Please check the examination details below before entering your candidate information

Candidate surname	Other names
StemUp Model Solution	

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

Friday 17 May 2019

Morning (Time: 1 hour 30 minutes)	Paper Reference **8PH0/02**

Physics

Advanced Subsidiary
Paper 2: Core Physics II

You must have:
Ruler, drawing compasses

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 how they 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 sample of steel in the form of a wire is subjected to an increasing load.

Which of the following is the best description of the elastic limit of the steel?

☐ **A** The stress at which the steel undergoes an increase in strain with no increase in stress.

☐ **B** The stress beyond which the stress and strain are no longer proportional.

☒ **C** The stress beyond which the steel becomes permanently deformed.

☐ **D** The stress at which the steel breaks.

(Total for Question 1 = 1 mark)

2 Radar is used to detect the position of an aircraft. Microwave pulses are emitted from the radar transducer. The pulses reflect from the aircraft and are received back at the same transducer. The time in seconds between emission and reception of the pulse is t.

The distance of the aircraft in metres from the transducer is given by

☐ **A** $2 \times 3.0 \times 10^8 \times t$

☐ **B** $2 \times 340 \times t$

☒ **C** $\dfrac{3.0 \times 10^8 \times t}{2}$

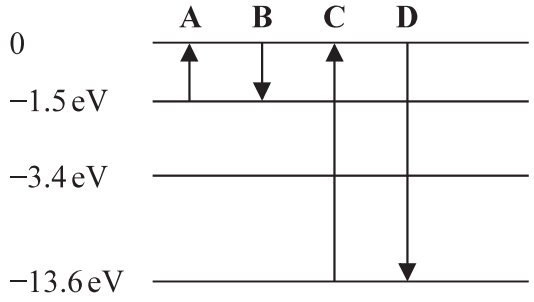
☐ **D** $\dfrac{340 \times t}{2}$

(Total for Question 2 = 1 mark)

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3 Some of the energy levels of an atom of a gas are shown.



During which transition, A, B, C or D, is electromagnetic radiation with the shortest wavelength emitted?

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

(Total for Question 3 = 1 mark)

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4 The Hooke's law equation is:

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

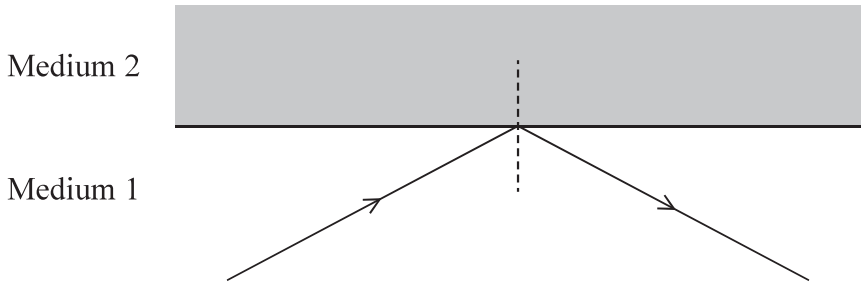
Which of the following gives the base units of k?

- ☒ **A** kg s^{-2}
- ☒ **B** kg m s^{-2}
- ☒ **C** N m
- ☒ **D** N m^{-1}

(Total for Question 4 = 1 mark)

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5 A ray of light travels through medium 1 of refractive index n_1 and is incident at an interface with medium 2 of refractive index n_2. The ray is totally internally reflected at the interface.



speed of the light in medium 1 = v_1

speed of the light in medium 2 = v_2

Which row of the table is correct for this situation?

☒	**A**	$v_1 > v_2$	$n_1 > n_2$
☒	**B**	$v_1 < v_2$	$n_1 > n_2$
☒	**C**	$v_1 > v_2$	$n_1 < n_2$
☒	**D**	$v_1 < v_2$	$n_1 < n_2$

