Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number

Candidate Number

Thursday 17 January 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **WPH02/01**

Physics

Advanced Subsidiary
Unit 2: Physics at Work

You must have:
Ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Pearson

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ⊠. If you change your mind, put a line through the box ⊠ and then mark your new answer with a cross ⊠.

1 The unit of charge is the coulomb.

Which of the following is equivalent to a coulomb?

☐ **A** A s

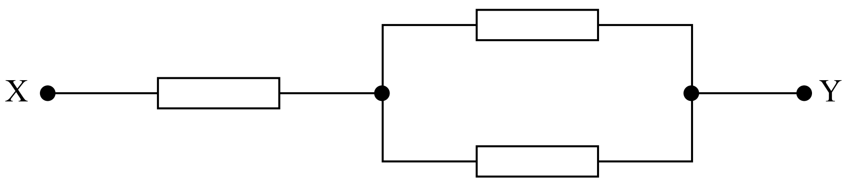
☐ **B** $\mathrm{A\,s^{-1}}$

☐ **C** $\mathrm{A^{-1}\,s}$

☐ **D** $\mathrm{A^{-1}\,s^{-1}}$

(Total for Question 1 = 1 mark)

2 In the combination shown below, each resistor has a resistance of 6 Ω.



Which of the following is the total resistance between X and Y?

☐ **A** 2 Ω

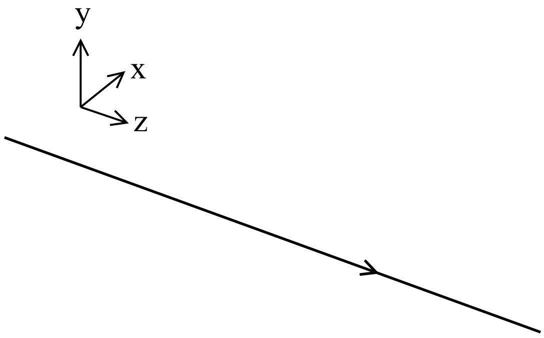
☐ **B** 4 Ω

☐ **C** 9 Ω

☐ **D** 18 Ω

(Total for Question 2 = 1 mark)

3 x, y and z are three perpendicular directions. A polarised light wave is travelling in the z direction.



Which of the following describes the direction of the oscillations of the polarised light wave?

- ☒ **A** They must be in the x direction.
- ☒ **B** They must be in a plane which is perpendicular to the x direction.
- ☒ **C** They must be in the z direction.
- ☒ **D** They must be in a plane which is perpendicular to the z direction.

(Total for Question 3 = 1 mark)

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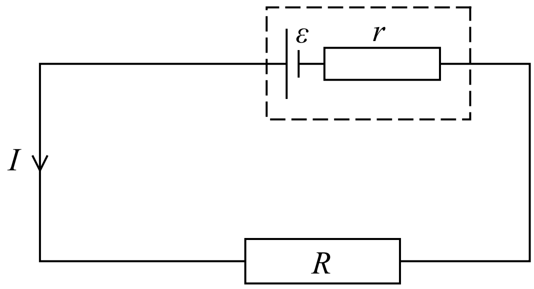
4 The circuit shows a cell of emf ε with internal resistance of r connected to a resistor of resistance R. The current in the circuit is I.



Which of the following is an expression for the terminal potential difference V across the cell?

- ☒ **A** $V = \varepsilon + IR$
- ☒ **B** $V = \varepsilon - IR$
- ☒ **C** $V = \varepsilon + Ir$
- ☒ **D** $V = \varepsilon - Ir$

(Total for Question 4 = 1 mark)

5 The equation $I = nqvA$ is quoted in the list of data, formulae and relationships.

When the temperature of a metallic conductor increases, which of the following quantities decreases?

☒ **A** n

☒ **B** q

☒ **C** v

☒ **D** A

(Total for Question 5 = 1 mark)

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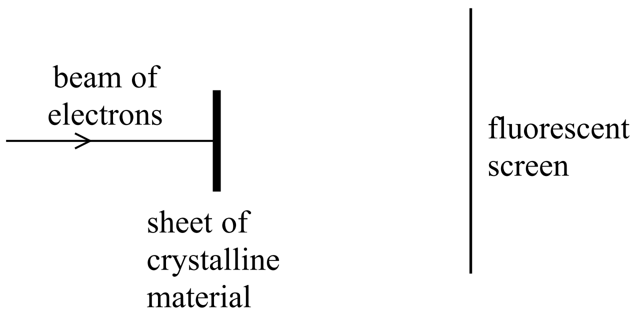
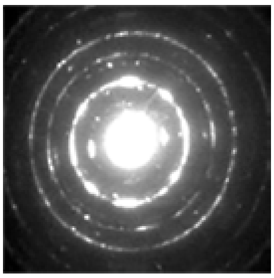
6 A beam of electrons is directed towards a thin sheet of crystalline material as shown.



