Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | | | | | |

Candidate Number | | | | |

Pearson Edexcel Level 3 GCE

Time 1 hour 30 minutes

Paper reference **8PH0/02**

Physics

Advanced Subsidiary
PAPER 2: Core Physics II

You must have:
Scientific calculator, 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.*
- In the question 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.
- The list of data, formulae and relationships is printed at the end of this booklet.

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 ▶

Pearson

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 Which of the following provides evidence for the particle model of electromagnetic radiation?

☒ **A** diffraction

☒ **B** interference

☒ **C** polarisation

☒ **D** visible line spectra

(Total for Question 1 = 1 mark)

2 In an investigation to determine the Young modulus of steel in the form of a wire, a student plots a straight line graph. The Young modulus is numerically equal to the gradient of the graph.

What quantities did the student plot on each axis on the graph?

		***y*-axis**	***x*-axis**
☒	**A**	strain	stress
☒	**B**	stress	strain
☒	**C**	$\frac{1}{\text{strain}}$	stress
☒	**D**	$\frac{1}{\text{stress}}$	strain

(Total for Question 2 = 1 mark)

3 Which of the following is the SI base unit for the Planck constant?

☒ **A** $\text{N m}^{-1}\,\text{s}^{-1}$

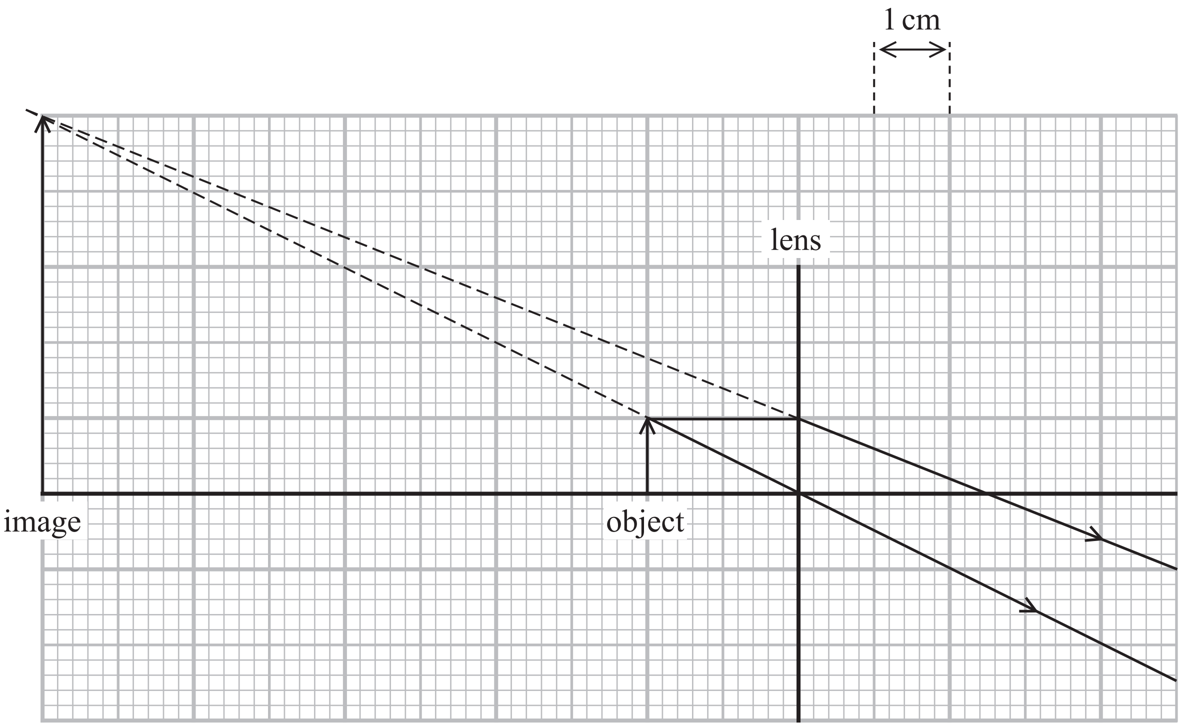
☒ **B** N m s

☒ **C** $\text{kg m}^{2}\,\text{s}^{-1}$

☒ **D** $\text{kg m}^{-2}\,\text{s}$

(Total for Question 3 = 1 mark)

4 A ray diagram, drawn to scale, is used to locate the size and position of an image formed by a lens as shown.



Which row in the table gives the focal length and the type of lens?

