# Engineering

# Unit 2 – Science for Engineering

# Scheme of work

# (60 GLH)

## Introduction

This outline scheme of work (SoW) is to offer a perspective of how to deliver the Cambridge Technicals in Engineering. There are many alternative methods and structures that could be used and therefore it is important to explore different methods of delivering the specification; considering different approaches depending on staffing and expertise within your centre and the resources you have available.

Consideration of how the **theoretical content** of the specification can be covered is best delivered in different ways, through:

* A variety of different teacher resources
* Stimulating discussions
* Group work
* Learner activities
* A variety of questions relating to all the different topics

Aiming for quality communication and professional standards of work will help to establish the connections between this qualification and real-world practice.

**Overview (by lesson, topic area and GLH)**

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|  | **Lesson** | **Topic Area** | **Suggested GLH** |
| **LO1** | 1 | SI units | 2 |
| 2 | Measurement terms Part 1; accuracy, error, calibration and correction | 2 |
| 3 | Measurement terms Part 2; relative and absolute error formulae | 2 |
| 4 | Standard deviation and standard error of the mean | 2 |
| 5 | Using measuring instruments | 2 |
| **LO2** | 6 | Scalars and vectors, force, work | 2 |
| 7 | Forces and motion; displacement, speed, velocity and acceleration | 3 |
| 8 | Kinematics; distance, velocity, speed, acceleration, mass and density | 3 |
| 9 | Dynamics Part 1; forces | 2 |
| 10 | Dynamics Part 2; work, power and energy | 2 |
| **LO3** | 11 | Electron flow, charge, current and potential difference; resistance and Ohm’s law | 2 |
| 12 | Power (electrical), energy and efficiency | 2 |
| 13 | Resistivity | 2 |
| 14 | Electric fields, field strength and capacitance | 2 |
| 15 | Inductance | 2 |

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|  | **Lesson** | **Topic Area** | **Suggested GLH** |
| **LO4** | 16 | Atoms, elastic deformation and forces; equilibrium and deformation | 2 |
| 17 | Basic material properties | 2 |
| 18 | Drift, electron flow and current | 2 |
| 19 | Force-extension graphs; Hooke’s law | 2 |
| 20 | Stress and strain; Young’s modulus | 2 |
| 21 | Non-destructive and destructive testing | 2 |
| **LO5** | 22 | Fluids and pressure | 2 |
| 23 | Archimedes’ principle | 2 |
| 24 | Fluid flow | 2 |
| 25 | Viscosity | 2 |
| **LO5** | 26 | Introduction to thermodynamics | 2 |
| 27 | Boyle’s, Charles’ and the pressure law | 2 |
| 28 | Gas equations | 2 |
| 29 | Energy flow | 2 |