The following pattern is produced on a fluorescent screen by the electrons.



Which of the following is a conclusion from this pattern?

☒ **A** Electrons behave as particles.

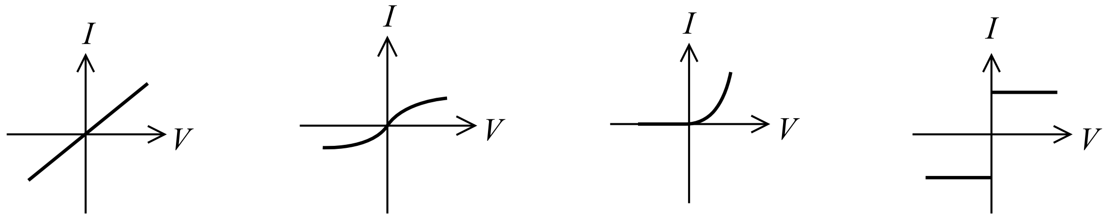
☒ **B** Light behaves as a wave.

☒ **C** The atoms in the crystalline material are arranged in circles.

☒ **D** The crystalline material is an ordered structure.

(Total for Question 6 = 1 mark)

7 Which graph shows how current varies with potential difference for an ohmic conductor at constant temperature?



☒ **A** ☒ **B** ☒ **C** ☒ **D**

(Total for Question 7 = 1 mark)

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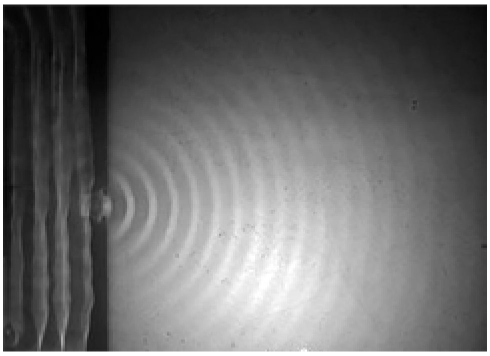
8 The photograph shows waves in a ripple tank passing through a gap in a barrier.



Which of the following properties of waves is being demonstrated as the waves pass through the gap?

☒ **A** diffraction

☒ **B** reflection

☒ **C** refraction

☒ **D** superposition

(Total for Question 8 = 1 mark)

9 Light travels through air and enters a glass block.

Which of the following quantities does **not** change as the light enters the glass block?

☒ **A** amplitude

☒ **B** frequency

☒ **C** velocity

☒ **D** wavelength

(Total for Question 9 = 1 mark)

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10 Four different types of lamp produce the same brightness.
The power consumption and the current are marked on the packaging for each lamp and shown in the table.

Type of lamp	Power / W	Current / A
filament	60	0.25
fluorescent	12	0.05
halogen	48	4
LED	6	0.5

Which type of lamp has the greatest efficiency?

☒ **A** filament

☒ **B** fluorescent

☒ **C** halogen

☒ **D** LED

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 A teacher demonstrates the photoelectric effect. He shines light from an ultraviolet (UV) lamp onto a metal surface.

(a) Calculate the maximum kinetic energy, in J, of the photoelectrons emitted from the metal surface.

frequency of UV radiation = 4.2×10^{15} Hz

work function of metal = 4.1 eV

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Maximum kinetic energy = ... J

(b) The teacher replaces the UV lamp with a more powerful source which emits UV radiation of the same frequency.

Explain why this results in more photoelectrons being emitted per second.