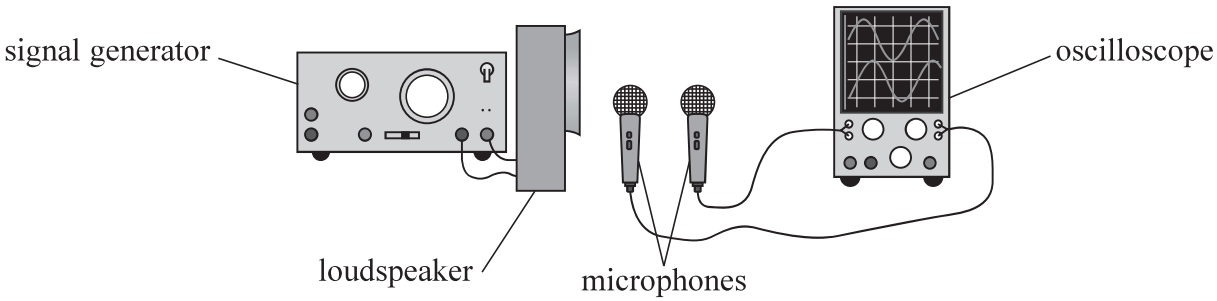
(Total for Question 5 = 1 mark)

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Questions 6 and 7 refer to the following information.

In an experiment to determine the speed of sound in air, a 2-beam oscilloscope is used to display the signals from two microphones. The microphones are placed in front of a loudspeaker that is connected to a signal generator.



The loudspeaker emits a sound of frequency f.

6 The microphones are placed at different distances from the loudspeaker. The time taken for the sound to travel from the first microphone to the second is t.

Which of the following expressions gives the phase difference between the two signals?

☒ **A** πtf

☒ **B** $2\pi tf$

☒ **C** $\frac{\pi f}{t}$

☒ **D** $\frac{2\pi f}{t}$

(Total for Question 6 = 1 mark)

7 The microphones are placed at equal distances from the loudspeaker. The signals are in phase. One of the microphones is moved further away from the loudspeaker. Initially the signals become out of phase. After moving the microphone a distance d the signals are back in phase.

Which of the following expressions gives the speed of sound?

☒ **A** $2fd$

☒ **B** fd

☒ **C** $\frac{2d}{f}$

☒ **D** $\frac{d}{f}$

(Total for Question 7 = 1 mark)

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8 Which of the following statements about waves is **not** correct?

☒ **A** An unpolarised wave may be polarised on reflection from a surface.

☒ **B** Longitudinal waves cannot be plane polarised.

☒ **C** The vibrations in an unpolarised wave are in many directions.

☒ **D** Transverse waves are always plane polarised.

(Total for Question 8 = 1 mark)

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9 In an investigation to determine the Young modulus of a material in the form of a wire, a tensile force of 14 N was applied to the wire. The length of the wire was 2.0 m. The diameter of the wire was 2.5 mm. The length of the wire increased by 0.20%.

(a) Calculate the Young modulus of the material.

(3)

$A = \pi d^2/4 = \pi \times (2.5 \times 10^{-3}\ m)^2 / 4 = 4.91 \times 10^{-6}\ m^2$

stress $\sigma = F/A = 14\ N \div 4.91 \times 10^{-6}\ m^2 = 2.85 \times 10^6\ N\ m^{-2}$

strain $= 0.20/100 = 0.0020$

$E = \text{stress/strain} = 2.85 \times 10^6 \div 0.0020 = 1.4 \times 10^9\ Pa$

Young modulus = $1.4 \times 10^9\ Pa$

(b) Calculate the energy stored in the stretched wire.

(2)

extension $\Delta x = 0.0020 \times 2.0\ m = 4.0 \times 10^{-3}\ m$

$\Delta E_{el} = \frac{1}{2} F \Delta x = \frac{1}{2} \times 14\ N \times 4.0 \times 10^{-3}\ m$

$\Delta E_{el} = 0.028\ J$

Energy stored = $0.028\ J$

(c) Explain why the wire chosen should be as long as possible.

(2)

The longer the wire, the larger the extension for a given force.

So the percentage uncertainty in the measurement of the extension is smaller (more accurate value of strain and E).

(Total for Question 9 = 7 marks)

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10 A student investigated how a converging lens can be used to project a magnified image onto a whiteboard.

In a darkened room, the student placed a smartphone 9.0 cm from the converging lens. The phone's display was projected onto the whiteboard. The converging lens was 75.0 cm from the whiteboard when a clear image was produced.

(a) Calculate the focal length of the lens.

