Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Wednesday 24 May 2023

Afternoon (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.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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 ▶

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 The wavelength of light emitted from a laser can be determined using a diffraction grating. The equation used to calculate the wavelength is

$$n\lambda = d\sin\theta$$

Which row of the table shows possible units for n and d?

		n	d
☒	**A**	no unit	mm^{-1}
☒	**B**	no unit	mm
☒	**C**	mm	no unit
☒	**D**	mm^{-1}	no unit

(Total for Question 1 = 1 mark)

2 A student carries out an investigation to determine the Young modulus of a material.

Which of the following gives two measuring instruments the student should use?

☒ **A** calipers and stopwatch

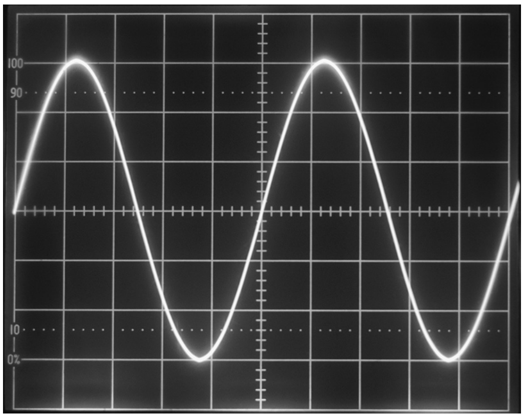
☒ **B** metre rule and micrometer

☒ **C** metre rule and stopwatch

☒ **D** micrometer and calipers

(Total for Question 2 = 1 mark)

3 A 2-beam oscilloscope is used to determine the speed of sound in air. The oscilloscope screen shown displays the signal used to produce the sound wave.



(Source: © Dorling Kindersley/UIG/SCIENCE PHOTO LIBRARY)

The time-base is set to $50\,\mu s/\text{division}$.

Which of the following gives the frequency, in Hz, of the signal?

☒ **A** $5 \times 50 \times 10^{-6}$

☒ **B** $2.5 \times 50 \times 10^{-6}$

☒ **C** $\dfrac{1}{5 \times 50 \times 10^{-6}}$

☒ **D** $\dfrac{1}{2.5 \times 50 \times 10^{-6}}$

(Total for Question 3 = 1 mark)

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4 A ball bearing falling freely through a liquid reaches terminal velocity. The terminal velocity is determined by measuring the time taken for the ball bearing to fall a measured distance.

The measured distance has a percentage uncertainty X.

The measured time has a percentage uncertainty Y.

Which of the following gives the percentage uncertainty in the value for the terminal velocity of the ball bearing?

☒ **A** X + Y

☒ **B** XY

☒ **C** $\dfrac{X}{Y}$

☒ **D** X – Y

(Total for Question 4 = 1 mark)

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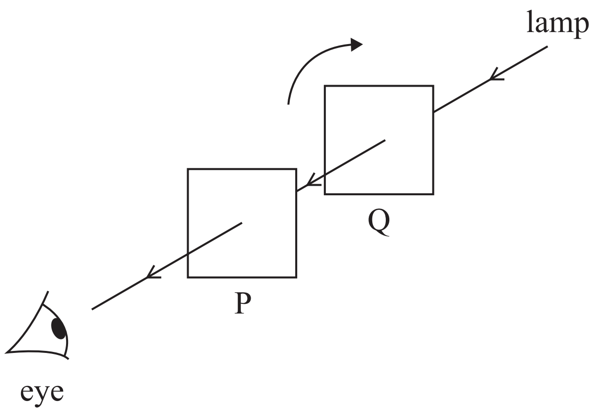
5 A lamp is switched on and viewed through two polarising filters P and Q, as shown.



The lamp appears dark when viewed through P and Q.
Q is rotated through 180°.

Which row of the table gives the appearance of the lamp after Q has rotated by 90° from its original position and by 180° from its original position?

