Please check the examination details below before entering your candidate information

Candidate surname	Other names
StemUp Model Solution	

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Wednesday 22 May 2024

Afternoon (Time: 1 hour 30 minutes)

Paper reference **8PH0/02**

Physics

Advanced Subsidiary

PAPER 2: Core Physics II

You must have:
Scientific calculator and ruler
Data, Formulae and Relationships Booklet (enclosed)

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.

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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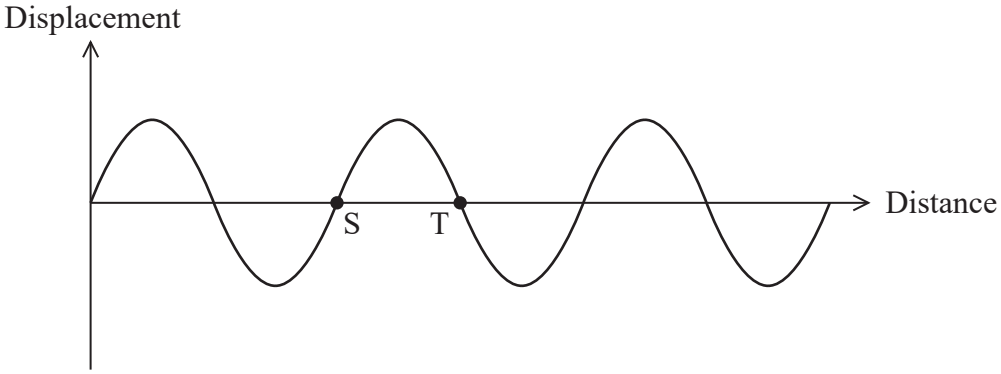
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SECTION A

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 The graph shows how the displacement of particles in a progressive wave varies with distance along the wave, at a particular instant.



Which of the following is the phase difference between the particles at S and T?

☒ **A** $\frac{\pi}{4}$

☒ **B** $\frac{\pi}{2}$

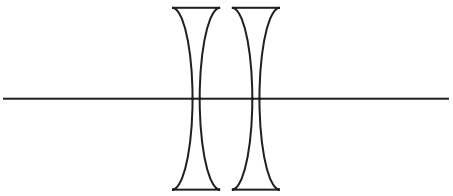
☒ **C** π

☒ **D** 2π

(Total for Question 1 = 1 mark)

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2 Two diverging lenses are combined, as shown.



The focal length of each lens is 0.2 m.

Which of the following is the total power of the combination?

- ☒ **A** 5 D
- ☒ **B** –5 D
- ☒ **C** 10 D
- ☒ **D** –10 D

(Total for Question 2 = 1 mark)

3 An electron in an atom absorbs energy E and is excited from one energy level to the next. When the electron returns to its original energy level a photon is emitted.

Which of the following is an expression for the wavelength of the emitted photon?

- ☒ **A** $\frac{hc}{E}$
- ☒ **B** $\frac{E}{hc}$
- ☒ **C** $\frac{Eh}{c}$
- ☒ **D** $\frac{c}{Eh}$

(Total for Question 3 = 1 mark)

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4 The image formed by a lens can be described as real or virtual.

Which row of the table describes a real image and a virtual image?

		Real image	Virtual image
☒	**A**	Formed on the same side of the lens as the object	Formed on the same side of the lens as the object
☒	**B**	Can be produced on a screen	Formed on the same side of the lens as the object
☒	**C**	Formed on the same side of the lens as the object	Can be produced on a screen
☒	**D**	Can be produced on a screen	Can be produced on a screen

(Total for Question 4 = 1 mark)

5 The photoelectric effect provides evidence for the particle nature of electromagnetic radiation.

Which of the following is **not** observed in the photoelectric effect?

☒ **A** Photoelectrons are released instantly.

☒ **B** Photoelectrons are only released above a certain frequency of radiation.

☒ **C** The energy of the photoelectrons is determined by the intensity of the light.

☒ **D** The energy of the photons is proportional to the frequency of the radiation.