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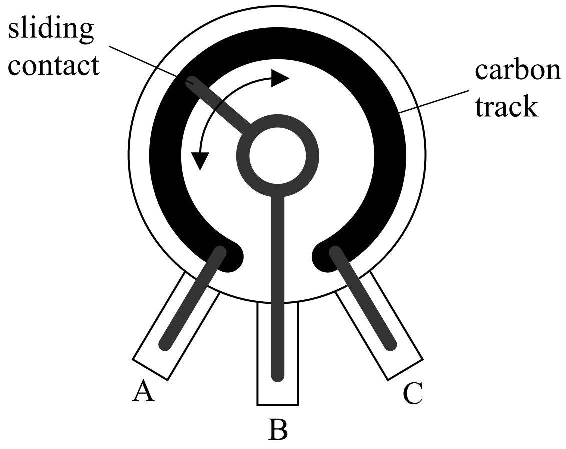
(Total for Question 11 = 6 marks)

12 The diagram shows a potentiometer. It consists of a track made from carbon. The resistance between terminal A and terminal C is equal to $47\,k\Omega$. A sliding contact moves around the track and is connected to terminal B.



(a) The carbon track has a uniform rectangular cross-section.

Calculate the thickness of the carbon track.

length of carbon track = $2.7 \times 10^{-2}\,m$
width of carbon track = $3.0\,mm$
resistivity of carbon = $2.5 \times 10^{-5}\,\Omega\,m$

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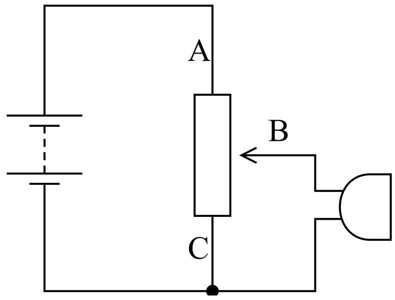
Thickness = ...

(b) The potentiometer can be connected to a 9 V supply to provide a variable output for a buzzer as shown.



Explain how this circuit provides the variable output for the buzzer. The current drawn by the buzzer is negligible.

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(Total for Question 12 = 6 marks)

*13 Helium was discovered in the 1860s by observing the spectrum produced by sunlight. An intense spectral line was seen, which did not correspond with any elements known at the time.

Explain how specific spectral lines are produced by a hot gas.

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(Total for Question 13 = 6 marks)

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14 A refractometer can be used to measure refractive index. A refractometer makes use of the total internal reflection of light at a boundary between two materials.

(a) Describe the conditions required for total internal reflection to take place at a boundary.

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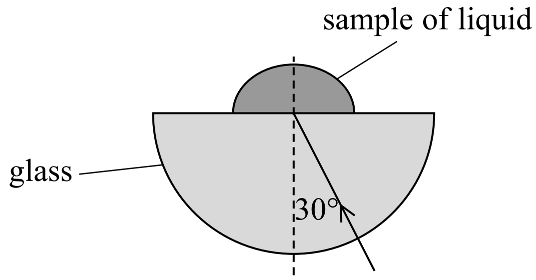
(b) One type of refractometer is shown.

A sample of liquid is placed on one side of a semicircular glass prism. A ray of light is shown passing into the prism.



Determine whether this ray will be totally internally reflected from the boundary between the prism and the liquid.