		Angle of rotation of 90°	Angle of rotation of 180°
☒	**A**	dark	dark
☒	**B**	dark	bright
☒	**C**	bright	dark
☒	**D**	bright	bright

(Total for Question 5 = 1 mark)

6 A textbook describes waves as having oscillations of different wavelengths in multiple planes. The oscillations are perpendicular to the direction of energy transfer.

Which of the following is being described?

☒ **A** stationary waves

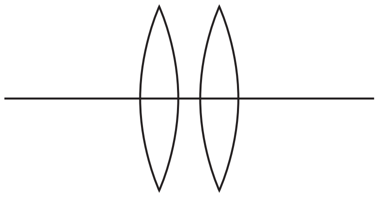
☒ **B** longitudinal waves

☒ **C** polarised transverse waves

☒ **D** unpolarised transverse waves

(Total for Question 6 = 1 mark)

7 Two thin converging lenses are placed next to each other as shown.



Each lens has a power of 4 D.

Which of the following is the total power of the combined lenses?

☒ **A** 1 D

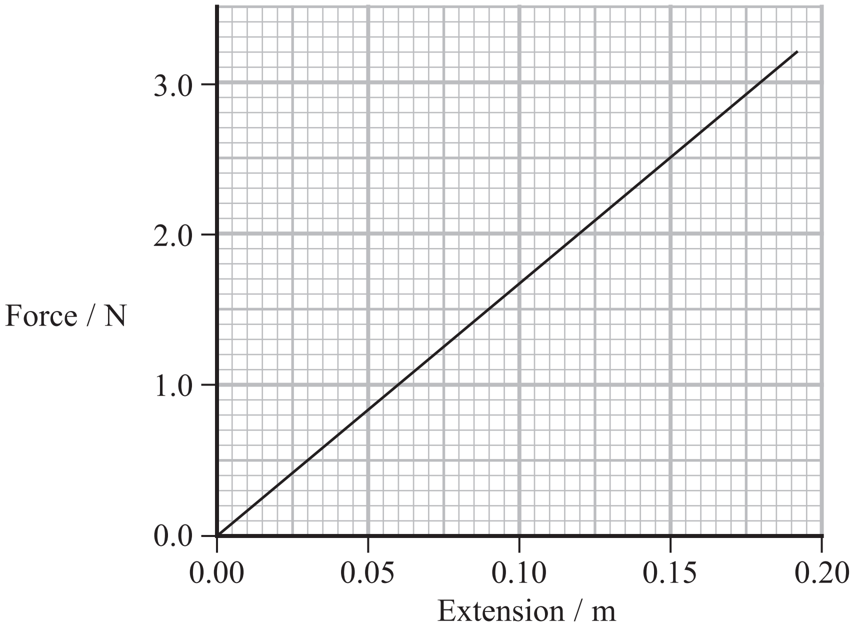
☒ **B** 2 D

☒ **C** 4 D

☒ **D** 8 D

(Total for Question 7 = 1 mark)

8 A force-extension graph for a spring is shown.



Which of the following gives the work done, in joules, in extending the spring by 0.15 m from its original length?

☒ **A** 0.15×2.5

☒ **B** $0.5 \times 0.15 \times 2.5$

☒ **C** $\dfrac{2.5}{0.15}$

☒ **D** $\dfrac{0.15}{2.5}$

(Total for Question 8 = 1 mark)

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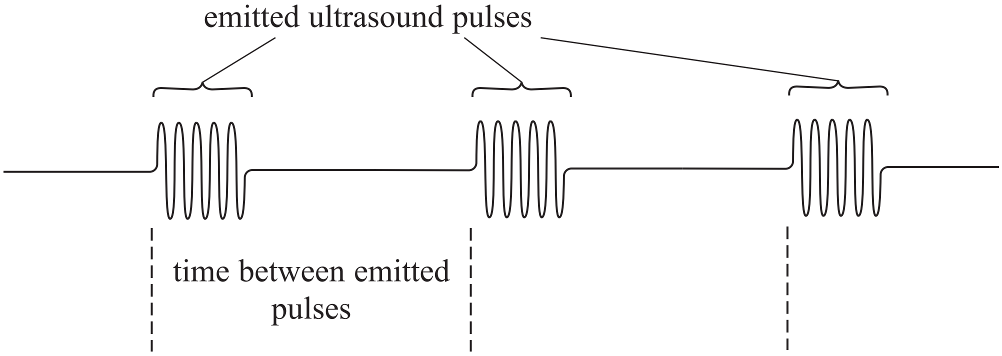
9 Bats use a pulse-echo technique to hunt for moths. The bat emits a series of ultrasound pulses as shown on the oscilloscope trace below.