(Total for Question 5 = 1 mark)

6 Which of the following is the S.I. base unit for breaking stress?

☒ **A** Pa

☒ **B** $kg\,m^2\,s^{-2}$

☒ **C** $N\,m^{-2}$

☒ **D** $kg\,m^{-1}\,s^{-2}$

(Total for Question 6 = 1 mark)

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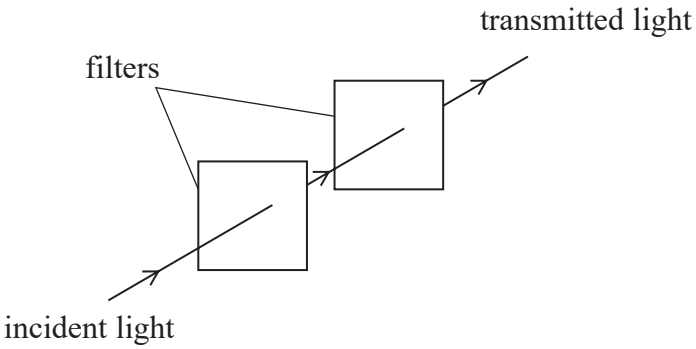
7 A ball bearing with radius r falls through a fluid with density ρ.

Which of the following is an expression for the upthrust acting on the ball bearing?

- ☒ **A** $\frac{4\pi r^3 \rho}{3}$
- ☒ **B** $\frac{4\pi r^3 \rho g}{3}$
- ☒ **C** $\frac{4\pi r^3 g}{3\rho}$
- ☒ **D** $4\pi r^2 \rho g$

(Total for Question 7 = 1 mark)

8 Unpolarised light passes through two polarising filters, as shown. The planes of polarisation of the two filters are parallel.



One filter is rotated so that the planes of polarisation of the two filters are perpendicular.

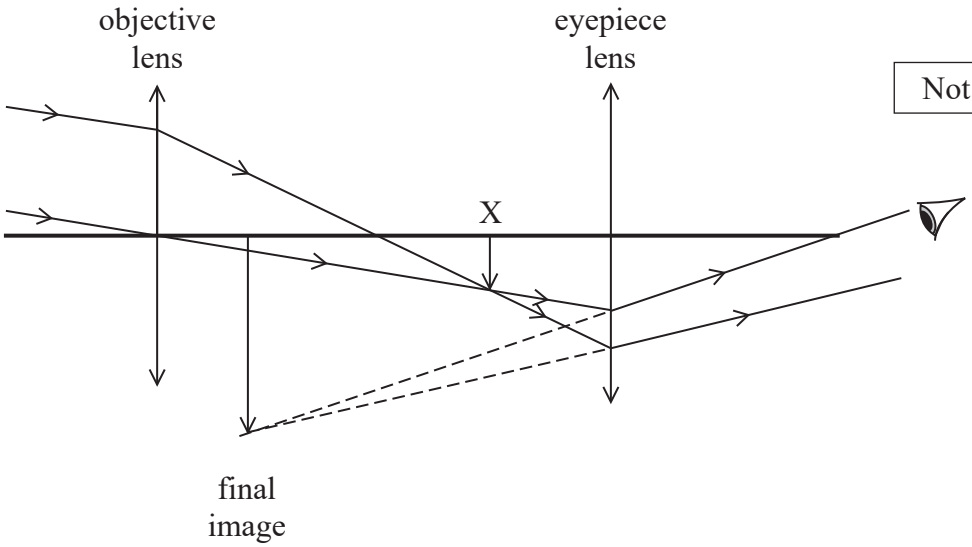
Which of the following describes the change to the intensity of the transmitted light?

- ☒ **A** decreases by half
- ☒ **B** falls to zero
- ☒ **C** increases
- ☒ **D** unchanged

(Total for Question 8 = 1 mark)

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9 A telescope is used to produce a magnified image of a full Moon. The telescope consists of two converging lenses, the objective lens and the eyepiece lens, as shown.



The objective lens produces an inverted image at point X. The image at point X is the object for the eyepiece lens. The eyepiece lens produces a magnified image.

(a) The power of the objective lens is 0.8 D.

Calculate the distance of the image at X from the objective lens.

(3)

P = 1/f so f = 1/P = 1/0.8 D = 1.25 m

The Moon is very far away (u ≈ ∞), so rays from a point on it arrive parallel and converge at the focal point.

