-for-champions.com/science/pressure.htm, and pressure in a column of fluid (http://www.youtube.com/watch?v=mzjlAla3H1Q)</p> <p>Learners could be tasked to research the difference between pressure, gauge pressure and absolute pressure. The following web page explains these: http://www.npl.co.uk/reference/faqs/what-are-absolute,-gauge-and-differential-pressures-'modes'-(faq-pressure)</p> <p>Teachers might develop worked examples and a learner worksheet of problems to solve involving pressures in fluids.</p>	2 hours
Archimedes' principle 	<p>Archimedes' principle states that the upward buoyant force exerted on a body immersed in a fluid is equal to the weight of the fluid that the body displaces. Teachers might be able to demonstrate Archimedes' principle by a practical experiment. Alternatively, web-based videos showing experiments could be used http://www.youtube.com/watch?v=eQsmq3Hu9HA</p> <p>The following interactive web page also shows Archimedes' principle http://www.onr.navy.mil/focus/blowballast/sub/work2.htm</p> <p>Teachers could develop worked examples in order to calculate upward buoyant force.</p>	1 hour
Fluid flow 	<p>Laminar and turbulent fluid flow can be demonstrated by the water flowing from a tap - as shown in the following video http://www.youtube.com/watch?v=VoBc60iUq2I</p> <p>Teachers may be able to demonstrate this to learners. Learners could be tasked to research fluid flow including: ideal fluid, streamline or laminar flow, turbulent flow, boundary layers.</p> <p>The following video tutorial explains laminar and turbulent flow in more detail https://www.youtube.com/watch?v=O2cpuJlWW-o</p>	2 hours

SUGGESTED ACTIVITIES

Title of suggested activity	Suggested activities	Suggested timings
Viscosity 	<p>Viscosity is a measure of the internal friction within a material and is an important concept in materials science (e.g. for lubricants and oils).</p> <p>Teachers might be able to demonstrate experimentally the viscosity of different materials. The following web-based video explains viscosity through an experiment using milk and honey: http://www.youtube.com/watch?v=1AESWxko4nI</p> <p>Learners might be tasked to further explore viscosity including the terms dynamic (absolute) and kinematic viscosity.</p> <p>The following web page explaining dynamic and kinematic viscosity might prove a useful starting point http://www.engineeringtoolbox.com/dynamic-absolute-kinematic-viscosity-d_412.html</p>	2 hours

SUGGESTED ACTIVITIES

LO No:	6	
LO Title:	Know the basic principles of thermal physics	
Title of suggested activity	Suggested activities	Suggested timings
Introduction to thermodynamics 	<p>Thermodynamics is a branch of science that deals with the relations between heat and other forms of energy.</p> <p>Teachers might begin with an introduction to thermodynamics including explaining the internal energy in a system, and what is meant by the thermodynamic scale. This could include an explanation of the kelvin scale and its relationship to internal energy.</p> <p>Teachers could develop worked examples and learner-based problems to solve.</p> <p>The following web-based resources explain internal energy http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/inteng.html and the Kelvin scale http://www.khanacademy.org/test-prep/mcat/physical-processes/gas-phase/v/absolute-temperature-and-the-kelvin-scale</p>	1 hour
Boyle's, Charles' and the Pressure Law 	<p>Boyle's Law, Charles' Law and the Pressure Law and their associated equations describe important phenomena relevant to thermodynamics.</p> <p>Learners might be tasked to research and explain each of these laws.</p> <p>Teachers could develop problems for learners to solve using each of the laws.</p> <p>It may be possible to demonstrate the laws using practical experiments.</p> <p>See Lesson Element Boyle's Law, Charles' Law and the Pressure Law.</p> <p>The following web-based resources may prove useful: http://www.grc.nasa.gov/WWW/k-12/airplane/boyle.html (an interactive explanation of Boyle's Law); http://www.grc.nasa.gov/WWW/k-12/airplane/glussac.html (an interactive explanation of Charles' Law); http://www.passmyexams.co.uk/GCSE/physics/pressure-temperature-relationship-of-gas-pressure-law.html (an interactive explanation of the Pressure Law).</p>	2 hours
Gas equations 	<p>Further laws that describe the behaviour of thermodynamic systems include the combined gas law and the characteristic (ideal) gas equation.</p> <p>Teachers might provide an explanation of these laws using worked examples, or learners might be tasked to research them independently.</p> <p>The following video tutorials explain the combined gas law https://www.youtube.com/watch?v=bftkRnTcfj8 and the characteristic gas equation http://www.khanacademy.org/science/chemistry/ideal-gas-laws/v/ideal-gas-equation-pv-nrt</p> <p>Teachers could develop a worksheet with problems for learners to solve using the gas laws.</p>	2 hours



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