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| Surname | Other names |
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**Pearson Edexcel Level 3 GCE**

| Centre Number | Candidate Number |
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# Physics

## Advanced Subsidiary
## Paper 2: Core Physics II

Friday 18 May 2018 – Morning
**Time: 1 hour 30 minutes**

Paper Reference
**8PH0/02**

**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 in Sections A and B.
- 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.*
- You may use a scientific calculator.
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

## 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.
- You are advised to show your working in calculations, including units where appropriate.

*Turn over* ▶

## SECTION A

**Answer ALL questions.**

**For questions 1-8, 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 Young Modulus of a material can be expressed by the formula $E = \dfrac{Fx}{A\Delta x}$.
The derivation of this formula is

$$E = \frac{\sigma}{\varepsilon}$$

So $\quad E = \ldots\ldots\ldots\ldots$

And $\quad E = \dfrac{Fx}{A\Delta x}$

Which of the following completes the second line of the derivation?

☐ **A** $\dfrac{\dfrac{x}{\Delta x}}{\dfrac{F}{A}}$

☐ **B** $\dfrac{\dfrac{\Delta x}{x}}{\dfrac{F}{A}}$

☐ **C** $\dfrac{\dfrac{F}{A}}{\dfrac{\Delta x}{x}}$

☐ **D** $\dfrac{\dfrac{F}{A}}{\dfrac{x}{\Delta x}}$

**(Total for Question 1 = 1 mark)**





P 5 1 5 7 8 A 0 2 2 8

**2** Fishermen use ultrasound pulses to detect shoals of fish under the surface of the water. Some fish are at a depth of 90 m below the surface.

Which of the following is the expression for the time $t$, in seconds, between the transmitted and the received pulse?

speed of sound in water = $1500\,\text{m}\,\text{s}^{-1}$

☒ **A** $t = \dfrac{90}{1500}$

☒ **B** $t = \dfrac{1500}{90}$

☒ **C** $t = \dfrac{90 \times 2}{1500}$

☒ **D** $t = \dfrac{1500}{90 \times 2}$

**(Total for Question 2 = 1 mark)**

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**3** Which of the following is a correct statement about a stationary wave?

☒ **A** All points on the wave oscillate in phase.

☒ **B** A node is formed at a point of constructive interference.

☒ **C** Stationary waves can only be formed from transverse waves.

☒ **D** Two points $\dfrac{\lambda}{2}$ apart oscillate with the same amplitude.

**(Total for Question 3 = 1 mark)**

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**4** Einstein's photoelectric equation states

$$hf = \phi + \frac{1}{2}mv^2_{\text{max}}$$

The quantity denoted by $\phi$ is the minimum

☒ **A** amount of energy of a photon needed to release an electron.

☒ **B** amount of energy of an electron needed to release a photon.

☒ **C** frequency of a photon needed to release an electron.

☒ **D** frequency of an electron needed to release a photon.

**(Total for Question 4 = 1 mark)**

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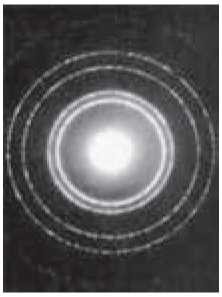
**5** The image shows a diffraction pattern formed when a beam of electrons passes through thin metal foil.

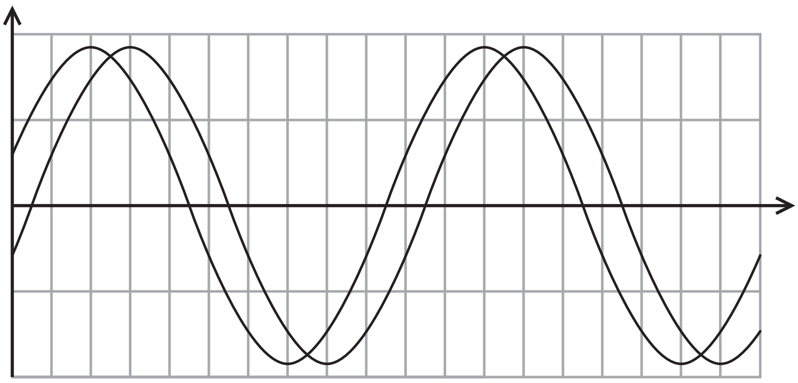


Which of the following would cause the diameter of the rings to increase?