(a) A stationary bat emits an ultrasound pulse that is reflected from a moth. The bat detects the reflected pulse 36 ms later.

Calculate the distance between the bat and the moth.

speed of sound = $340\,\mathrm{m\,s^{-1}}$

(3)

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Distance = ...

(b) The bat flies towards the moth.

Explain why the bat must change the time between the emitted pulses as the distance between the bat and the moth decreases.

(3)

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(Total for Question 9 = 6 marks)

10 The speed of the blood in a blood vessel can indicate a person's health. A high speed may indicate a high stress on the walls of the blood vessel.

(a) The speed v of the blood in a blood vessel with a diameter d is given by

$$v = \frac{k\eta}{\rho d}$$

where η is the viscosity of the blood
ρ is the density of the blood
k is a constant with no units.

Show that the unit for η is Pa s.

(3)

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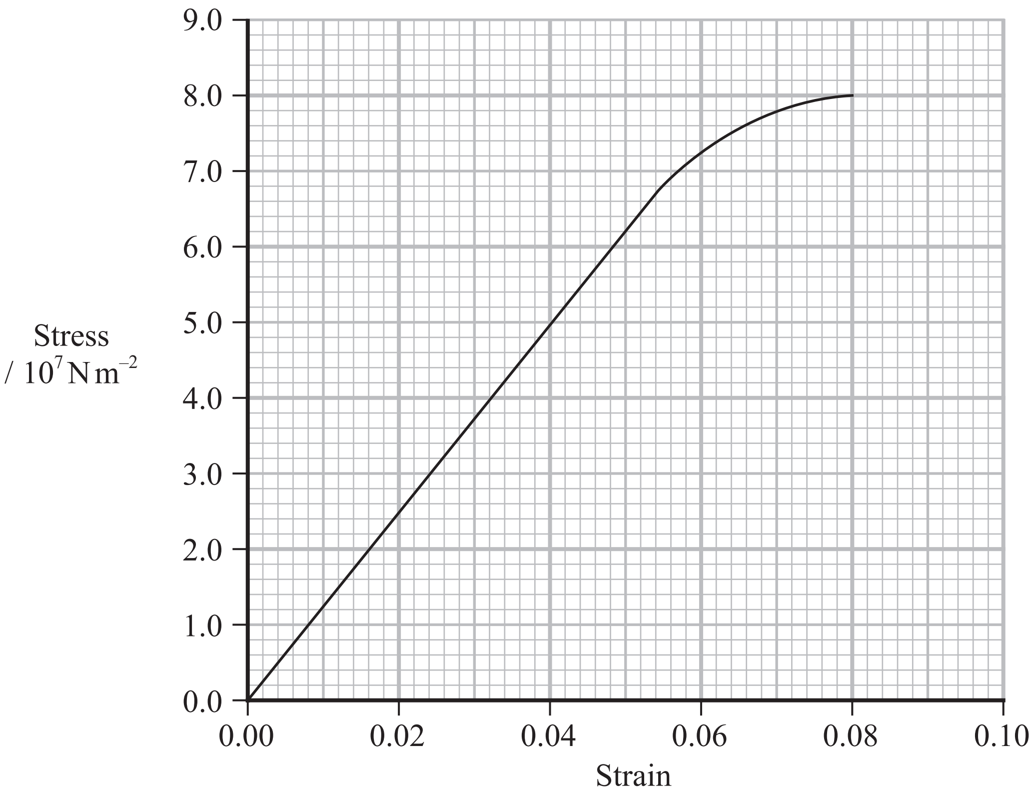
(b) As the speed of the blood changes, the wall of the blood vessel expands and contracts.