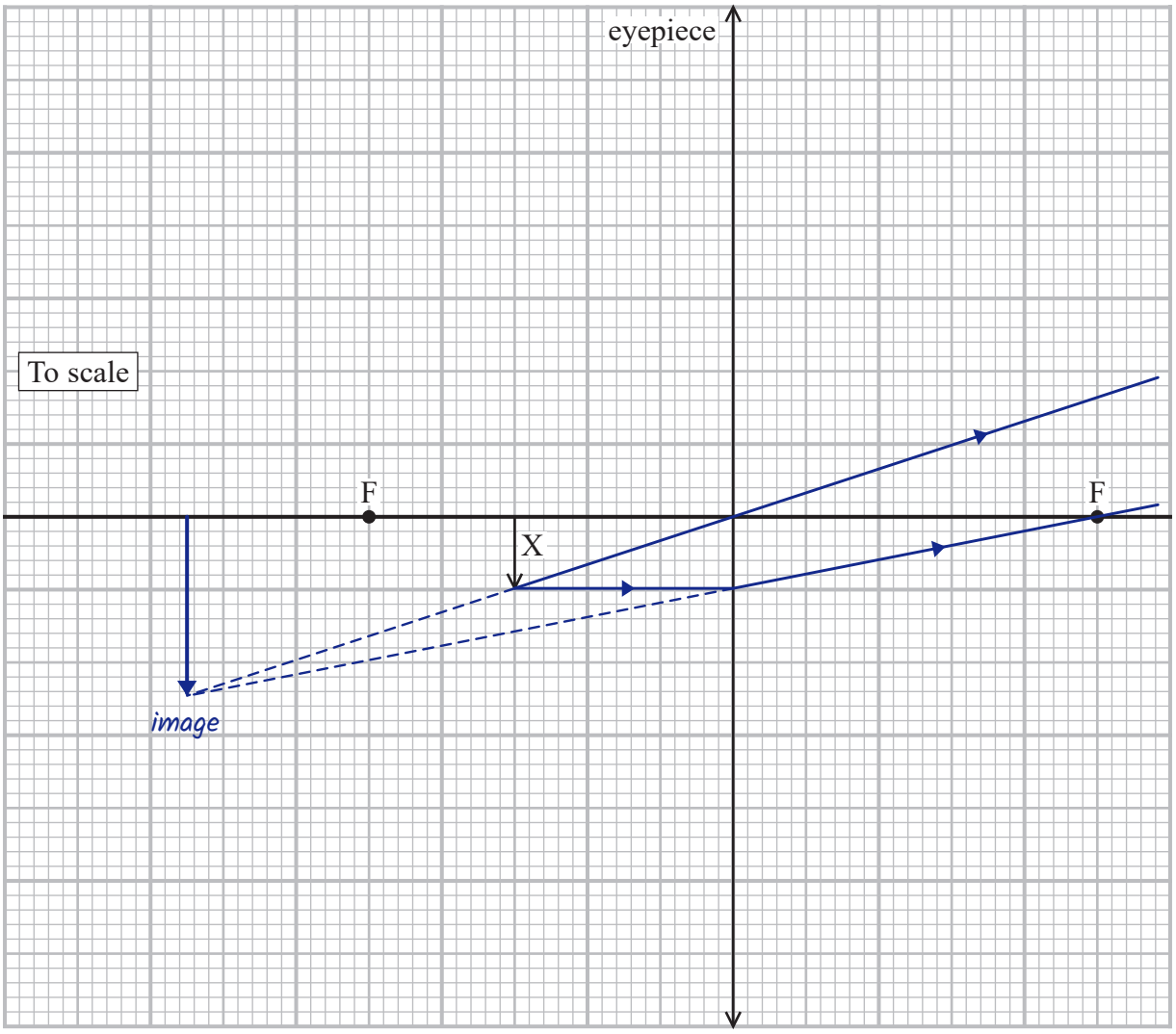
1/f = 1/u + 1/v with 1/u ≈ 0, so v = f = 1.25 m

Distance = *1.25 m*

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(b) Complete the ray diagram, to scale, to determine the magnification of the image formed by the eyepiece lens.

(4)



m = v/u = 7.5 cm ÷ 3.0 cm (or image height ÷ object height = 2.5 cm ÷ 1.0 cm)

m = 2.5

Magnification = 2.5

(Total for Question 9 = 7 marks)

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10 Scientists can use a pulse-echo technique with ultrasound to detect plastic in the oceans. A transducer that emits and detects ultrasound pulses is positioned just below the surface of the water.