	Focal length / cm	Type of lens
☒ **A**	2.5	converging
☒ **B**	2.5	diverging
☒ **C**	10	converging
☒ **D**	10	diverging

(Total for Question 4 = 1 mark)

5 A student measures the diameter of a steel wire in order to determine the cross-sectional area of the wire. The percentage uncertainty in the measurement of the diameter was 1.8%.

Which of the following is the percentage uncertainty in the value for the cross-sectional area?

☒ **A** 1.8%

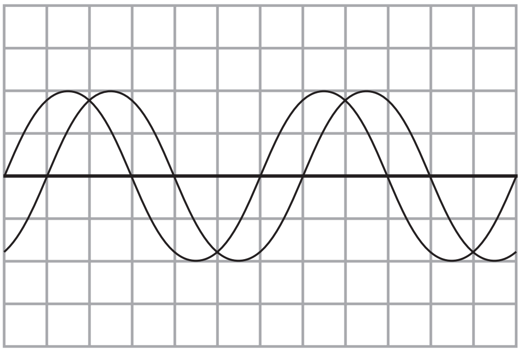
☒ **B** (1.8 + 1.8)%

☒ **C** (1.8 + 1.8 + 1.8)%

☒ **D** (1.8×1.8)%

(Total for Question 5 = 1 mark)

6 A two-beam oscilloscope is used to display signals from two microphones as shown.

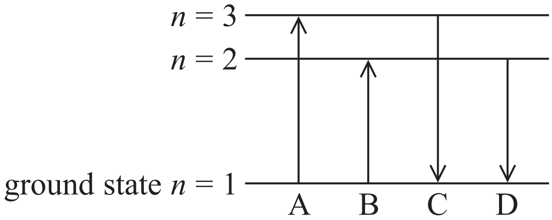


Which of the following could be the phase difference in radians between the traces?

- ☒ **A** $\frac{\pi}{6}$
- ☒ **B** $\frac{\pi}{4}$
- ☒ **C** $\frac{\pi}{3}$
- ☒ **D** $\frac{\pi}{2}$

(Total for Question 6 = 1 mark)

7 The energy level diagram shows four possible energy transitions for an electron in an atom.

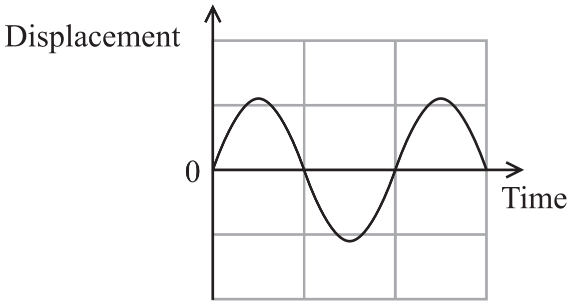


Which arrow shows the transition made by the electron when the atom emits radiation with the longest wavelength?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 7 = 1 mark)

8 A displacement-time graph is shown for a particle in a transverse wave.



Which property of the wave can **not** be determined directly from the displacement-time graph?

