Write your name here

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

Centre Number | Candidate Number

# Physics

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

Thursday 8 June 2017 – Afternoon
**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* ▶


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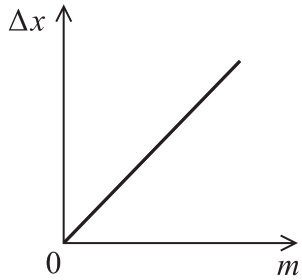
## SECTION A

**Answer ALL questions.**

**All multiple choice questions must be answered with a cross ☒ in the box for the correct answer from A to D. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

**1** A spring is hung vertically and masses are added to the lower end.
The graph shows how the extension $\Delta x$ of the spring varies with the mass $m$ added.




The work done in extending the spring can be expressed as

☐ **A** $mg\Delta x$

☐ **B** $\dfrac{mg}{\Delta x}$

☐ **C** $\dfrac{1}{2}mg\Delta x$

☐ **D** $\dfrac{mg}{2\Delta x}$

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

---

**2** The velocity of a wave on a string is given by $v = \sqrt{\dfrac{T}{\mu}}$ where $T$ is the tension in the string and $\mu$ is a constant.

Which of the following pairs of variables, if plotted, would produce a straight line graph?

| | ***x*-axis** | ***y*-axis** |
|---|---|---|
| ☐ **A** | $T$ | $\sqrt{v}$ |
| ☐ **B** | $v$ | $T$ |
| ☐ **C** | $\dfrac{1}{v}$ | $T$ |
| ☐ **D** | $\sqrt{T}$ | $v$ |

**(Total for Question 2 = 1 mark)**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**3** In an experiment to determine the wavelength of light, a diffraction grating is illuminated with light from a monochromatic source. A series of bright spots is observed.

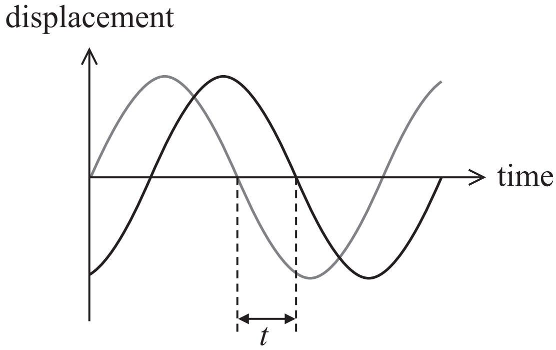
The experiment is repeated and the distance between consecutive bright spots increases.

Select the row of the table that gives two changes to the experimental set up which would both cause the distance between consecutive bright spots to increase.

| | Number of slits per mm in the diffraction grating | Wavelength of the light source |
|---|---|---|
| ☒ **A** | Increased | Increased |
| ☒ **B** | Increased | Decreased |
| ☒ **C** | Decreased | Increased |
| ☒ **D** | Decreased | Decreased |

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

**4** Displacement-time graphs are shown for two waves, each of frequency $f$ and period $T$.




The phase difference in radians between the two waves is given by

☒ **A** $\frac{2\pi t}{T}$

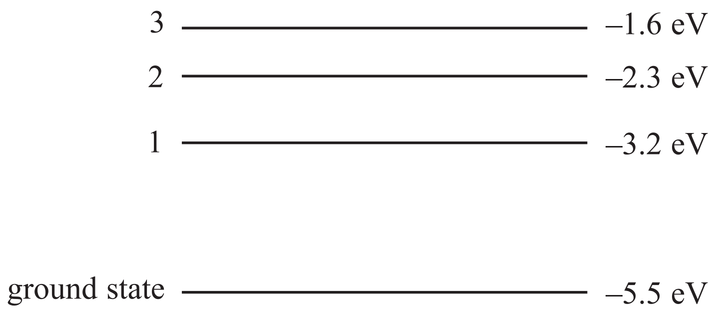
☒ **B** $\frac{\pi t}{T}$

☒ **C** $\frac{2\pi t}{f}$

☒ **D** $\frac{\pi t}{f}$

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

**5** The diagram shows the lowest energy levels for a certain atom.




A photon with energy 3.2 eV is absorbed.