(a) An ultrasound pulse was transmitted. The pulse was reflected from a piece of plastic under the surface and the pulse was detected 4.1 ms later.

Calculate the distance between the plastic and the transducer.

speed of sound in salt water = 1500 m s^{-1}

(3)

s = ut and the pulse travels to the plastic and back, so 2s = ut

2s = 1500 m s^{-1} × 4.1 × 10^{-3} s = 6.15 m

s = 6.15 ÷ 2 = 3.08 m ≈ 3.1 m

Distance = *3.1 m*

(b) Give a reason why the ultrasound is emitted in short pulses.

(1)

So that the reflected pulse returns (is detected) before the next pulse is transmitted.

(c) Explain why small pieces of plastic are more likely to be detected by using ultrasound with a high frequency.

(2)

A high frequency ultrasound wave has a short wavelength (v = fλ).

Short wavelengths diffract less around small objects, so they are reflected from small pieces of plastic and a greater amount of detail can be detected.

(Total for Question 10 = 6 marks)

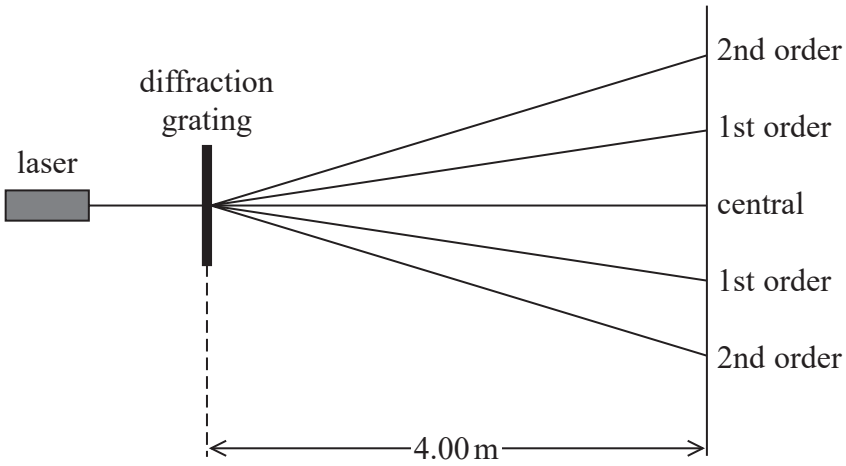
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11 A technician shone light from a laser through a diffraction grating. A pattern was observed on a screen 4.00 m away. The pattern consisted of 5 maxima, as shown.

Not to scale



The diffraction grating has 4.00×10^2 lines per millimetre.

(a) The technician wanted to check that the wavelength emitted by the laser was within the range 450 nm ± 10 nm.

She measured the distance between the two second order maxima as 3.25 m.

Deduce whether the light from the laser was within the range 450 nm ± 10 nm.

(4)

Distance from central maximum to 2nd order maximum = 3.25 ÷ 2 = 1.625 m

tan θ = 1.625 ÷ 4.00 so θ = 22.1°

$d = 1 \div (4.00 \times 10^2\ mm^{-1}) = 1/400\ mm = 2.50 \times 10^{-6}\ m$

$n\lambda = d \sin\theta$ with $n = 2$: $2\lambda = 2.50 \times 10^{-6}\ m \times \sin 22.1°$

$\lambda = 4.70 \times 10^{-7}\ m = 470\ nm$

The allowed range is 440 nm to 460 nm, so 470 nm is outside the range: the laser is not within 450 nm ± 10 nm.

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(b) The electrons in an electron beam have a speed of approximately 10% of the speed of light. It is possible to demonstrate diffraction with this electron beam when the electron beam is incident on a graphite target.

If the spacing of the atoms in the graphite target were equal to the spacing of lines on the diffraction grating used by the technician, this electron beam would **not** show diffraction effects.

Explain why. Your answer should include calculations.

(4)

Speed of electrons v = 10% of c = $0.1 \times 3.00 \times 10^{8} = 3.0 \times 10^{7}$ m s^{-1}

$p = mv = 9.11 \times 10^{-31}$ kg $\times$ 3.0×10^{7} m s^{-1} = 2.73×10^{-23} kg m s^{-1}

$\lambda = h/p = 6.63 \times 10^{-34}$ J s $\div$ 2.73×10^{-23} kg m s^{-1} = 2.4×10^{-11} m

The spacing would be $d = 2.50 \times 10^{-6}$ m. The electron wavelength is much smaller than (about 10^{-5} times) the size of the gap, and diffraction is only significant when λ is similar to the gap, so little or no diffraction would occur.