☒ **A** amplitude

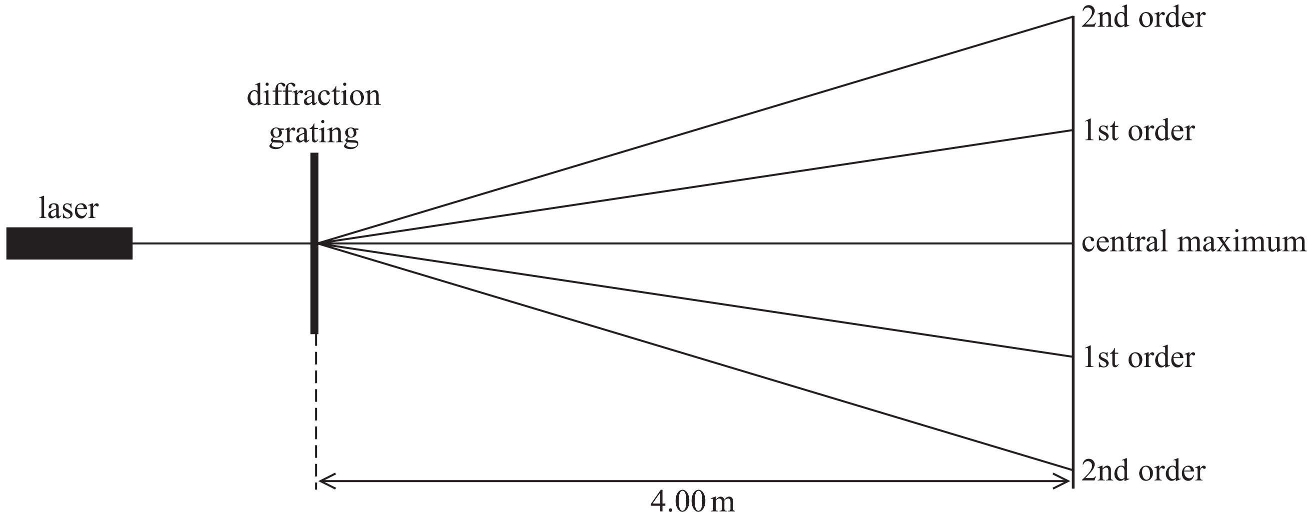
☒ **B** frequency

☒ **C** time period

☒ **D** wavelength

(Total for Question 8 = 1 mark)

9 A student used a diffraction grating to determine the wavelength of the light emitted by a laser. Light from the laser passed through the diffraction grating and the student observed a pattern on a wall 4 m away. The pattern consisted of a central maximum and 1st and 2nd order maxima as shown.



The student measured the distance between the central and a 2nd order maximum as 1350 mm. The diffraction grating had 300 slits mm^{-1}.

(a) The colours and corresponding wavelengths of light emitted by commonly used lasers are given in the table.

blue	450–490 nm
green	520–560 nm
red	635–700 nm

Deduce the colour of the laser light the student used in this experiment.

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(b) Measuring the distance between the two 2nd order maxima would produce a smaller percentage uncertainty in the value of wavelength.

Give a reason why.

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(Total for Question 9 = 5 marks)

***10** In 1969, astronauts placed an array of mirrors on the surface of the Moon. Scientists can use these to monitor the distance from Earth to the Moon. Light from a laser is used with a pulse-echo technique.

Describe how the distance of the Moon from Earth can be determined using a pulse-echo technique.

(Total for Question 10 = 6 marks)

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11 A student used steel ball bearings falling through a viscous liquid to investigate the relationship between the terminal velocity v of a ball bearing and its radius r.

(a) The student used ball bearings with different radii.

Describe how the student can make measurements of the ball bearing to determine its radius.

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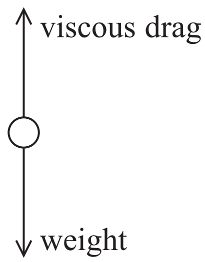
(b) A free body force diagram for a ball bearing of radius 5.00 mm falling through the liquid is shown. The upthrust on the ball bearing has been ignored.

Diagram **NOT** to scale



(i) Show that the weight of a ball bearing with a radius of 5.0 mm is about 4×10^{-2} N.

density of steel = $8.0 \times 10^{3}\,\text{kg}\,\text{m}^{-3}$

(3)

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(ii) Calculate the terminal velocity of the ball bearing as it falls through the liquid. You may ignore the upthrust on the ball bearing.

viscosity of liquid = 1.8 Pa s

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Terminal velocity = ...

(c) Explain how the student can ensure that Stokes' law will apply to the ball bearings falling through the viscous liquid.

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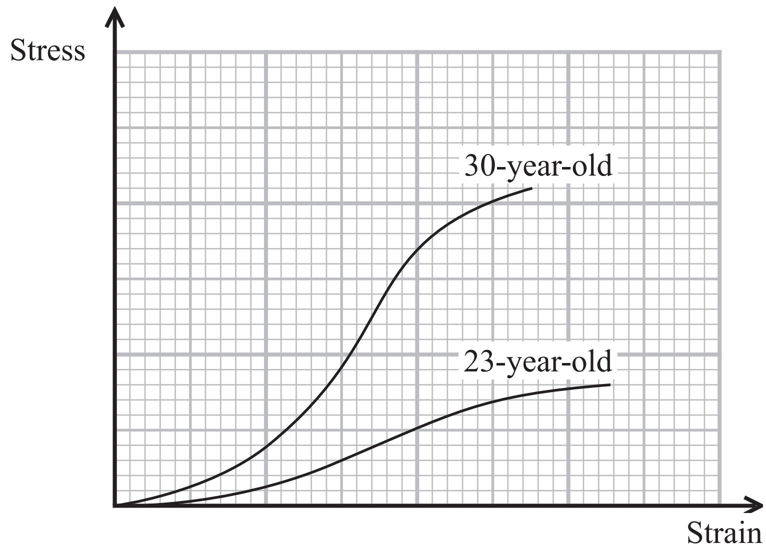
(Total for Question 11 = 10 marks)

12 The power of the lens in the human eye changes as the lens changes shape. This enables a person to see objects at different distances clearly. To change the shape, muscles in the eye put the lens under stress.