- ☒ **A** Decreasing the number of electrons in the beam.
- ☒ **B** Decreasing the speed of electrons in the beam.
- ☒ **C** Increasing the number of electrons in the beam.
- ☒ **D** Increasing the speed of electrons in the beam.

**(Total for Question 5 = 1 mark)**

**6** The graphs show the position of two identical waves at a time $t$.




Which of the following is the phase difference between these two waves?

- ☒ **A** $\pi$
- ☒ **B** $\frac{\pi}{2}$
- ☒ **C** $\frac{\pi}{5}$
- ☒ **D** $\frac{\pi}{10}$

**(Total for Question 6 = 1 mark)**

**Questions 7 and 8 refer to an experiment to investigate stationary waves on a string.**

A string of length $l$, fixed at both ends, is placed under tension $T$ and plucked. The fundamental frequency $f$ of the vibrating string is measured and the speed $v$ of the wave on the string is calculated.

**7** Which of the following gives the speed of the wave?

☒ **A** $v = 4fl$

☒ **B** $v = 2fl$

☒ **C** $v = fl$

☒ **D** $v = \dfrac{fl}{2}$

**(Total for Question 7 = 1 mark)**

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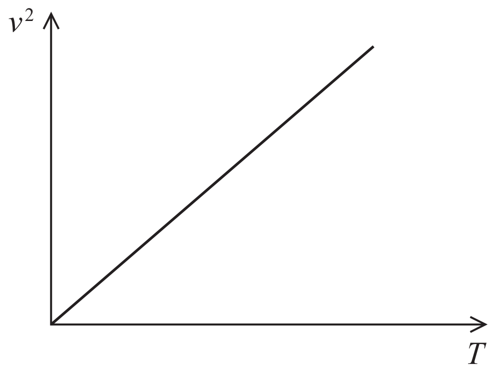
**8** Corresponding values of $v^2$ against $T$ are plotted. A straight line graph is obtained, as shown.




Which of the following expressions for the mass per unit length $\mu$ of the string is correct?

☒ **A** $\mu = \text{gradient}$

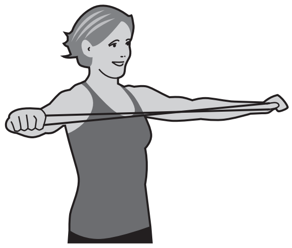
☒ **B** $\mu = \sqrt{\text{gradient}}$

☒ **C** $\mu = \dfrac{1}{\text{gradient}}$

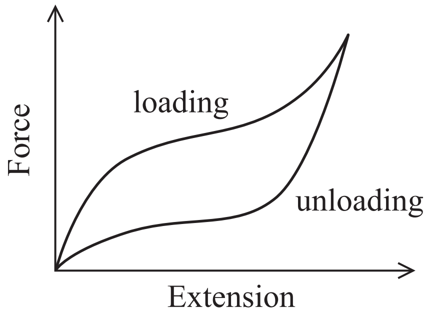
☒ **D** $\mu = \dfrac{1}{\sqrt{\text{gradient}}}$

**(Total for Question 8 = 1 mark)**

***9** A resistance band is a length of an elastic material that can be used for exercise. The user repeatedly applies an increasing tensile force (loading) and then releases the force (unloading).



The force-extension graph for the resistance band is shown.




The user finds that the band gets warm during use.

Describe, with reference to the graph, the behaviour of the resistance band when it is repeatedly loaded and unloaded.