An electron could move from

☒ **A** ground state to level 1.

☒ **B** ground state to level 2.

☒ **C** level 1 to ground state.

☒ **D** level 2 to ground state.

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

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**6** The rate at which energy is transferred to a solar cell of radius $r$ is $P$.

In the same conditions, the rate at which energy is transferred to a solar cell of radius $2r$ is given by

☒ **A** $\frac{P}{4}$

☒ **B** $\frac{P}{2}$

☒ **C** $2P$

☒ **D** $4P$

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

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**7** For two waves of light to be coherent the waves must

☒ **A** always have a phase difference equal to 0.

☒ **B** oscillate in the same plane.

☒ **C** have a similar amplitude.

☒ **D** originate from one source.

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

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**8** Prenatal ultrasound scans are performed to produce an image of a fetus.

The ultrasound wave is transmitted in pulses so that

☒ **A** exposure of the patient to ultrasound radiation is reduced.

☒ **B** smaller distances can be measured.

☒ **C** the reflected pulse can be detected before the next pulse is transmitted.

☒ **D** there is less diffraction.

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

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**9** In the 1920s Louis de Broglie proposed that an electron could behave as a wave.

Calculate the wavelength of an electron that is travelling at a speed of $2.2 \times 10^7\,\mathrm{m\,s^{-1}}$.

**(3)**

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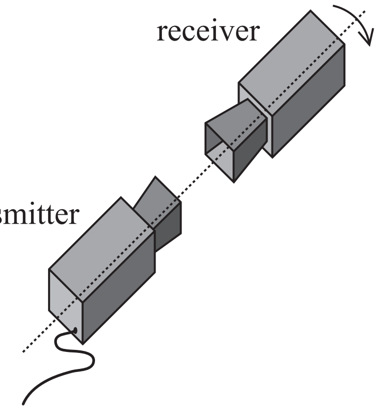
Wavelength = .............................................................

**(Total for Question 9 = 3 marks)**

**10** Details supplied with a school microwave transmitter and receiver include the following information:

| |
|---|
| Transmitter supplies a 10 GHz polarised EM wave.<br>Receiver detects EM waves in a single plane containing the direction of propagation, producing an audible output proportional to the microwave intensity. |

(a) The receiver and transmitter are initially set up, as shown in the diagram, so that a maximum audible output is produced.




The receiver is rotated through 180° relative to the transmitter.

Describe what is heard as the receiver is rotated.

**(2)**

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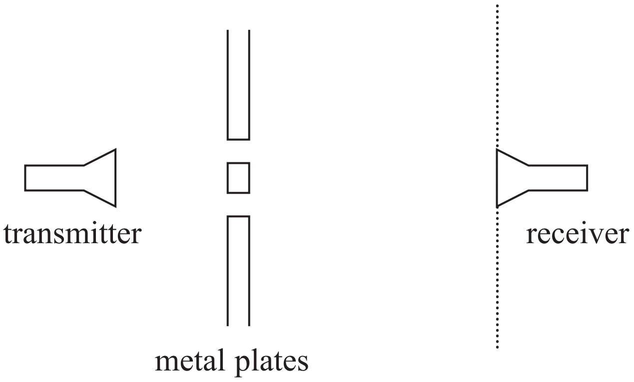
(b) A student uses the microwave transmitter and receiver to investigate interference using the set-up shown.




As the receiver is moved along the dotted line, alternate points of maximum and minimum intensity are detected.

Explain why points of maximum and minimum intensity are detected.

**(4)**

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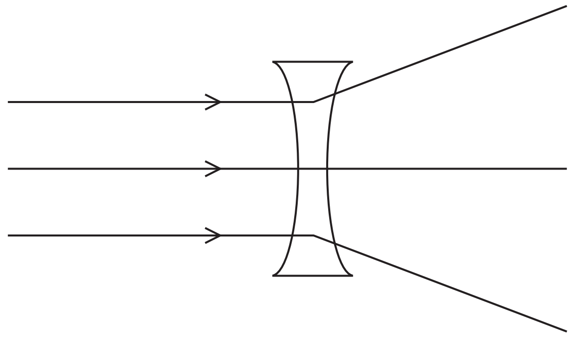
**(Total for Question 10 = 6 marks)**

**11** Converging and diverging lenses may be used in glasses to correct problems with eyesight.

(a) The diagram shows three parallel rays of light incident on a diverging lens and the path of the rays after passing through the lens. The diagram is drawn to actual size.