| **Lesson** | **Learning outcomes and topics** | **Unit content to be covered, activities, links to useful resources** |
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| **Engineering Unit 2: Science for Engineering** | | |
| 1 | LO1: SI units | 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.  Explain SI prefixes and their application with examples. Worksheet for learners.  Useful resources: ASE companion to signs, symbols and systematics (<https://www.ase.org.uk/bookshop/signs-symbols-and-systematics-ase-companion-16-19-science>) and National Physical Laboratory (NPL) website which has ‘good practice’ guides to use with learners (<https://www.npl.co.uk/>). |
| 2 | LO1: Measurement terms Part 1; accuracy, error, calibration and correction | 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.  Web resources (such as those in the Delivery Guide): <https://www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/6098/Why-Calibrate-an-Instrument>) could be developed as hand-outs for group discussion. |
| 3 | LO1: Measurement terms Part 2; relative and absolute error formulae | Continue to introduce measurements terms from unit specification (1.3); illustrate with definitions and numerical examples.  Develop worksheet for learners; to complete/match definitions and with series of numerical examples to complete.  Useful web resource: <https://www.mathsisfun.com/measure/error-measurement.html>. |
| 4 | LO1: Standard deviation and standard error of the mean | Explain the terms ‘standard deviation’ and ‘standard error of the mean’; show worked numerical examples and explain meaning of results obtained  Develop worksheet for learners to complete with numerical examples; use engineering examples where possible.  Web resources from Delivery Guide (videos) could be used in class. |
| 5 | LO1: Using measuring instruments | Introduction to the use of measuring instruments; developing into types of measuring instruments using the categories in the exemplification in unit specification (1.5).  Learners could undertake a small group activity researching the types of instrument used in each category, the quantities being measured, how the instrument works and how it is used. Focus should be on how to use instruments to take measurements. Present finings back to group as poster or presentation.  Alternatively, practical examples could be used in the workshop/laboratory.  Resources: NPL website has range of good practice guides on taking measurements which could be useful (<https://www.npl.co.uk/resources/gpgs>). |
| 6 | LO2: Scalars and vectors, force, work | Recap (from previous work at level 2) on scalar and vector quantities.  Develop/adopt example problems and produce worksheet for learners.  Resources: web resources such as <https://www.youtube.com/watch?v=P1lSWWUkMdQ> (review of scalars and vectors); previous exam paper questions and solutions; from OCR website. A further useful resource throughout this section is the book Bird, John “Mechanical Engineering Principles” (2014). |
| 7 | LO2: Forces and motion; displacement, speed, velocity and acceleration | Present examples on displacement, distance travelled, speed, velocity and acceleration (using graphical methods). Use exemplified definitions in unit specification (2.1); use science/engineering examples.  Develop/adopt worksheet examples for learners to complete, and to assess peer-to-peer in class.  Resources: use previous exam paper questions and solutions for practice; web resources on kinematics such as; <https://www.physicsclassroom.com/class/1DKin/Lesson-1/Introduction>. |
| 8 | LO2: Kinematics; distance, velocity, speed, acceleration, mass and density | Present distance, velocity and time problems using engineering examples. Solve using the SUVAT equations (unit specification 2.2). Explain mass and density. Examples should include rearrangement of formulae to find unknown. Use density formula (with rearrangement).  Develop worksheet for use in class; for peer marking/discussion.  Resource: web-based resources introducing SUVAT equations (<https://www.physicsclassroom.com/class/1DKin/Lesson-6/Kinematic-Equations>). |
| 9 | LO2: Dynamics Part 1; forces | Introduce concepts of force (N) and weight (W). Illustrate formulae relating force, mass and acceleration; weight due to gravity. Use formulae for moments of a force, and torque. Show problems relating to force, weight, moments and torque (following unit specification content in 2.4).  Develop worksheet for use in class; for peer marking/discussion. Use example questions from past OCR exam papers.  Some concepts could be demonstrated practically e.g. force, weight, turning moments, centre of gravity.  Resources: web-based video resources for difficult concepts such as centre of gravity (<https://www.khanacademy.org/science/ap-physics-1/ap-linear-momentum/center-of-mass-ap/v/center-of-mass>). |