(Total for Question 11 = 8 marks)

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12 A student investigated the properties of metal wires.

(a) Describe how the student should determine the diameter of a wire.

(3)

Measure the diameter using a micrometer screw gauge (or digital calipers).

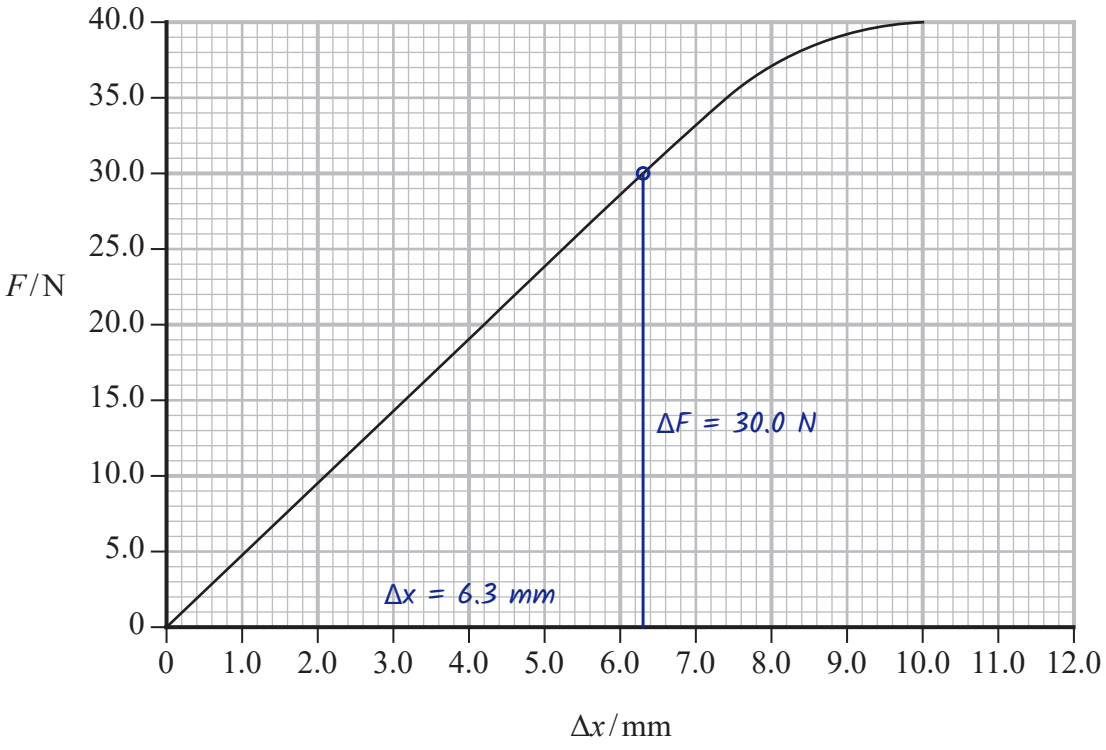
Take measurements at different points along the wire and at different orientations (rotate the gauge through 90°).

Repeat the measurements and calculate the mean diameter.

(b) The student applied increasing force F and determined the corresponding extensions Δx of the wire.

The force was applied in increments of 5 N, up to a maximum value of 40 N.

The student plotted a graph of F against Δx, as shown.



The Young modulus E of the material of the wire is given by the expression

$$E = \text{gradient} \times \frac{x}{A}$$

where A is the cross-sectional area of the wire and x is the original length of the wire.

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(i) Derive the expression

$$E = \text{gradient} \times \frac{x}{A}$$

(2)

E = stress ÷ strain, with stress = F/A and strain = Δx/x

E = (F/A) ÷ (Δx/x) = (F/Δx) × (x/A)

For a graph of F against Δx the gradient = F/Δx, so E = gradient × x/A

(ii) The values of the Young modulus for some metals are shown.

Metal	Young modulus / GPa
aluminium	67
copper	117
steel	184
tin	47

Deduce which metal the student's wire was made from.