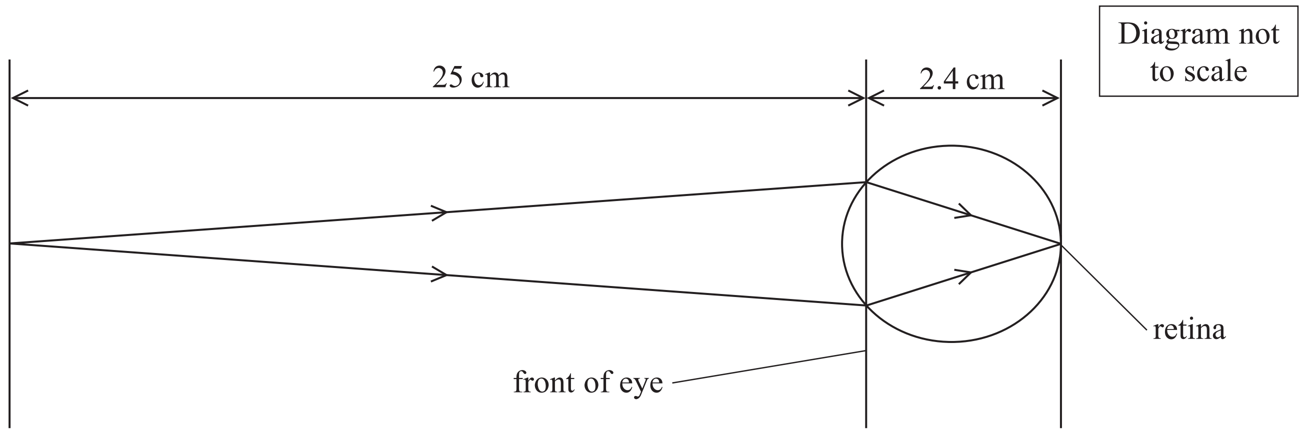
Add to the diagram to determine the focal length of the lens.

**(2)**

Focal length = ..............................................

(b) The eye acts as a converging lens system.

The diagram shows light rays from an object 25 cm in front of an eye converging to a point on the retina at the back of the eye. The eye has a depth of 2.4 cm.




Calculate the optical power of the eye.

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Power = ..............................................

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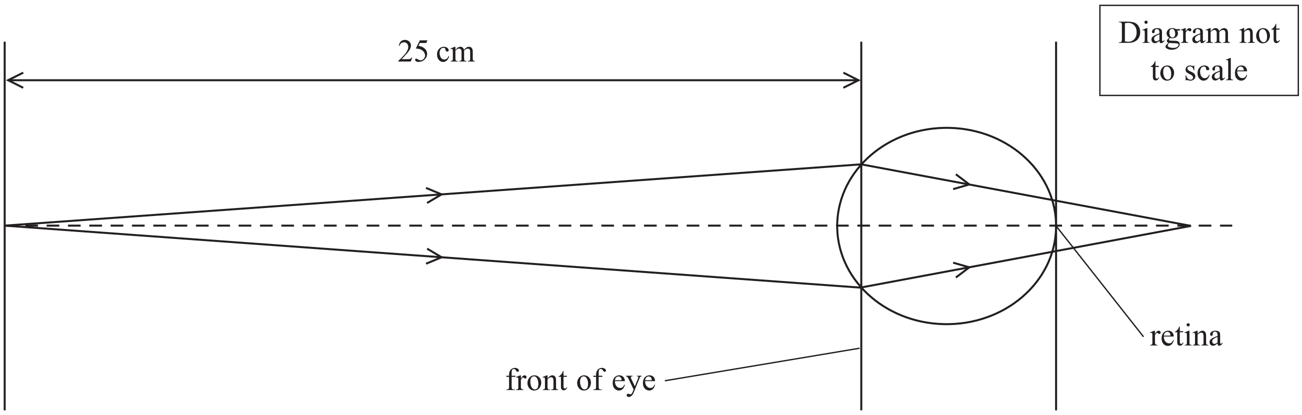
(c) A person who is long-sighted cannot clearly see objects that are close to the eye.