(a) A stress-strain graph for the eye lens for people of different ages is shown.



(i) State one difference between the lens of a 23-year-old and the lens of a 30-year-old.

(1)

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(ii) Give a reason for your answer, making reference to the graph.

(1)

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(b) A teacher was modelling the human eye. He placed an object 60 cm from a converging lens system. A real image of the object was observed with a magnification of 0.5

The converging lenses that were available to the teacher had powers of 2D, 3D and 4D.

Deduce which lens, or combination of lenses, the teacher used.

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(Total for Question 12 = 6 marks)

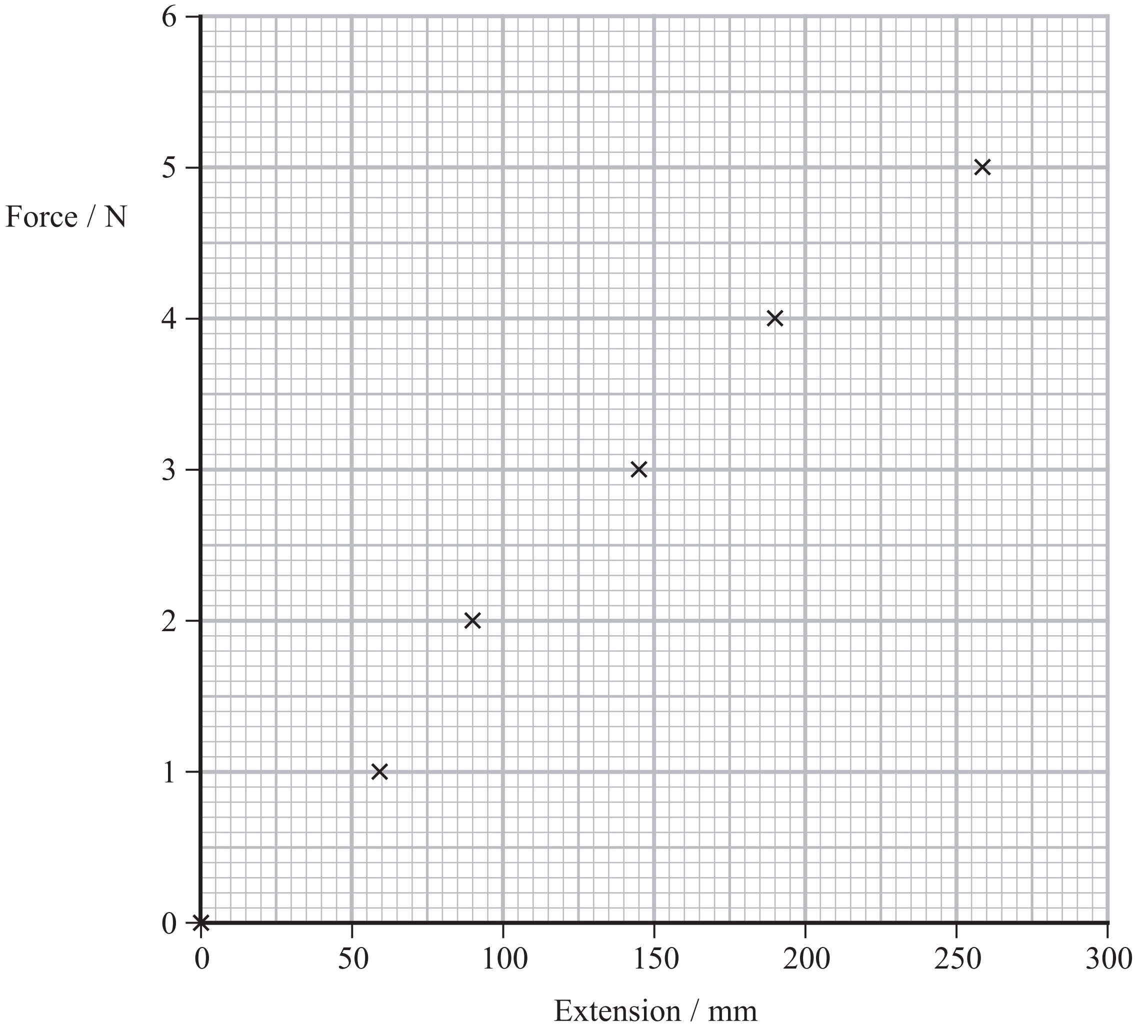
13 A manufacturer gives the following information about a spring.