$x = 3.00\,\text{m}$
$A = 1.14 \times 10^{-7}\,\text{m}^2$

(4)

Gradient of straight section = ΔF/Δx = 30.0 N ÷ 6.3 × 10^{-3} m = 4.76 × 10^{3} N m^{-1}

E = gradient × x/A = 4.76 × 10^{3} N m^{-1} × 3.00 m ÷ 1.14 × 10^{-7} m^{2}

E = 1.25 × 10^{11} N m^{-2} = 125 GPa

The wire is made from copper, because 117 GPa is the value closest to the calculated value.

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(iii) The student repeated measurements of force and extension using a thinner wire of the same metal and length. He changed the values of the force he applied to the wire.

Explain **two** changes that the student should make to the values of the force he applied to the wire.

(4)

Use a smaller maximum force, because the thinner wire has a smaller cross-sectional area so the same force gives a greater stress: the breaking force is smaller and the limit of proportionality would be exceeded at a lower force.

Use smaller increments in the force, so that enough readings (more readings) are obtained in the linear part of the graph, before the limit of proportionality is reached.

(Total for Question 12 = 13 marks)

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13 When an object moves through a fluid Stokes' law may apply.

(a) State two conditions that determine whether Stokes' law applies to a moving object.

(2)

The object must be small and spherical.

It must move at a slow speed so that the flow is laminar (not turbulent).

*(b) A teacher demonstrated the viscosity of fluids using a falling-ball method. The teacher released a ball bearing at the surface of a tall column of a viscous fluid.

The teacher repeated the demonstration using an identical ball bearing falling through a fluid with a higher viscosity.

Explain the motion of the two ball bearings as they fell.

(6)

Initially the weight of each ball bearing is greater than the upthrust, so there is a downward resultant force on it and the ball bearing accelerates downwards.

As the speed increases, the viscous drag force increases, so the resultant force and the acceleration decrease.

Eventually weight = upthrust + viscous drag, so the resultant force is zero and the ball bearing falls at a constant speed, its terminal velocity.

In the fluid with the higher viscosity the viscous drag force at any given velocity is greater ($F = 6\pi\eta rv$), so the drag balances the weight minus upthrust at a lower speed.

The ball bearing therefore reaches a lower terminal velocity in the more viscous fluid.

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(c) (i) A ball bearing fell at terminal velocity through a liquid.

The ball bearing fell 0.75 m in a time of 3.4 s.

viscosity of liquid = 1.8 Pa s
radius of ball bearing = 5.0 mm

Calculate the viscous drag force on the ball bearing.

(3)

At terminal velocity $a = 0$ so $s = ut$: $v = 0.75\ m \div 3.4\ s = 0.22\ m\ s^{-1}$

$F = 6\pi\eta rv = 6\pi \times 1.8\ Pa\ s \times 5.0 \times 10^{-3}\ m \times 0.22\ m\ s^{-1}$

$F = 0.037\ N$

Viscous drag force = 0.037 N

(ii) A student considers what would happen if the temperature of the liquid increases.

The student writes the following statement.

"When the temperature of the liquid increases the viscosity decreases. Therefore, when the ball bearing is falling at terminal velocity the viscous drag force will be less."

Assess the validity of the student's statement.

(3)

At terminal velocity, viscous drag force + upthrust = weight.

The weight and the upthrust are unchanged by the temperature, so at terminal velocity the viscous drag force is unchanged.

As the viscosity decreases, the terminal velocity increases ($F = 6\pi\eta rv$), so the drag is the same. The student is incorrect.

(Total for Question 13 = 14 marks)

TOTAL FOR SECTION A = 56 MARKS

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SECTION B

Answer ALL questions in the spaces provided.

14 Read the extract and answer the questions that follow.

Scientists have observed small dust particles 'jumping' above the Moon's surface. Small particles on the surface of the Moon acquire a charge due to the photoelectric effect, caused by incident ultraviolet radiation from the Sun. Electrostatic forces between charged dust particles cause these particles to move. It is believed this is a mechanism by which dust particles can be transported across vast regions of the Moon.

(a) Explain how the incident ultraviolet radiation causes dust particles to become charged by the photoelectric effect.