Rays of light from an object 25 cm in front of the eye would converge to a point behind the retina as shown in the diagram.




This may be corrected by using an additional converging lens.

State how an additional converging lens would enable the light rays from an object 25 cm in front of the eye to converge at a point on the retina.

**(1)**

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**(Total for Question 11 = 6 marks)**

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**12** On sunny days a mirage can sometimes be observed when a virtual image of the sky is seen on the surface of a road.

The Sun's rays heat up the surface of the road. The heated road then heats the surrounding air so that the layer of air just above the road is at a higher temperature than the air above it.
Warm air has a lower refractive index than cool air.

(a) State what is meant by a virtual image.

**(1)**

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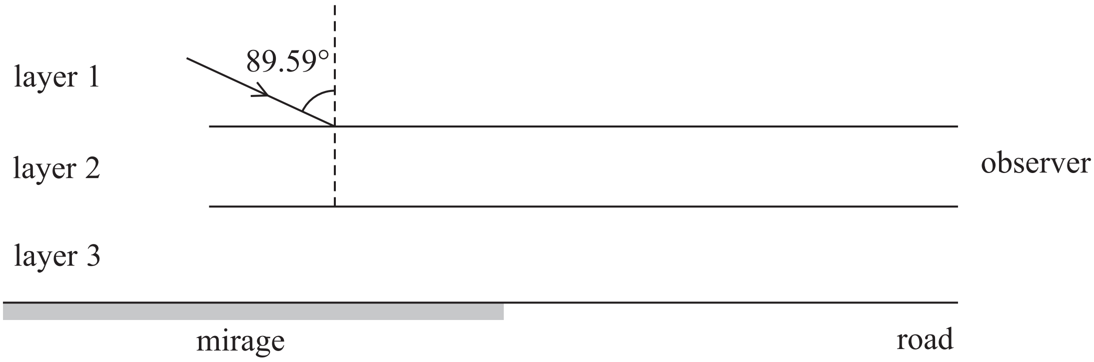
(b) The diagram represents a simple model which is sometimes used to explain how a mirage is formed. The three layers, each with a different refractive index, represent air at three different temperatures. Layer 3 represents the air at the highest temperature closest to the road. A light ray is shown incident at the interface between layer 1 and layer 2.




| | refractive index |
|---|---|
| layer 1 | 1.00032 |
| layer 2 | 1.00030 |
| layer 3 | 1.00028 |

critical angle for light travelling from layer 1 to layer 2 = 89.64°
critical angle for light travelling from layer 2 to layer 3 = 89.64°

Use the information to discuss whether the observer sees a mirage on the road in the position shown.

**(6)**

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**(Total for Question 12 = 7 marks)**

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**13** A student carries out an experiment to determine the viscosity of glycerol. She does this by determining the terminal velocity of a steel sphere falling through glycerol.

(a) The equation shows how the terminal velocity of a solid sphere falling through a liquid depends on the density of both the solid and the liquid.

$$v = \frac{Vg(\rho_s - \rho_l)}{6\pi r\eta}$$

where
$\rho_l$ = density of liquid
$\rho_s$ = density of solid
$r$ = radius of sphere
$V$ = volume of sphere
$\eta$ = viscosity of liquid
$v$ = terminal velocity

The derivation of the equation for terminal velocity has been started below.
Complete the derivation.

**(3)**

*At terminal velocity: weight of solid sphere = drag + upthrust*

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(b) (i) The student drops a steel sphere with a radius of 4.0 mm into a cylinder of glycerol. The sphere reaches terminal velocity and takes 3.9 s to fall 0.50 m.

Calculate the viscosity of glycerol.

density of steel = 7800 kg $m^{-3}$
density of glycerol =1300 kg $m^{-3}$

**(4)**

Viscosity of glycerol = ........................................