**(6)**

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**(Total for Question 9 = 6 marks)**

**10** A student is investigating the extension of a spring.

A force of 29 N is applied to the spring and it extends by 32 cm. The spring obeys Hooke's law.

(a) Calculate the work done on the spring.

**(2)**

Work done = ..........................................

(b) Calculate the extension of the spring when a force of 27 N is applied.

**(2)**

Extension = ..........................................

**(Total for Question 10 = 4 marks)**

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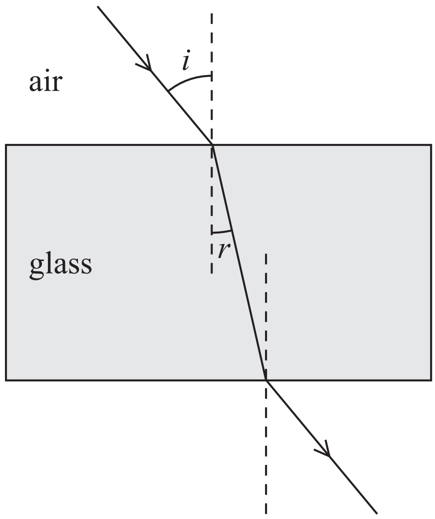
**11** A student is carrying out an experiment to identify which type of glass a rectangular block is made from.

The student shines a ray of light onto one surface of the rectangular block.




The student marks the path of the ray on paper. He takes corresponding measurements of the angle of incidence *i* and the angle of refraction *r* at the air-glass interface.

(a) State two precautions the student should take to improve the accuracy of these measurements.

**(2)**

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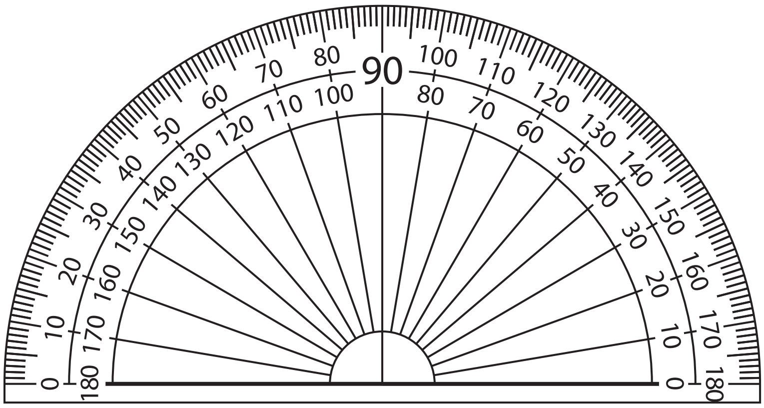
(b) The student uses the protractor shown.



He records his results in the table.

| ***i*** / ° | ***r*** / ° |
|---|---|
| 10 | 5 |
| 20 | 13 |
| 30 | 17 |
| 40 | 24 |
| 50 | 29 |
| 62 | 37 |

(i) Comment on whether the student has recorded his measurements of $i$ and $r$ to the correct number of significant figures.

**(2)**

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(ii) Calculate the percentage uncertainty in the value of $r$ when $i = 50°$.