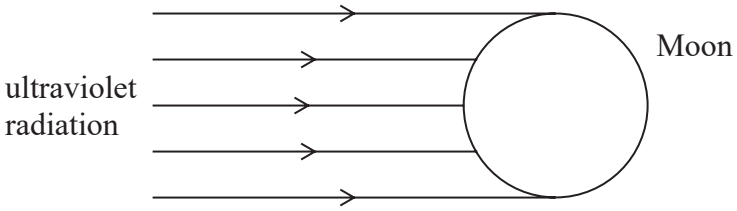
(3)

Electrons in the dust particles absorb the energy of photons in the ultraviolet radiation.

One photon interacts with one electron, transferring all of its energy (E = hf).

If the photon energy is greater than the work function, the electron is released from the surface of the dust particle, so the particle loses electrons and becomes (positively) charged.

(b) The angle at which the ultraviolet radiation is incident on the Moon varies across its surface, as shown.



The number of dust particles per unit area that become charged is greatest where the ultraviolet radiation is incident on the Moon's surface at 90°.

Explain why.

(3)

At 90° the ultraviolet radiation is spread over a smaller area of the surface, so the intensity of the UV is higher.

So there is a larger number of photons incident per unit area per second.

So a greater number of photoelectrons are released per unit area, and more dust particles become charged.

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(c) The work functions of some minerals that have been found on the surface of the Moon are shown.

Mineral	Work function / eV
ilmenite	4.3
olivine	7.9
pyroxene	5.1

Ultraviolet radiation with a frequency of 2.0×10^{15} Hz is incident on a sample of one of these minerals and electrons are emitted by means of the photoelectric effect.

The released electrons have a maximum kinetic energy of 4.0 eV.

Deduce the mineral from which the photoelectron is released.

(3)

$hf = 6.63 \times 10^{-34}\ J\ s \times 2.0 \times 10^{15}\ Hz = 1.33 \times 10^{-18}\ J$

In eV: $1.33 \times 10^{-18}\ J \div 1.60 \times 10^{-19}\ J\ eV^{-1} = 8.3\ eV$

$hf = \phi + \frac{1}{2}mv^2_{max}$ so $\phi = 8.3\ eV - 4.0\ eV = 4.3\ eV$

So the mineral is ilmenite.

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(d) The motion of a charged dust particle on the Moon is influenced by nearby charged dust particles as well as by the Moon's gravity. The lack of an atmosphere on the Moon means that the dust particles experience no resistive forces.

A particular dust particle experiences an electrostatic force of 8.2×10^{-17} N that is perpendicular to the gravitational force. The magnitude of the resultant force on the particle is 8.7×10^{-17} N.

Calculate the magnitude and direction of the acceleration of the particle.

gravitational field strength on the Moon = $1.6\,\text{N kg}^{-1}$
weight of dust particle on the Moon = 3.0×10^{-17} N

(5)

$W = mg$ so $m = 3.0 \times 10^{-17}\ N \div 1.6\ N\ kg^{-1} = 1.9 \times 10^{-17}\ kg$

$\Sigma F = ma$ so $a = 8.7 \times 10^{-17}\ N \div 1.9 \times 10^{-17}\ kg = 4.6\ m\ s^{-2}$

The acceleration is in the direction of the resultant force. The electrostatic force (8.2×10^{-17} N) is horizontal and the weight (3.0×10^{-17} N) acts vertically downwards.

$\cos\theta = 8.2 \times 10^{-17}\ N \div 8.7 \times 10^{-17}\ N$ so $\theta = 20°$ below the horizontal, i.e. 70° to the vertical (downwards).

Magnitude of acceleration = $4.6\ m\ s^{-2}$

Direction of acceleration = 70° to vertical, downwards

(Total for Question 14 = 14 marks)

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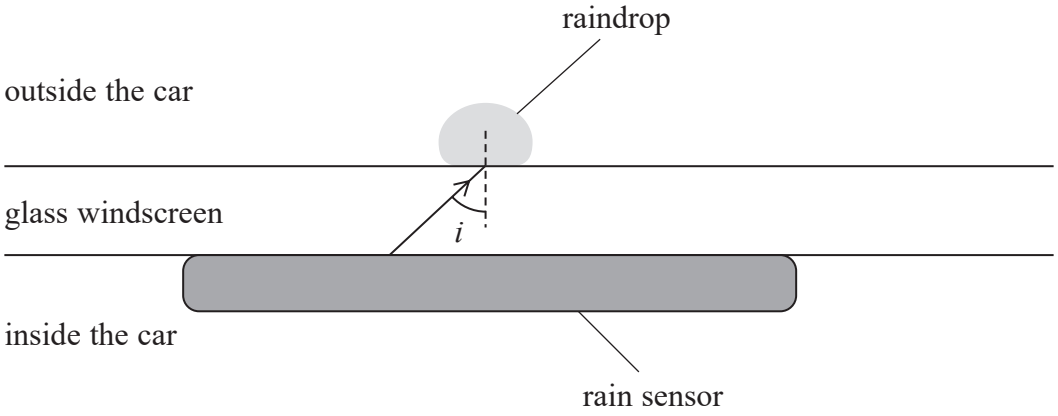
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15 A rain sensor is mounted on the inside of a car windscreen. When the rain sensor detects raindrops on the windscreen, a motor is switched on to operate the windscreen wipers.