(ii) There are two cylinders available for the student to use. One cylinder has a diameter of 1.5 cm and the other has a diameter of 5.0 cm.

State and justify which cylinder the student should use in order to gain a more accurate value for the viscosity of glycerol.

**(2)**

**(Total for Question 13 = 9 marks)**

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**14** Two students are carrying out an investigation to determine a value for the speed of sound in air.

They stand 80 m from a building. One student hits two pieces of wood together to make a loud sound and a short time later an echo is heard. The other student uses a stopwatch to measure the time interval $t$ between the two pieces of wood being hit and the echo being heard. The procedure is repeated. The students also measure the air temperature.

(a) Explain how a sound wave travels through air.

**(2)**

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(b) The students repeat the investigation on a different day. The results are shown in the table.

| | **temperature / °C** | $t_1$ **/ s** | $t_2$ **/ s** | $t_3$ **/ s** | **mean** $t$ **/ s** |
|---|---|---|---|---|---|
| **Day 1** | 12 | 0.51 | 0.43 | – | 0.47 |
| **Day 2** | 18 | 0.44 | 0.69 | 0.48 | 0.46 |

(i) Deduce why the students thought it necessary to make a third measurement on day 2.

**(1)**

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(ii) Calculate the percentage uncertainty in the mean value of time on day 1.

**(2)**

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Percentage uncertainty = ..........................................

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(iii) Calculate the difference in the value for the speed of sound between day 1 and day 2 obtained from these results.

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Difference in speed = ..........................................................

(iv) The students state that the difference in the speed of sound between day 1 and day 2 is due to the change in air temperature.

Explain whether the results obtained are sufficient for this statement to be made.

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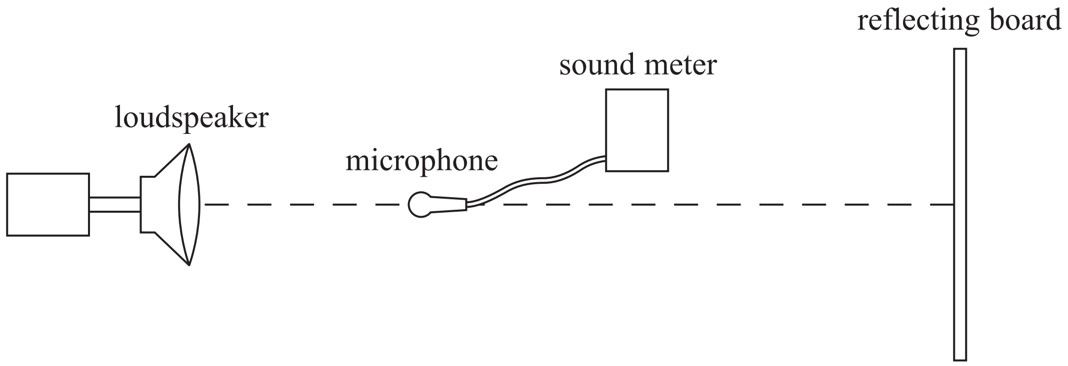
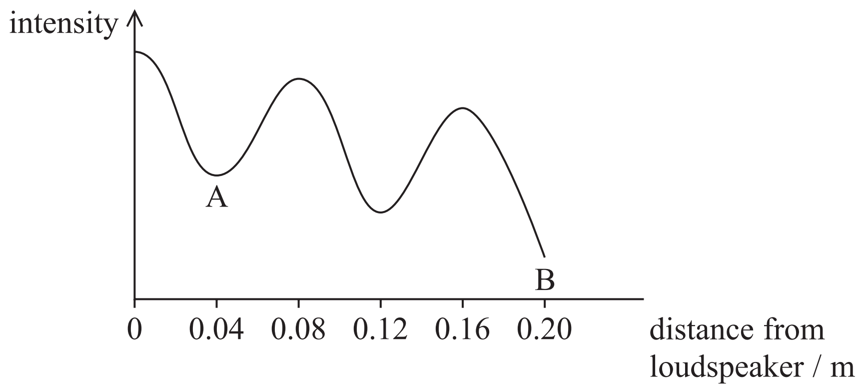
(c) An alternative method to determine a value for the speed of sound is shown in the diagram.