**(2)**

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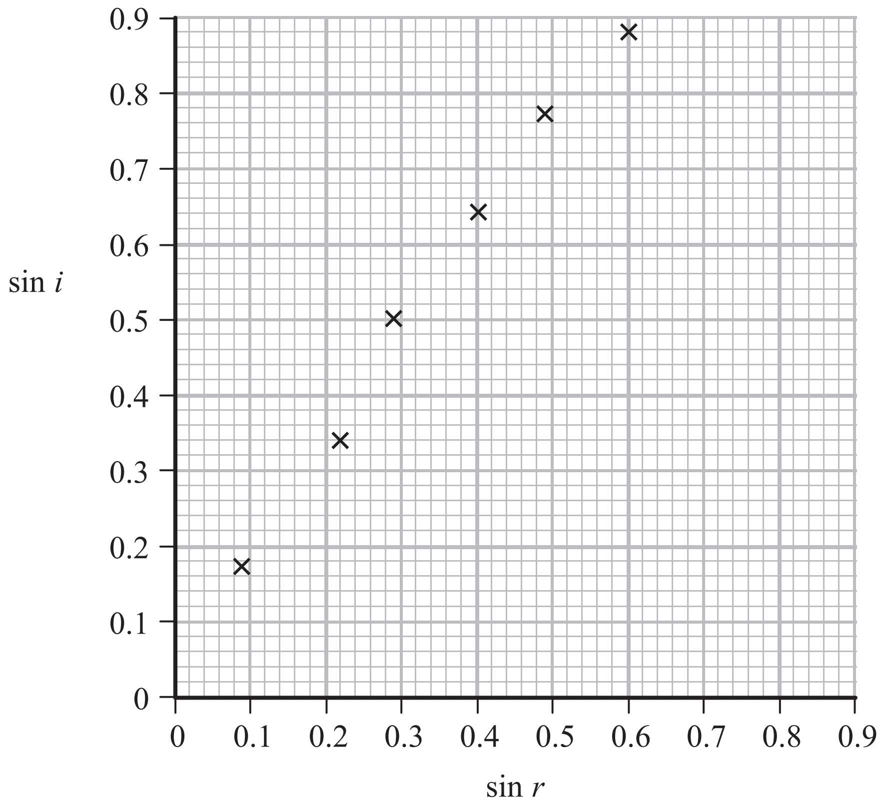
Percentage uncertainty in $r$ = ..............................................................

(c) The student plots his results on a graph of sin *i* against sin *r*.




The refractive index for three types of glass is shown.

| Type of glass | Refractive index |
|---|---|
| Silica | 1.458 |
| Crown | 1.755 |
| Flint | 1.925 |

(i) Draw a line of best fit.

**(1)**

(ii) Deduce which type of glass the rectangular block is made from.

**(3)**

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Type of glass ........................................................................................................

**(Total for Question 11 = 10 marks)**

**12** In 1925 Franck and Hertz were awarded the Nobel Prize in Physics "for their discovery of the laws governing the impact of an electron upon an atom".
In one of their experiments, a beam of high-speed electrons is fired through mercury vapour.

An electron in the beam collides with a mercury atom, which becomes excited. The atom returns to its initial state by emitting electromagnetic radiation of a single frequency.

(a) Explain why excited atoms only emit certain frequencies of radiation.

**(5)**

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(b) An electron travelling with a speed of $2.5 \times 10^6\ \mathrm{m\,s^{-1}}$ collides with a stationary mercury atom and continues at a speed of $2.1 \times 10^6\ \mathrm{m\,s^{-1}}$.

The table gives a range of wavelengths for ultraviolet, visible and infrared radiation.

| **Type of radiation** | **Typical range of wavelengths / m** |
|---|---|
| ultraviolet | $2.0 \times 10^{-7}$ to $4.0 \times 10^{-7}$ |
| visible | $4.0 \times 10^{-7}$ to $7.8 \times 10^{-7}$ |
| infrared | $7.8 \times 10^{-7}$ to $1.0 \times 10^{-3}$ |

Deduce the type of radiation that is emitted by the stationary mercury atom.

**(4)**

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Type of radiation ..........................................................

**(Total for Question 12 = 9 marks)**

**13** Huygens' principle states that every point on a wavefront is a source of wavelets which spread out at the same speed.

(a) State what is meant by a wavefront.

**(1)**

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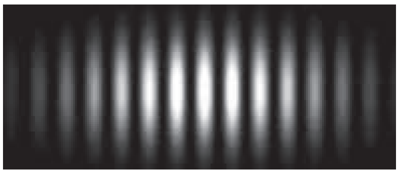
(b) In an experiment to demonstrate interference of light, monochromatic light from a laser is shone onto two narrow slits. A series of light and dark lines is observed on a screen placed a distance away from the slits.