(a) The rain sensor consists of a series of infrared emitters and detectors. Infrared rays are emitted from a sensor, travel through the glass windscreen and are incident on the outside surface.

A ray is incident on the boundary between the glass and a raindrop, as shown.



The angle of incidence i is 45°.

Determine what happens to the ray at this boundary.

refractive index of glass = 1.5
refractive index of water = 1.3

(3)

$n_1 \sin \theta_1 = n_2 \sin \theta_2$: $1.5 \times \sin 45° = 1.3 \times \sin \theta_2$

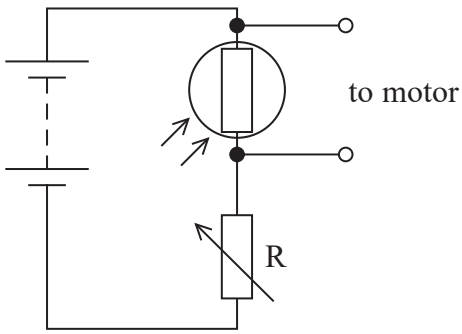
$\sin \theta_2 = 0.816$ so angle of refraction $\theta_2 = 55°$

(Critical angle: $\sin C = 1.3/1.5$ so $C = 60°$; the angle of incidence 45° is smaller than C, so there is no total internal reflection.)

So the ray is refracted into the raindrop, bending away from the normal.

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(b) A student modelled a simple infrared detector, using a light dependent resistor (LDR) in series with a variable resistor R. She connected a motor in parallel with the LDR, as shown.



(i) The intensity of the light incident on the LDR increased.

Explain what happened to the speed of the motor. Your answer should include reference to conduction electrons.

(4)

When the light intensity increases, more electrons are released in the LDR, so the number of conduction electrons (per unit volume) increases.

So the LDR has a lower resistance.

The LDR and R are a potential divider, so the ratio R_{LDR}/R decreases and the ratio V_{LDR}/V_R decreases: the LDR gets a smaller share of the supply pd.

The motor is in parallel with the LDR, so the pd across the motor decreases and the speed of the motor decreases.

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(ii) The power supply consisted of several 1.5 V cells in series.

The student set the resistance of resistor R to 270 Ω and measured the potential difference across the motor as 5.0 V. In this situation the resistance of the LDR was 193 Ω. The motor had a very high resistance.

Deduce the number of cells the student used.

(3)

The motor has a very high resistance, so the pd across the LDR = 5.0 V.

$R_T = R_1 + R_2 = 270\ \Omega + 193\ \Omega = 463\ \Omega$

$V_{LDR}/V_s = R_{LDR}/R_T$ so $V_s = 5.0\ V \times 463\ \Omega \div 193\ \Omega = 12\ V$

Number of cells = 12 V ÷ 1.5 V = 8 cells

(Total for Question 15 = 10 marks)

TOTAL FOR SECTION B = 24 MARKS
TOTAL FOR PAPER = 80 MARKS

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Pearson Edexcel Level 3 GCE

Wednesday 22 May 2024

Afternoon (Time: 1 hour 30 minutes)

Paper reference **8PH0/02**

Physics

Advanced Subsidiary
PAPER 2: Core Physics II

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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

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

$v = u + at$

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

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

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

$$F = 6\pi\eta r v$$

Hooke's law

$$\Delta F = k\Delta x$$

Young modulus

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

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

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

Elastic strain energy

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

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

$$hf = \phi + \tfrac{1}{2} m v_{max}^2$$

de Broglie wavelength

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

END OF DATA, FORMULAE AND RELATIONSHIPS LIST

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