A loudspeaker is placed at a distance from a vertical reflecting board. Sound waves reflect off the board and set up a standing wave between the loudspeaker and the board. A microphone connected to a sound meter is moved in a straight line from the loudspeaker to the board. As the microphone is moved, the sound meter records the varying intensity of the standing wave.

The sketch graph shows how the intensity varies with distance from the loudspeaker.




(i) Explain why the intensity at point B is less than the intensity at point A.

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(ii) Use the graph to determine a value for the speed of sound.

frequency of sound wave = 2.0 kHz

**(3)**

Speed of sound = ..........................................

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

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***15** The behaviour of electromagnetic radiation can be described in terms of a photon model or a wave model.

In the photoelectric effect, electromagnetic radiation is incident on a metal plate and under certain conditions electrons are emitted.

It is observed that, for a given metal,

- no electrons are emitted if the frequency of the incident radiation is below a certain threshold frequency.
- electrons are emitted instantaneously if the frequency of the incident radiation is above a certain threshold frequency.
- the kinetic energy of the emitted electrons depends only on the frequency of the incident radiation.

Discuss how the photon model of electromagnetic radiation can explain these observations and why the wave model of electromagnetic radiation cannot.

**(6)**

**(Total for Question 15 = 6 marks)**

**TOTAL FOR SECTION A = 60 MARKS**

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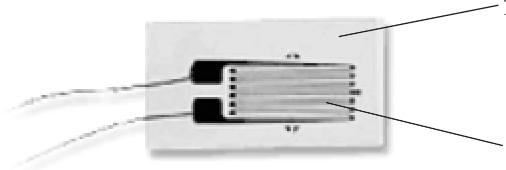
## SECTION B

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

**16** A medical scanner uses a moving table to position the patient. Strain gauges are used to monitor the shape of the table which enables a more precise positioning of the patient.

Strain gauges consist of a thin length of wire attached, in a zigzag pattern, to a small flexible piece of plastic. The strain gauge is attached to the table. When the table is subjected to forces, the dimensions of the plastic change. This causes a change in the length of the wire and hence a change in the resistance of the wire.




(a) Resistance can be measured directly using an ohmmeter or indirectly using measurements from a voltmeter and ammeter.

Describe **two** benefits of using an ohmmeter compared to using a voltmeter and an ammeter.

**(2)**

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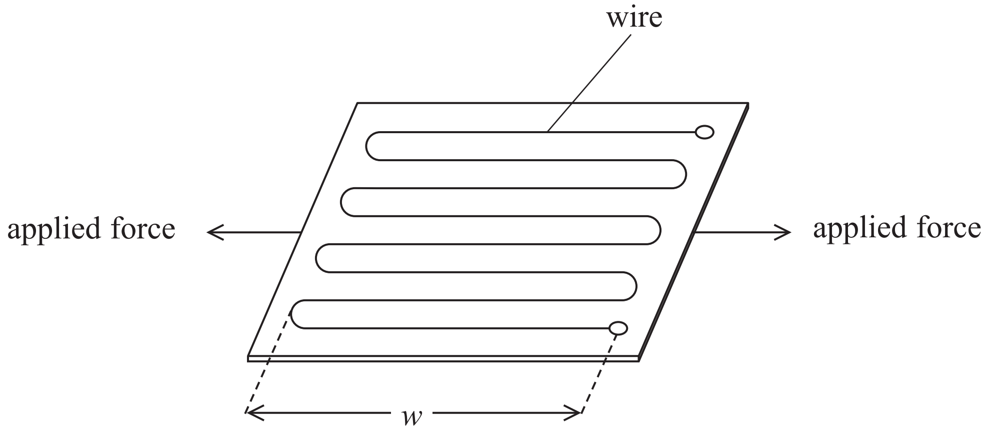
(b) The diagram shows forces applied to a strain gauge. The ‘width’ of the strain gauge is defined by the distance $w$.




(i) State and justify how the applied forces change the resistance of the wire.