(i) State one safety precaution that should be taken with this procedure.

**(1)**

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(ii) Thomas Young first demonstrated the principle of this experiment in 1803 in support of the theory that light behaves as a wave.

Give a reason why some scientists at the time did not accept the wave theory of light.

**(1)**

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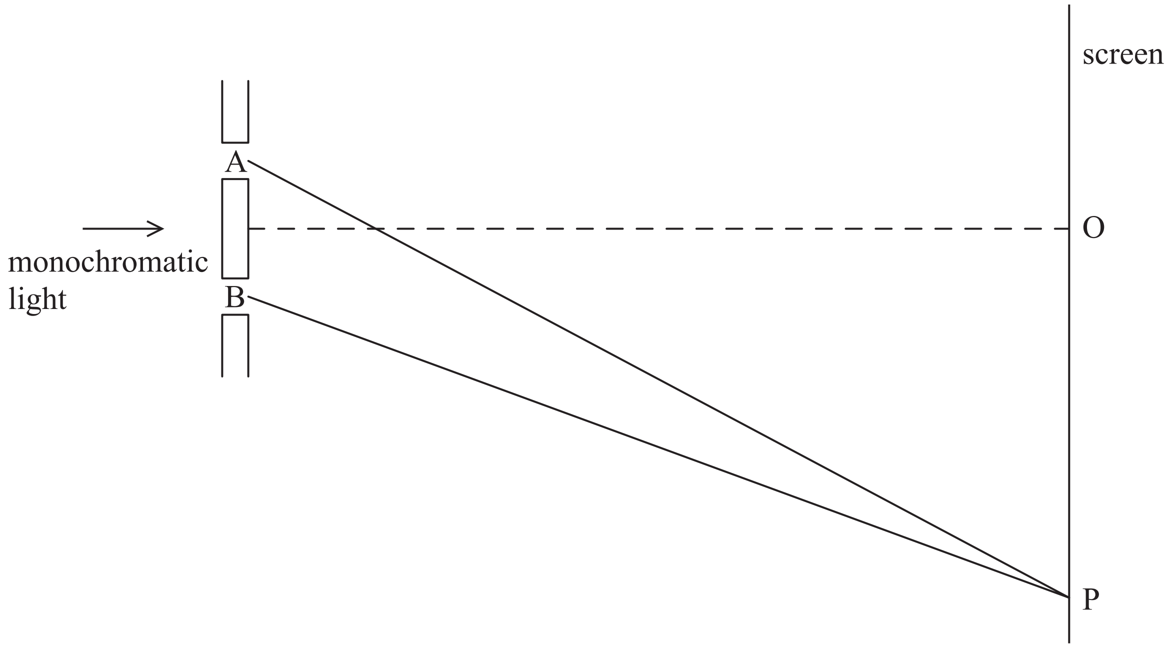
(c) The experiment was carried out with laser light of wavelength 600 nm. The diagram below shows two paths taken by the light after it has passed through the two slits A and B. The diagram is not to scale.




(i) Point O is a point equidistant from the two slits.

Explain why there is a bright line at this point.

**(3)**

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(ii) The next bright line is observed on the screen at point P. Lines AP and BP show the path of the light from each slit to the screen at P.

State the difference in the lengths of the paths AP and BP.

**(1)**

Difference in lengths of paths = ..............................................