The wall of a blood vessel consists of collagen fibres.

The graph shows the stress-strain relationship up to the breaking stress of the collagen fibres.



(i) Calculate the Young modulus of collagen fibres.

(2)

Young modulus = ...

(ii) Describe the behaviour of collagen fibres when the stress in the fibres is increased from the elastic limit until the fibres break.

(3)

(Total for Question 10 = 8 marks)

11 In a demonstration of the photoelectric effect, electromagnetic radiation of frequency f was incident on the surface of a metal. The maximum kinetic energy E_{max} of the emitted photoelectrons was determined for increasing values of f.

(a) No photoelectrons are emitted when the frequency of the radiation is below a certain value.

Explain why.

(3)

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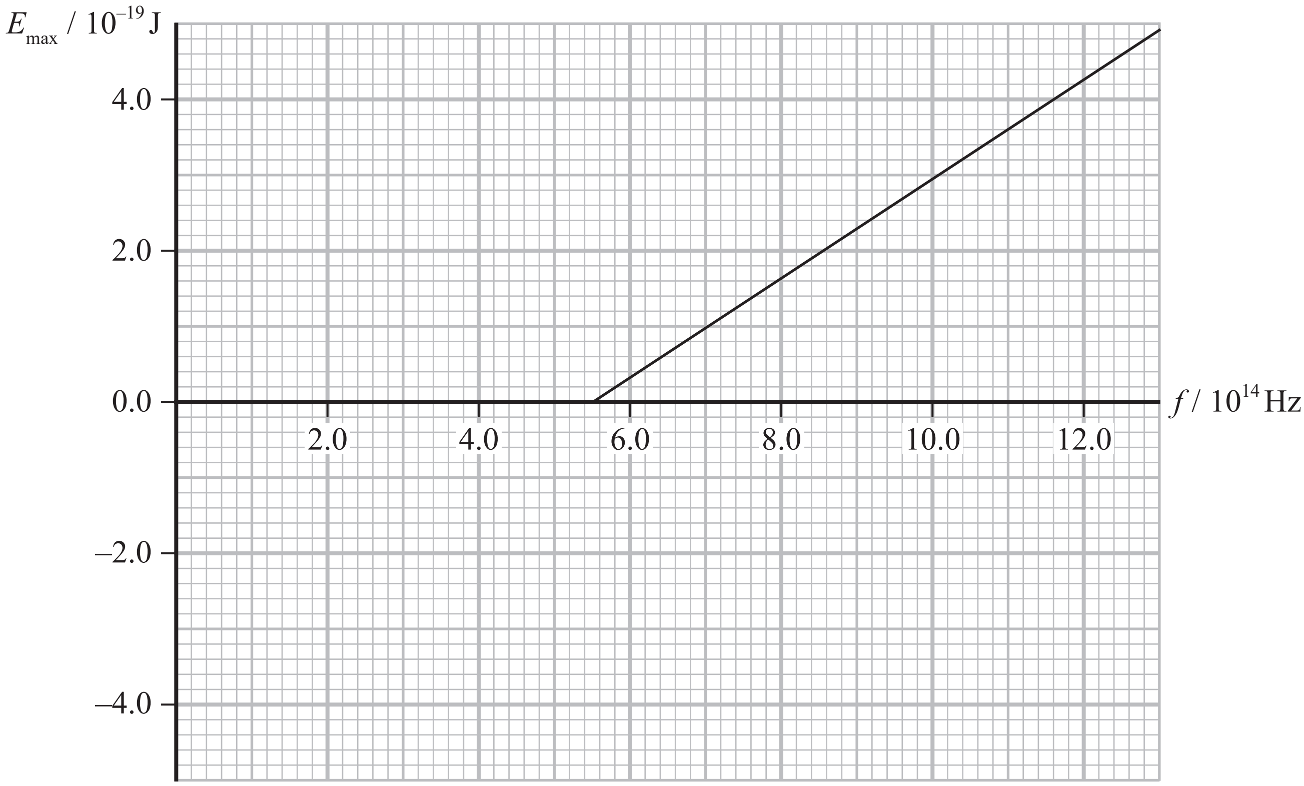
(b) The graph shows the variation of E_{max} with f.