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(ii) The gauge factor $GF$ of a strain gauge is given by

$$GF = \frac{\Delta R}{\varepsilon R}$$

where $\varepsilon$ is the strain
$R$ is the initial resistance
$\Delta R$ is the change in resistance

When forces are applied to the strain gauge, the resistance of the gauge changes by 0.10%.

Calculate the change in the width of the strain gauge.

$w = 5.0$ cm
$GF = 2.0$

**(3)**

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Change in width = ..............................................................

(c) Explain the benefit of arranging the wire in a zigzag pattern.

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**(Total for Question 16 = 9 marks)**

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**17** Read the following article and then answer the questions that follow.

> "The fastest, tallest and longest dive coaster, on which amusement park thrill seekers can experience free fall, is set to open next summer at Cedar Point in Sandusky, Ohio. Valravn is designed to take riders up to a 66 m peak from which they plummet vertically with an acceleration *g* and feel weightless.
>
> The advent of steel-frame roller coasters in 1959 made taller structures possible.
>
> Whereas height remains one of the best ways to attain intense speeds, a coaster car can also be shot from its starting point via electromagnetic propulsion or a catapult. Cars on these launched coasters have the potential to go from zero to 130 $km\,h^{-1}$ in two seconds.
>
> Although coasters can definitely go faster, they're limited by the acceleration those higher speeds would require. Roller coasters reach their peak speeds in a matter of seconds. The achieved acceleration is what causes *g*-forces, which allows riders to feel an increased or decreased sense of their mass. These *g*-forces can be dangerous but they are also well understood by physicists, so roller coasters are built according to strict standards that keep them well within safe levels.
>
> Coasters are only permitted to accelerate up to 6*g*."
>
> (Source: Shriek Science: Simple Physics Powers Extreme Roller Coasters Hackett Jennifer, Oct 14, 2015)

(a) The article claims that a rider will feel weightless as they plummet from a height of 66 m. It takes 2.62 s for the car to fall 33.0 m from rest.

Deduce whether the claim about weightlessness is true.

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(b) As mentioned in the passage, large accelerations can also be achieved by *launched coasters* which launch the cars horizontally from their starting position.

Use the data in the passage to deduce whether the acceleration achieved in this way meets roller coaster standards.

**(3)**

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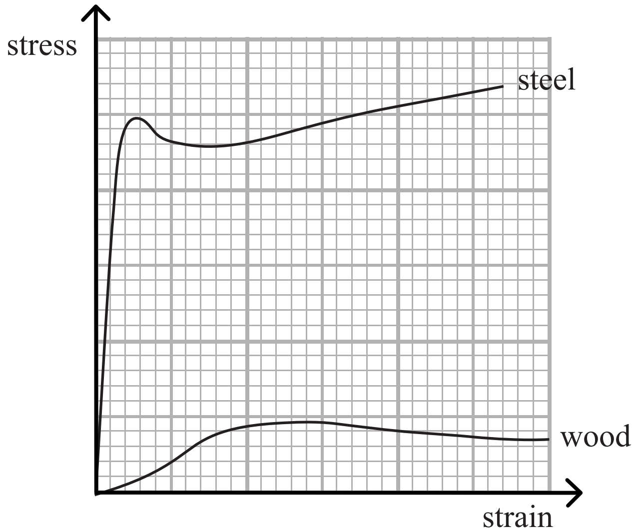
(c) The graph shows typical stress-strain curves for wood and steel.




Discuss how the use of steel, rather than wood, has made the construction of faster and taller roller coasters possible.

**(5)**

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**(Total for Question 17 = 11 marks)**

**TOTAL FOR SECTION B = 20 MARKS**
**TOTAL FOR PAPER = 80 MARKS**

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## List of data, formulae and relationships

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

**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

$$\Sigma F = ma$$

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

$$W = mg$$

$$\textit{moment of force} = Fx$$

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

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

$$I = nqvA$$

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**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

$$\text{Stress } \sigma = \frac{F}{A}$$

$$\text{Strain } \varepsilon = \frac{\Delta x}{x}$$

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

Elastic strain energy

$\Delta E_{el} = ½F\Delta x$

**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

$hf = \phi + ½mv^2_{max}$

de Broglie wavelength

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



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