**(Total for Question 13 = 7 marks)**

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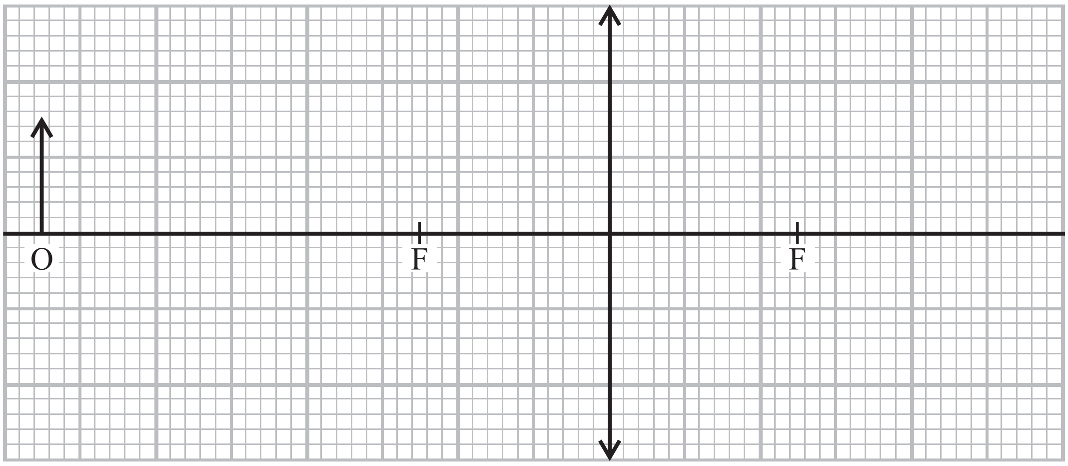
**14** A camera uses a converging lens to produce an image.

(a) The diagram represents an object O and a converging lens.




(i) Complete the ray diagram to determine the position of the image.

**(3)**

(ii) Determine the magnification of this image.

**(2)**

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Magnification = ..............................................

(iii) State, with justification, whether the image is real or virtual.

**(1)**

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(b) In some cameras, lenses of different focal lengths can be used. A particular camera can use a lens of focal length 50 mm or a lens of focal length 200 mm. Both lenses are made from the same material.

(i) Describe a method to determine an approximate value for the focal length of a converging lens.

**(2)**

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(ii) Explain why the lens with the shorter focal length is thicker at its centre.

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(iii) Both photographs show the same scene photographed from the same position.

Photograph 1

Photograph 2

One photograph was taken using the lens of focal length 50 mm and the other was taken using the lens of focal length 200 mm.

Deduce which lens was used to take photograph 2.

**(5)**

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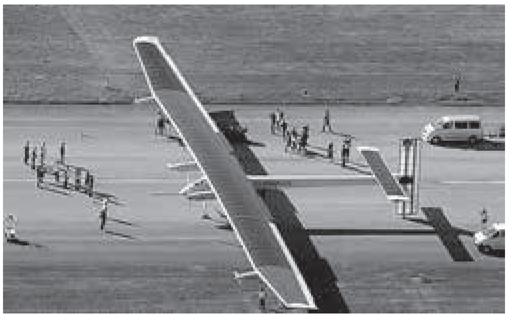
**(Total for Question 14 = 15 marks)**

**TOTAL FOR SECTION A = 59 MARKS**

## SECTION B

**Answer ALL questions in the spaces provided.**

**15** Read the passage and answer the questions below.



© Reuters

The Solar Impulse 2 is a solar-powered plane that completed a round the world trip in 2016 without using fossil fuels.
The wings are covered in thin solar panels, keeping the total mass of the plane and pilot at 1600 kg. The need to reduce the weight limits the efficiency of the solar panels to 23%. However, in daylight, these panels generate enough energy to run the four 7.5 kW electric motors that keep the plane airborne and to fully charge the batteries that power the plane during the night. The batteries take about 6 hours to fully charge.
In daylight the plane flies at a height of 8500 m to harness the most sunlight, and at night descends to 1500 m. This descent makes use of the gravitational potential energy gained during the day to help the plane get through the night.
(Source: www.solarimpulse.com)

(a) The solar panels consist of a series of photocells connected to an external circuit that includes the batteries. When light strikes the photocells, electrons gain energy and are able to move through the external circuit so that the batteries charge up.

Explain why the batteries charge more quickly in high intensity light.