(i) A photon with frequency 10.0×10^{14} Hz is incident on the metal surface causing a photoelectron to be released.

Calculate the maximum possible velocity v_{max} of the photoelectron.

(2)

v_{max} = ...

(ii) The table shows the work function ϕ for three metals.

Metal	**ϕ / eV**
caesium	2.2
zinc	4.3
beryllium	5.0

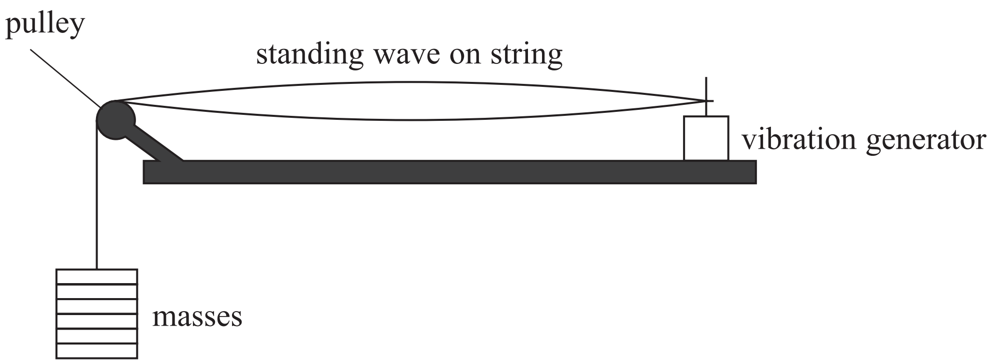
Deduce which metal was used in this demonstration.

(3)

(Total for Question 11 = 8 marks)

12 A student was studying musical instruments.

(a) The student set up a standing wave on a string using the apparatus shown.



The standing wave had one antinode, as shown above, when the vibration generator had a frequency f.

The student then increased the frequency.

Describe what was observed as f was gradually increased to $2f$.

(2)

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(b) A guitar has metal strings under tension. When a string is plucked it vibrates, producing a sound wave in the air.

Describe how the vibrating string produces pressure variations in the air.

(3)

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(c) A guitar player changes the length of string that vibrates by pressing on the string as shown.

The guitar player plucks a string to play a note. A standing wave with one antinode is set up on the string.

He can vary the length of string that vibrates from 21 cm to 63 cm.

Deduce whether a note of frequency 196 Hz can be played on the string.

tension in string = 56 N
mass per unit length of the string = $5.0 \times 10^{-3}\,\text{kg}\,\text{m}^{-1}$

(4)