1. Follows Hooke's law up to loads of 5 N
2. Maximum extension without permanent deformation 0.4 m
3. Stiffness 21 N m^{-1} ±5%
4. Stores up to 1.6 J

A student carried out an investigation on the spring to test this information.

She applied a range of forces from 0 N to 5 N to the spring. She measured the length of the spring and recorded the extension for each force.

She plotted a graph of force against extension.



(a) Determine the stiffness of the spring.

(3)

Stiffness = ...

(b) Discuss the extent to which the student's results are consistent with the information given by the manufacturer.

(6)

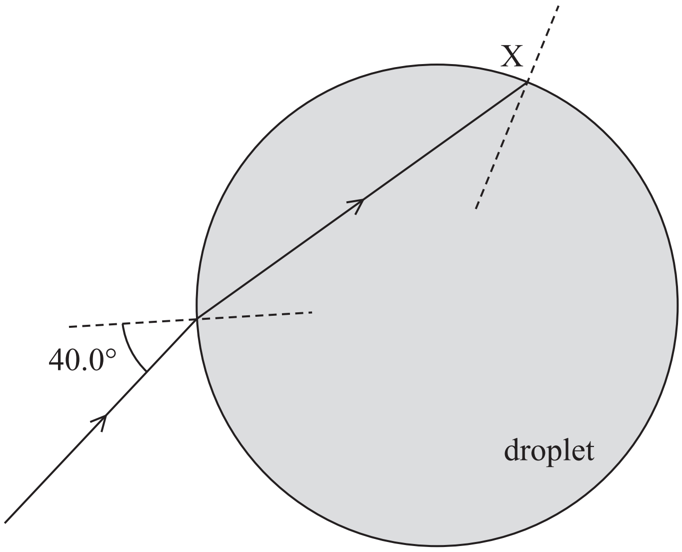
(Total for Question 13 = 9 marks)

14 Lighthouses are located along coastlines to aid navigation. A lighthouse emits an intense beam of light. In clear weather the beam is visible for long distances, but in foggy weather the visibility of the beam is limited.

(a) The beam is refracted by water droplets in the air.

A light ray in the beam is incident on a spherical water droplet with an angle of incidence of 40.0°. The ray passes through the droplet and meets the water-air boundary at X as shown.

Diagram **NOT** to scale



Deduce whether the ray leaves the water droplet at point X.

speed of light in water = $2.25 \times 10^8\,\mathrm{m\,s^{-1}}$

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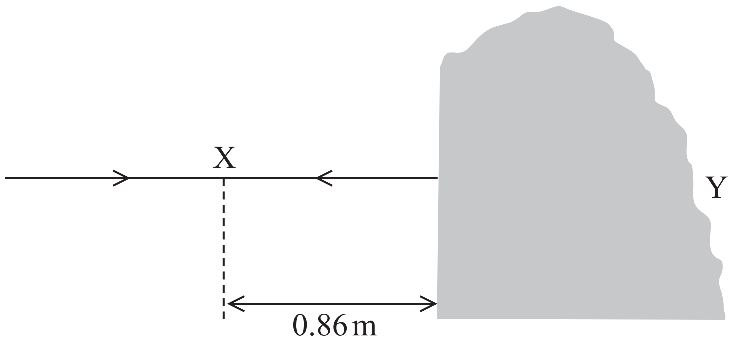
(b) A lighthouse is also fitted with a foghorn to emit a loud sound in foggy weather.

A sound wave is incident normally on a large rock and is reflected. The reflected wave meets the incoming wave, creating a standing wave. The closest node to the rock is at point X, 0.86 m from the rock as shown.



(i) Calculate the speed of the sound wave.

frequency of sound wave = 200 Hz

(3)

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Speed of sound wave = ...