**(4)**

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(b) The solar panels are illuminated with an average light intensity of $1300\,W\,m^{-2}$ over an 8 hour period in any day.

Calculate the electrical energy generated by the solar panels in one day.

**(4)**

upper area of wings = $200\,m^2$

Energy = ..........................................

(c) During the night the motors are switched off for 4 hours.
Calculate the battery energy saved by switching off the motors.

**(2)**

Battery energy saved = ..........................................

(d) The plane flies at the greater height during the day. At night it glides down to the lower height over a period of 4 hours, with the motors switched off.

Calculate the change in gravitational potential energy as the plane glides down.

**(2)**

Change in gravitational potential energy = ..........................................

(e) After four hours the engines are switched on again.

Explain whether the plane should fly at a slower horizontal speed at its lower height.

**(3)**

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(f) Comment on how projects such as the Solar Impulse 2 might be of benefit to society at large.

**(1)**

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**(Total for Question 15 = 16 marks)**

**16** A small helium balloon is released into the air. The balloon initially accelerates upwards.

The resultant force $F$ on the balloon is given by

$$F = \text{upthrust} - \text{weight} - \text{viscous drag}$$

(a) Eventually the balloon reaches a constant upwards speed.

Calculate a value for the viscous drag force acting on the balloon at this speed.
The balloon may be considered as a sphere with radius 12 cm.

**(4)**

density of air = $1.2\,\mathrm{kg\,m^{-3}}$
mass of unfilled balloon = 4.0 g
mass of helium in balloon = 1.2 g

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Viscous drag force = ........................................................................

(b) The viscosity of the air decreases as the balloon rises.

On a warmer day a balloon of the same total mass and radius rises at a lower constant upwards speed.

Give a reason why.

**(1)**

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**(Total for Question 16 = 5 marks)**

**TOTAL FOR SECTION B = 21 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 | $c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$ | |

### Mechanics

Kinematic equations of motion

$$s = \frac{(u+v)t}{2}$$

$$v = u + at$$

$$s = ut + \tfrac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

$$moment\ of\ force = Fx$$

Momentum

$$p = mv$$

Work, energy and power

$$\Delta W = F\Delta s$$

$$E_k = \tfrac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

### Electric circuits

Potential difference

$$V = \frac{W}{Q}$$

Resistance

$$R = \frac{V}{I}$$

Electrical power and energy

$$P = VI$$

$$P = I^2R$$

$$P = \frac{V^2}{R}$$

$$W = VIt$$

Resistivity

$$R = \frac{\rho l}{A}$$

Current

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nqvA$$

**Materials**

Density

$$\rho = \frac{m}{V}$$

Stokes' law

$F = 6\pi\eta rv$

Hooke's law

$F = k\Delta x$

Pressure

$$p = \frac{F}{A}$$

Young modulus

Stress $\sigma = \dfrac{F}{A}$

Strain $\varepsilon = \dfrac{\Delta x}{x}$

$$E = \frac{\sigma}{\varepsilon}$$

Elastic strain energy

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

**Waves and Particle Nature of Light**

Wave speed

$v = f\lambda$

Speed of a transverse wave on a string

$$v = \sqrt{\frac{T}{\mu}}$$

Intensity of radiation

$$I = \frac{P}{A}$$

Power of a lens

$$P = \frac{1}{f}$$

$P = P_1 + P_2 + P_3 + \ldots$

Thin lens equation

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

Magnification for a lens

$$m = \frac{\text{image height}}{\text{object height}} = \frac{v}{u}$$

Diffraction grating

$n\lambda = d \sin \theta$

Refractive index

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

$$n = \frac{c}{v}$$

Critical angle

$$\sin C = \frac{1}{n}$$

Photon model

$E = hf$

Einstein's photoelectric equation

$hf = \phi + \frac{1}{2}mv^2_{max}$

de Broglie wavelength

$$\lambda = \frac{h}{p}$$

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