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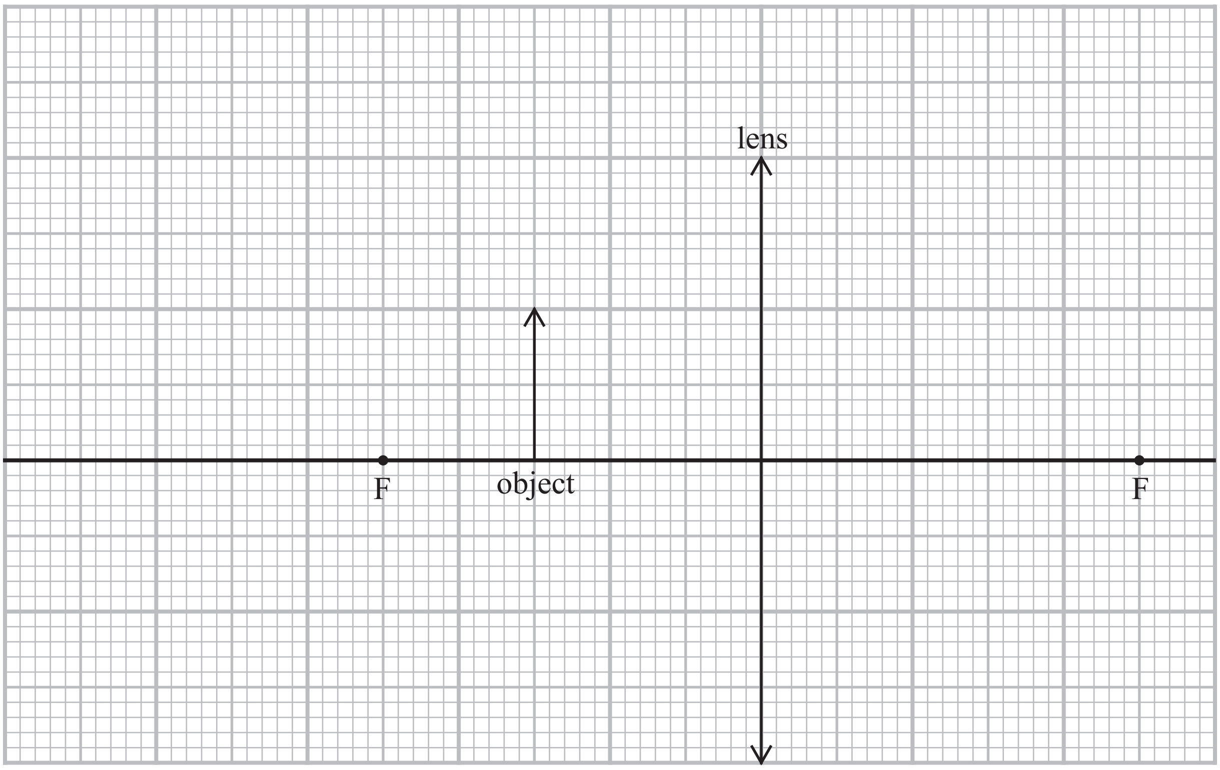
(Total for Question 12 = 9 marks)

13 A jeweller inspects the quality of a diamond. She uses a converging lens to produce a magnified image of the diamond.

(a) Complete the ray diagram to show how a converging lens produces a magnified image of the object shown.

(2)



(b) With the naked eye, the jeweller can detect a scratch that has a width of 0.1 mm or greater.

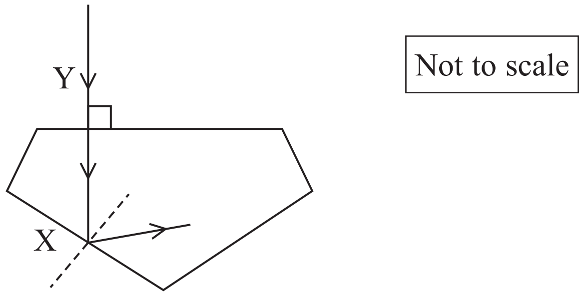
The diamond has a scratch that is 10 μm wide. The jeweller holds the diamond 0.012 m from the converging lens and views the image of the diamond.

Deduce, by calculation, whether the scratch is detectable by the jeweller using the lens.

power of lens = 45 D

(5)

(c) A ray of light enters the diamond along the normal at point Y as shown.



The ray is incident at the diamond-air interface at X with an angle of incidence equal to 40°.

Deduce whether the ray follows the path at X, as shown.

speed of light in diamond = $1.25 \times 10^{8}\,\mathrm{m\,s^{-1}}$

(4)

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(Total for Question 13 = 11 marks)

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14 Carbon monoxide gas is produced in a pond by the decay of organic matter.

(a) A bubble of carbon monoxide rises at a steady speed through the still water of the pond. The weight of the bubble is negligible.