$_{\text{liquid}}\mu_{\text{glass}} = 1.15$

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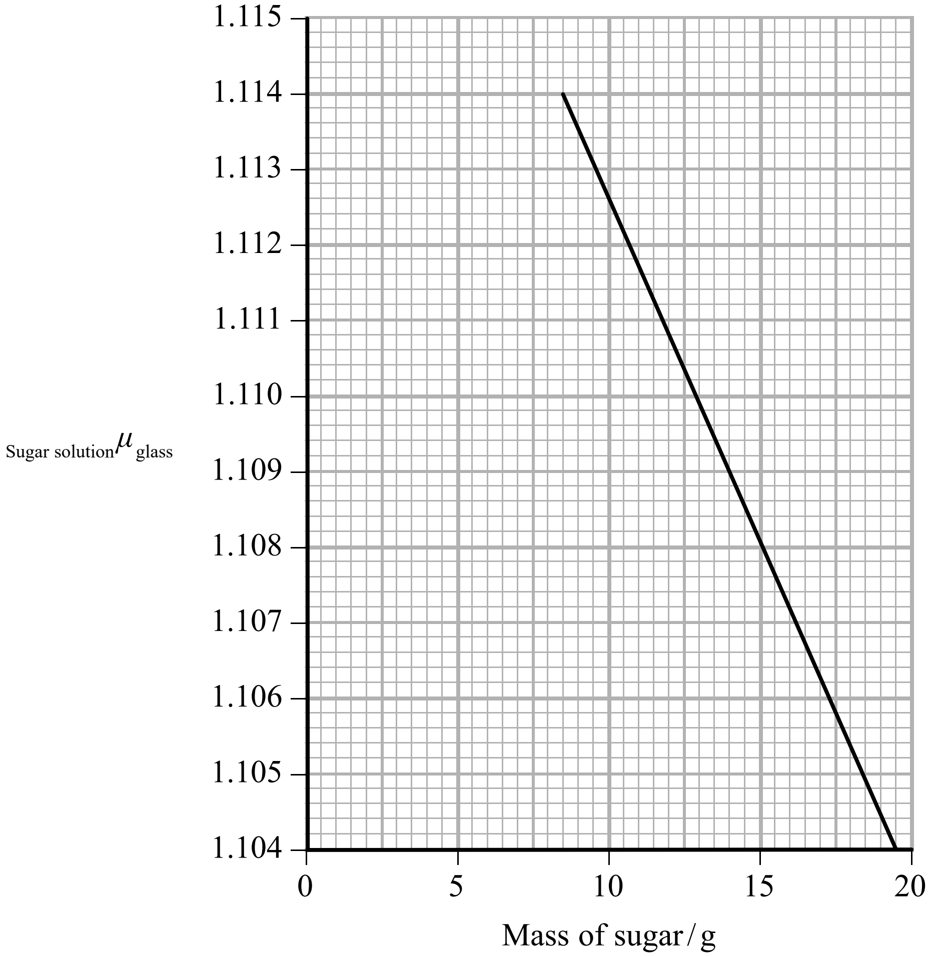
(c) The graph shows how the refractive index ${}_{\text{sugar solution}}\mu_{\text{glass}}$ varies with the mass of sugar dissolved in a fixed volume of water.



Explain why the critical angle would have to be measured to a precision of more than two significant figures in order to determine the sugar content to the nearest gram.

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(Total for Question 14 = 7 marks)

15 Scientists have succeeded in levitating droplets of liquid. A standing wave is created using ultrasound generated by two sources, one above and one below the liquid. The droplets of liquid are trapped at positions corresponding to nodes as shown.

(a) Explain how a standing wave is formed.

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(b) Describe the motion of the air at a node and at an antinode.

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(c) The scale of the photograph is half full-size.

Determine the frequency of the ultrasound wave.

speed of ultrasound in air = $320\,\mathrm{m\,s^{-1}}$

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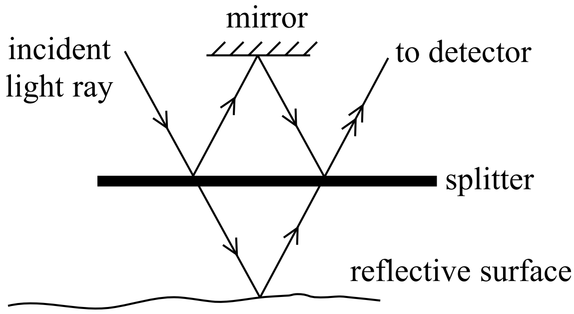
Frequency = ...

(Total for Question 15 = 11 marks)

16 In some scientific equipment it is important that surfaces are extremely flat. One method that can be used to measure the variation in the height of a reflective surface is shown in the diagram.



An incident light ray is directed at a splitter. The splitter partially reflects and partially transmits the ray. The reflected ray then hits a mirror and is reflected back to the splitter. The transmitted ray hits the reflective surface and reflects back to the splitter.
The two rays then travel to a detector where superposition occurs.

(a) Explain what is meant by superposition.

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(b) The distance from the splitter to the mirror is the same as the distance from the splitter to the reflective surface.

Explain why light of maximum brightness will be measured at the detector.

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(c) The reflective surface is moved so that the ray of light is reflected from different points on the surface.

Explain why, at a particular position, the brightness measured at the detector becomes a minimum.

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(d) This method can measure the variation in height of a reflective surface to within about 100 nanometres.

Estimate the wavelength of the light used.

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Wavelength = ...

(Total for Question 16 = 9 marks)

17 Ultrasound is regularly used to produce images of babies in the womb as shown.

*(a) Explain how a pulse-echo technique provides details of the position of a baby.

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(b) Ultrasound can also produce information about the speed of blood flow around different parts of the baby's body.

Explain how the ultrasound can be used in this way.

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(c) Before the use of ultrasound, X-rays were used to monitor babies in the womb.