| 10 | LO2: Dynamics Part 2; work, power and energy | Introduce concept of work done - Joule (J). Present problems relating to work, power and energy. Present problems relating to kinetic energy (KE) and gravitational potential energy (GPE). Use work done, KE, GPE and power equations (including rearrangement to find unknown). Use engineering examples where available.  Develop worksheet for use in class; for peer marking/discussion. Use example questions from past OCR exam papers.  Simple experiments could be used to show KE and GPE, work and power.  Resources: web-based resources to introduce concepts; work, power and energy. ([www.schoolphysics.co.uk/age16-19/Mechanics/Dynamics/text/Force\_Work\_Energy\_Power\_equations/index.html](http://www.schoolphysics.co.uk/age16-19/Mechanics/Dynamics/text/Force_Work_Energy_Power_equations/index.html)). |
| 11 | LO3: Electron flow, charge, current and potential difference; resistance and Ohm’s Law | Explain atomic structure and electric current. Explain with worked examples charge, potential difference and resistance. Series and parallel resistors in circuits; total resistance and total current.  Develop/adopt example questions for learners to attempt in class.  Simple experiments could be used to reinforce understanding of current, potential difference and resistance.  Resources: use web-based resources such as; <https://www.allaboutcircuits.com/textbook/direct-current/chpt-1/conventional-versus-electron-flow/> (electron flow) and <https://www.electronics-tutorials.ws/resistor/res_5.html> (resistor circuits). |
| 12 | LO3: Power (electrical), energy and efficiency | Use domestic or industrial examples to illustrate power, energy and efficiency. Illustrate with examples use of power (P), energy (W) formula. Present examples involving efficiency.  Develop in-class example sheet for learners to complete using defining formulae and their transposition. Leaners peer-mark and discuss worksheet examples. Experiments could be used to illustrate efficiency of a device or system.  Resources: learners could be directed to web-based resources such as; <http://www.electronics-tutorials.ws/resistor/res_5.html> showing power and energy with examples. |
| 13 | LO3: Resistivity | Explain resistivity formula and illustrate its use with worked examples.  Resistivity of different material types, and for materials of different cross-sectional area could be could be shown with practical activities.  Present learners with examples to solve; give whole class feedback once completed.  Resources: direct learners to web-based resources that reinforce theory; <https://www.electrical4u.com/electrical-resistance-and-laws-of-resistance/>. |
| 14 | LO3: Electric fields, field strength and capacitance | Explain concepts of electric fields, electric field strength and capacitance. Introduce SI units and defining equation (unit specification 3.14. 3.15, 3.16, 3.19 and 3.19) using worked examples.  Experiments can be used to show charging and discharging of a capacitor – with application of defining equations.  Learners solve problems using defining formula, including; transposition of subject.  Resources: see **Lesson Element** for experiment on charging/discharging of a capacitor; <http://www.schoolphysics.co.uk/age16-19/Electricity%2520and%2520magnetism/Electrostatics/text/Capacitor_energy_stored/index.html> explains charge on capacitor. |
| 15 | LO3: Inductance | Introduce concept of inductance (L) and unit Henry (H). Show worked examples of use of defining formula for self-inductance (unit specification 3.21). Learners solve problems using defining formula, including; transposition of subject.  Simple experiments could be used to show principles of induction (energy stored in a coil).  Resources: learners could study web-based resources explaining inductance (<https://www.electronics-tutorials.ws/inductor/inductor.html>). |
| 16 | LO4: Atoms, elastic deformation and forces; equilibrium and deformation | Explain elastic deformation (separation of atoms in solid materials), forces between atoms and equilibrium separation.  Set small group activity to research and present findings on topic.  Resources: resources from the Institute of Physics could be useful such as the following on deformation of metal solids; <http://practicalphysics.org/explaining-deformation-metal-solids.html>. |
| 17 | LO4: Basic material properties | Set an activity for leaners to investigate, in pairs or small groups, content exemplified in unit specification 4.3.  Learners present findings with suitable engineering examples as a simple poster of presentation back to whole group.  Resources: web-based videos can be used to illustrate material properties such as [http://www.youtube.com/ watch?v=OkuDM3hYutI](http://www.youtube.com/%20watch?v=OkuDM3hYutI%20) showing malleability. |
| 18 | LO4: Drift, electron flow and current | Explain the concepts of electron flow in materials, and how this relates to the flow of electric current.  Illustrate use of current formula (unit specification 4.7) with worked examples, and worksheet for learners to solve.  Resources: learners could self-study web-based resources such as; <http://resources.schoolscience.co.uk/CDA/16plus/copelech2pg3.html> explaining drift velocity. |