(ii) The rock is about 2 m wide and 2 m high.

Explain why sound would be heard at point Y behind the rock.

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(Total for Question 14 = 9 marks)

15 The Planck constant is an important universal constant used in the study of wave–particle duality.

(a) In a demonstration of the photoelectric effect, ultraviolet radiation with a frequency of 2.8×10^{16} Hz is incident on the surface of clean zinc. Electrons are released from the surface of the zinc.

Calculate the maximum velocity of the released electrons.

work function of zinc = 6.9×10^{-19} J

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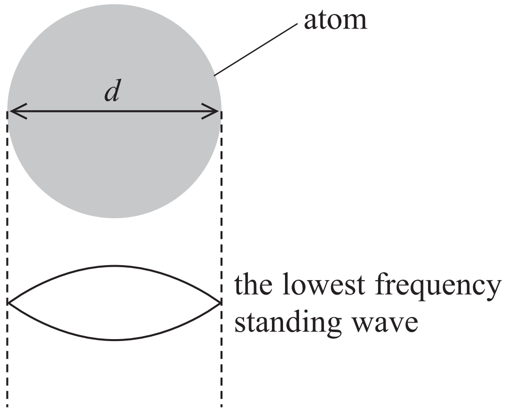
Maximum velocity = ...

(b) Atomic electrons are confined within the atom. One model of atomic electrons suggests that the wave associated with an atomic electron forms a standing wave that fits exactly into the diameter *d* of the atom.

(i) The diagram shows the lowest frequency standing wave that fits into the diameter of the atom.



Calculate the momentum of the electron.

$d = 2.00 \times 10^{-10}$ m

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Momentum = ...

(ii) Electrons in an atom can only exist at discrete energy levels.

Explain how this standing wave model can account for this.

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(Total for Question 15 = 7 marks)

TOTAL FOR SECTION A = 60 MARKS

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SECTION B

Answer ALL questions in the spaces provided.

16 Read the extract and answer the questions that follow.

Gravitricity is developing a new technology to capture and store the excess power generated by renewable energy resources. A large load is suspended by cables in a disused mineshaft. During periods of low power demand, excess generated power is used to winch the load upwards. During periods of high demand, the load is lowered down the shaft, causing electricity to be generated. The system can produce electricity at low power for several hours, or a short burst of electricity at high power.

(Source based on: https://gravitricity.com/)

(a) One such system is planned to use a load of mass 2500 tonnes. The load will be at the top of a shaft. The load will be lowered down the shaft at a steady speed. A useful power output of 15 MW will be generated. The system will have an efficiency of 80%.

Calculate the speed of the load.

1 tonne = 1000 kg

(3)

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Speed = ...

(b) The system can generate “a short burst of electricity at high power”.

Explain why high power can be generated for only a short time.

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(c) A load of 5.0×10^3 tonnes is held stationary by several vertical steel cables. The strain on the cables is 5.0×10^{-3}.

Calculate the total cross-sectional area of the cables holding the load.

Young modulus of steel = 180 GPa
1 tonne = 1.0×10^3 kg

(2)

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Cross-sectional area = ...

(d) The speed of the load in the shaft will depend on the variation of the electricity supply and demand throughout the day.

Explain why the total area of the cables will need to be greater than that calculated in (c) to limit the strain to no more than 0.005

(3)

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(Total for Question 16 = 10 marks)

17 A photographer uses a light meter to measure the intensity of light entering a camera. A simple light meter consists of a light dependent resistor (LDR) connected in a circuit.

(a) The resistance of an LDR depends on the intensity of light incident on the LDR.

Explain how the change in resistance may be modelled in terms of conduction electrons.

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(b) The light meter records an intensity of $1100\,\mathrm{W\,m^{-2}}$. The LDR in the light meter has a surface area of $4.0 \times 10^{-5}\,\mathrm{m^2}$.

Calculate the energy that is transferred to the LDR every 60 seconds.

(2)

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Energy = ...

(c) The light incident on the camera lens is unpolarised. The photographer places a polarising filter in front of the camera lens.

Explain how the polarising filter affects the intensity of light incident on the camera lens.

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(Total for Question 17 = 10 marks)

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

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

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

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

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

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

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

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

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

Electricity

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

$\Delta F = k\Delta x$

Young modulus

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

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

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

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

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

P 6 9 4 4 1 R A 0 2 8 2 8