The free-body force diagram below shows the forces acting on the bubble.

diameter of bubble = 1.5 mm

(i) Show that the upthrust acting on the bubble is about 1.7×10^{-5} N.

density of water = 997 kg m^{-3}

(3)

(ii) Calculate the steady speed at which the bubble rises.

viscosity of water = 0.0011 Pa s

(2)

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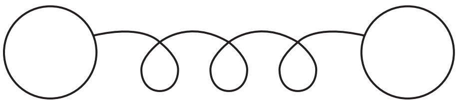
Speed = ...

(b) A molecule of carbon monoxide consists of one atom of carbon bonded to one atom of oxygen.

The bond between the two atoms can be modelled as a spring as shown.



The spring has a stiffness constant *k*.

At equilibrium the distance *d* between the two atoms is 12 nm.

External forces caused *d* to increase to 18 nm.

Calculate the increase in the potential energy between the two atoms.

$k = 1195\,\mathrm{N\,m^{-1}}$

(2)

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Increase in potential energy = ...

(Total for Question 14 = 7 marks)

TOTAL FOR SECTION A = 57 MARKS

SECTION B

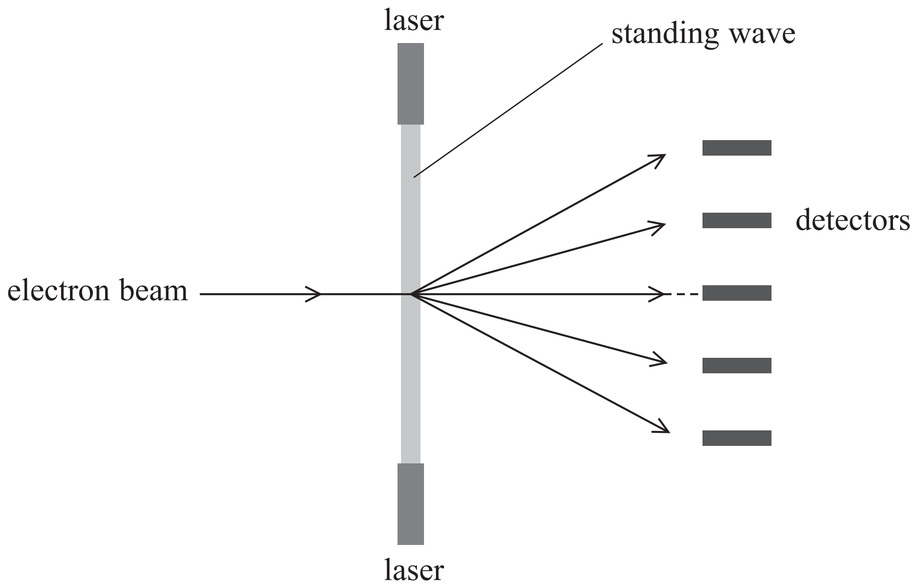
Answer ALL questions in the spaces provided.

15 Read the extract and answer the questions that follow.

In 1933 it was predicted that a standing light wave could act as a diffraction grating that could diffract electrons. The prediction was tested 70 years later due to the development of powerful lasers.

Two identical lasers, emitting coherent light, were pointed towards each other to create the standing wave. A narrow beam of electrons passed through the standing wave. The nodes in the standing wave acted like gaps in a diffraction grating.

The pattern of the diffracted electrons was observed by detectors placed behind the standing wave as shown.



(a) Describe how a standing wave can be created from the light emitted by the two lasers.

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(b) A diffraction pattern is detected 0.24 m from the grating created by the laser light. The distance between the central maximum and the 1st order maxima of the diffraction pattern is 55 μm.

Calculate the wavelength of the electrons in the beam that passes through the standing wave created by the laser light.

wavelength of light from laser = 532 nm

(3)

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Wavelength = ...

(c) The wavelength of monochromatic light can be determined using a diffraction grating with about 500 lines per mm.

Explain why the wavelength of electrons can **not** be determined using this diffraction grating.

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*(d) A laser produces light with discrete wavelengths.

The laser contains a gas. A current in the gas causes the atoms in the gas to move to an excited state.