Explain why ultrasound is safer for babies than X-rays.

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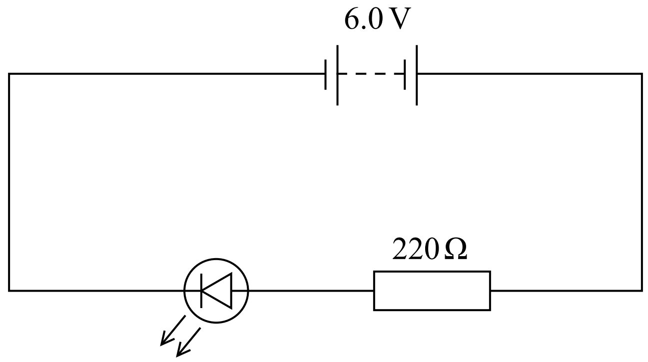
(Total for Question 17 = 10 marks)

18 The circuit shown includes a light-emitting diode (LED).



(a) When operating normally, the potential difference across the LED is 1.8 V.

Show that the current is about 20 mA.

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(b) Calculate the power transferred to the LED.

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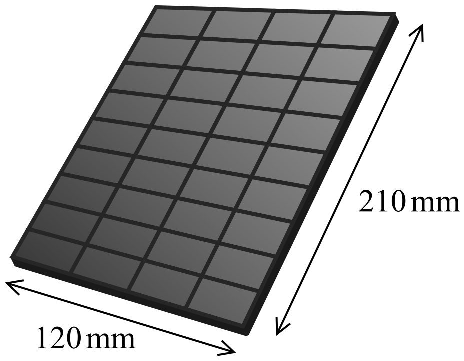
Power = ...

(c) The battery in the circuit was rechargeable. The battery was charged for 5 minutes, using the solar cell shown. The radiation flux of sunlight incident on the solar cell was $680\,\mathrm{W\,m^{-2}}$.



When the battery was replaced in the circuit, the LED lit for 80 minutes. The efficiency of the LED was 90%.

Calculate the overall efficiency of this system.

(5)

Efficiency = ...

(d) When an LED begins to conduct, the energy transferred by an electron moving through the potential difference across the LED becomes a photon of emitted light.

(i) State a formula to calculate the energy transferred by an electron moving through a potential difference V.

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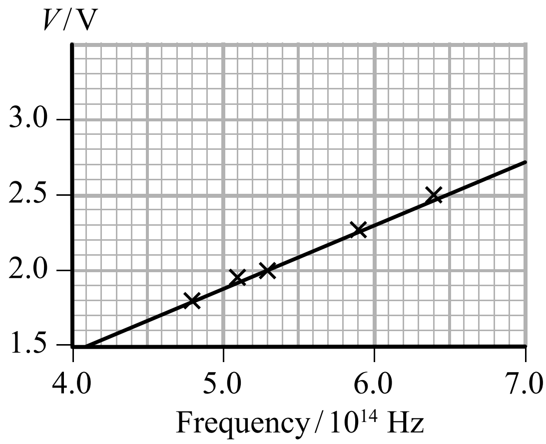
(ii) By investigating different colour LEDs, a graph was obtained of the potential difference V at which light is emitted against the frequency of the emitted light.



Determine a value for the Planck constant.

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Planck constant = ...

(Total for Question 18 = 15 marks)

TOTAL FOR SECTION B = 70 MARKS
TOTAL FOR PAPER = 80 MARKS

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\,s^{-2}}$	(close to Earth's surface)
Electron charge	$e = -1.60 \times 10^{-19}\ \mathrm{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
Gravitational field strength	$g = 9.81\ \mathrm{N\,kg^{-1}}$	(close to Earth's surface)
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$	

Unit 1

Mechanics

Kinematic equations of motion
$v = u + at$
$s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

Forces
$\Sigma F = ma$
$g = F/m$
$W = mg$

Work and energy
$\Delta W = F\Delta s$
$E_k = \frac{1}{2}mv^2$
$\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law $F = 6\pi\eta rv$

Hooke's law $F = k\Delta x$

Density $\rho = m/V$

Pressure $p = F/A$

Young modulus $E = \sigma/\varepsilon$ where
Stress $\sigma = F/A$
Strain $\varepsilon = \Delta x/x$

Elastic strain energy $E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i/\sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$
	$\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$
	$\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$