| 19 | LO4: Force-extension graphs; Hooke’s law | Explain basic concepts of force-extension graphs, illustrating Hooke’s law. Highlight difference between elastic and plastic deformation, and key features of force-extension graphs for different materials.  Practical tensile testing of materials (if resources are available) could be used to reinforce learning. Resources could be accessed using local partners (e.g. college or university).  Resources: web-based videos can be used showing tensile testing (<https://www.youtube.com/watch?v=D8U4G5kcpcM>); also see **Lesson Element.** |
| 20 | LO4: Stress and strain; Young’s modulus | Explain stress and strain; relating to defining equations. Relate to Young’s modulus.  Produce numerical examples to illustrate stress and strain formulae – and learner worksheet with examples to complete (requiring transposition of subject).  Resources: web-based resources showing explaining stress-strain graphs and relationship with Hooke’s Law/Young’s modulus could be useful; <http://physicsnet.co.uk/a-level-physics-as-a2/materials/stress-strain/> and <http://physicsnet.co.uk/a-level-physics-as-a2/materials/young-modulus/>. |
| 21 | LO4: Non-destructive and destructive testing | Set learners a research activity to investigate destructive and non-destructive techniques.  Simple experiments can be used to show destructive testing taking place (e.g. tensile testing, impact testing); access might be possible to show NDT methods.  Resources: British Institute of Non-destructive Testing website has introductory videos (<http://www.bindt.org/videos/>) . |
| 22 | LO5: Fluids and pressure | Provide introduction to fluids and pressure; fluids at rest and key terms (from unit specification 5.2). Illustrate numerical problems involving pressure on a point, and in a column of fluid.  Devise worksheet with problems for leaners to solve. Peer marking, and feedback could be used.  Resources: resources showing how to solve problems in a column of fluid could be used (<http://www.youtube.com/watch?v=mzjlAla3H1Q>). |
| 23 | LO5: Archimedes’ principle | Explain, using examples, Archimedes’ principle.  Learners could be set research activity, working individually in pairs, to produce a presentation on Archimedes’ principle.  An experiment could be used to reinforce understanding.  Resources: videos showing experiments could be used if access to resources is limited (<https://www.youtube.com/watch?v=eQsmq3Hu9HA>). |
| 24 | LO5: Fluid flow | Explain fluid flow and types (from unit specification 5.7). Use examples.  Experiments could be used to show turbulent and laminar flow.  Resources: videos showing turbulent and laminar flow could be used as an introduction (<http://www.youtube.com/watch?v=VoBc60iUq2I>). |
| 25 | LO5: Viscosity | Practical activities could be used to introduce the concept and definitions of viscosity.  Learners could explore experimentally the viscosity of different materials.  Resources: web-based videos showing viscosity of different materials can be used as an introduction (<https://www.youtube.com/watch?v=1AESWxko4nI>). |
| 26 | LO6: Introduction to thermodynamics | Provide an introduction to thermodynamics; internal energy in a system, and what is meant by the thermodynamic scale. Introduce specific and latent heat capacity using numerical examples, and the efficiency equation.  Develop a worksheet with problems for learners to complete and peer assess and discuss.  Resources: use previous exam paper questions and solutions for practice; ; use web-based resources such as the following explaining the Kelvin scale <https://www.khanacademy.org/test-prep/mcat/physical-processes/gas-phase/v/absolute-temperatureand-the-kelvin-scale>. |
| 27 | LO6: Boyle’s, Charles’ and the pressure law | Explain each of the gas laws. Solve numerical problems using each of the gas laws, including transposition of the subject.  Practical activities could be used to illustrate each of the gas laws.  Develop a worksheet with problems for learners to complete and peer assess and discuss.  Resources: use previous exam paper questions and solutions for practice; ; see **Lesson Element** on Boyle’s law, Charles’ law and the pressure law. |
| 28 | LO6: Gas equations | Introduce the combined gas law and the characteristic (ideal) gas equation using suitable numerical examples.  Develop worksheet with problems for learners to solve and discuss.  Resources: use previous exam paper questions and solutions for practice; ; learners can access web-based videos and tutorials such as the following video tutorials explain the combined gas law <https://www.youtube.com/watch?v=bftkRnTcFj8> and the characteristic gas equation <https://www.khanacademy.org/science/chemistry/gases-and-kinetic-molecular-theory/ideal-gas-laws/v/ideal-gas-equation-pv-nrt>. |
| 29 | LO6: Energy flow | Explain the non-flow and steady-flow energy equations, using numerical examples to illustrate. Include examples requiring rearrangement.  Develop worksheet with problems for learners to solve and discuss.  Resources: use previous exam paper questions and solutions for practice; the Stirling engine video (<https://www.youtube.com/watch?v=zCGTNArwJ0s>) can be used as an introduction to energy flow. |

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