Explain why the excited atoms emit light with discrete wavelengths.

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(Total for Question 15 = 16 marks)

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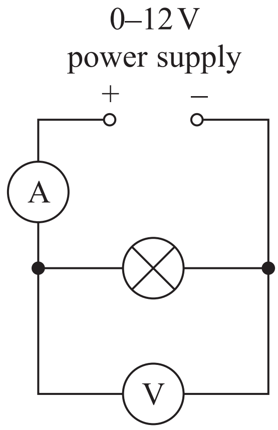
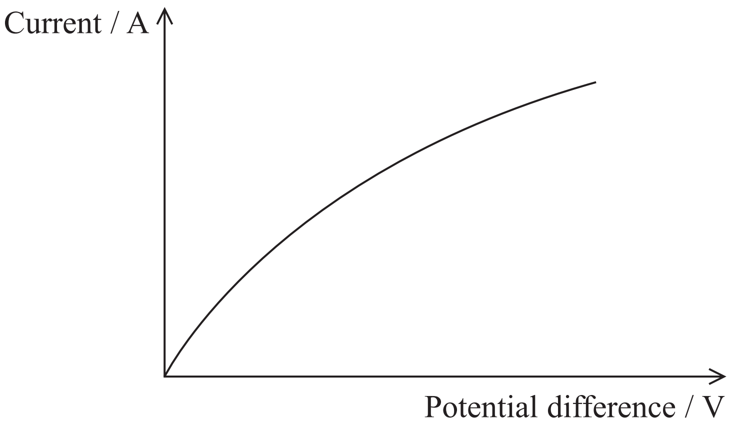
16 A student investigated the current-potential difference relationship for a filament bulb. She set up the circuit as shown.



The student increased the output from the power supply from 0 V to 12 V in steps of 2 V. She recorded corresponding currents from the ammeter.

(a) A graph of her results is shown.



Explain the shape of the graph.

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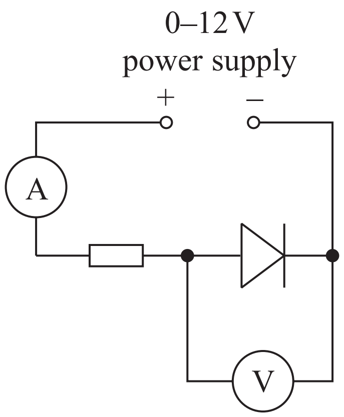
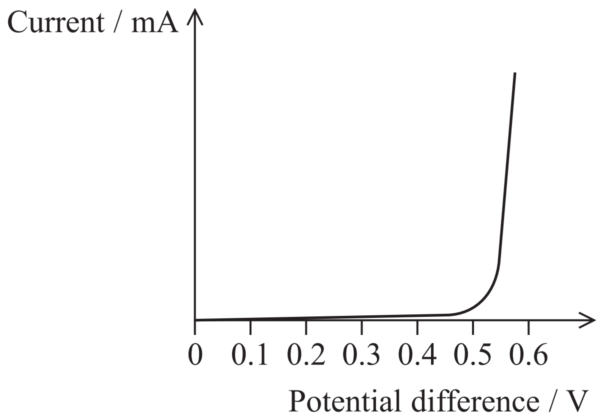
(b) The student replaced the bulb in the circuit with a diode in forward bias and a resistor as shown.



The graph shows how current varies with potential difference for a diode in forward bias.



Describe how the student could adapt her method to plot the variation of current with potential difference for the diode in forward bias.

You should include any changes to the circuit.

(3)

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(Total for Question 16 = 7 marks)

TOTAL FOR SECTION B = 23 MARKS
TOTAL FOR PAPER = 80 MARKS

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

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

$$v = u + at$$

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

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

Forces

$$\Sigma F = ma$$

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

$$W = mg$$

$$moment\ of\ force = Fx$$

Momentum

$$p = mv$$

Work, energy and power

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

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

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

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

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

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

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

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

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

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

de Broglie wavelength

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

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