(2)

$1/f = 1/u + 1/v = 1/0.090\ m + 1/0.750\ m = 12.4\ m^{-1}$

$f = 1/12.4 = 8.0 \times 10^{-2}\ m$

Focal length = $8.0 \times 10^{-2}\ m$

(b) The image projected onto the whiteboard was real.

State what is meant by a real image.

(1)

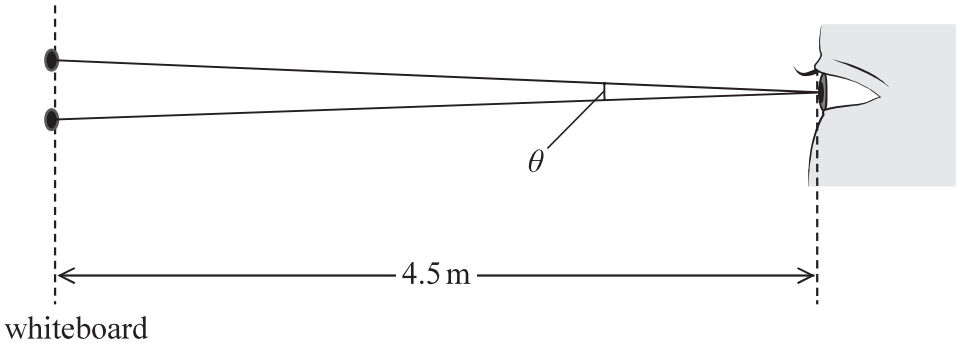
Light rays actually pass through the image (the rays converge to a point where the image is formed), so it can be formed on a screen.

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(c) The display on the phone contained two dots that were 5.0 mm apart. The student stood 4.5 m from the whiteboard and viewed the image of the dots.

Rays of light from the images of the two dots on the whiteboard were incident at the student's eye with an angle θ between them as shown.



The student could distinguish the two dots if the angle θ was greater than 0.0003 radians.

Deduce whether the student could distinguish the two dots clearly.

(5)

magnification $m = v/u = 0.750\ m \div 0.090\ m = 8.3$

m = image height/object height, so distance between the dots on the whiteboard:

image separation = $8.3 \times 5.0\ mm = 42\ mm = 0.042\ m$

$\tan(\theta/2) = (0.042/2)\ m \div 4.5\ m = 4.6 \times 10^{-3}$

$\theta/2 = 0.27°$, so $\theta = 0.53°$ (small angle: $\theta \approx 0.042\ m \div 4.5\ m$)

θ in radians $= 0.53 \times \pi/180 = 0.0093$ rad

0.0093 rad is greater than 0.0003 rad (θ is about 30 times larger), so the student could distinguish the two dots clearly.

(Total for Question 10 = 8 marks)

11 The photograph shows a guitar. The strings of the guitar are at the same tension.



When a string is plucked, a standing wave is set up on the string.

*(a) Explain how a standing wave is set up on a string.

(6)

When the string is plucked, waves travel along the string and are reflected at the fixed ends, so there are two waves of the same frequency travelling in opposite directions along the string.

These two waves superpose (interfere).

Where the waves are in phase (path difference = $n\lambda$) there is constructive interference, and these points are antinodes, with maximum amplitude.

Where the waves are in antiphase (path difference = $(n + \frac{1}{2})\lambda$) there is destructive interference, and these points are nodes, with minimum (zero) amplitude.

The nodes and antinodes stay in fixed positions, so a standing wave is formed, with nodes at the fixed ends of the string.

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(b) A thicker string produces a note with a lower fundamental frequency than a thinner string of the same material.

Justify this statement.

(5)

Assumption: the strings are the same length (and at the same tension), and a thicker string of the same material has a greater mass.

So the thicker string has a greater mass per unit length μ.

The fundamental has wavelength $\lambda = 2L$, so the wavelength is the same in each string.

The speed of the wave on a string is $v = \sqrt{(T/\mu)}$; T is the same, so v is lower on the thicker string.

Using $v = f\lambda$: $f = v/\lambda = (1/\lambda)\sqrt{(T/\mu)}$, so $f \propto 1/\sqrt{\mu}$.

Therefore the thicker string, with larger μ, has a lower fundamental frequency.

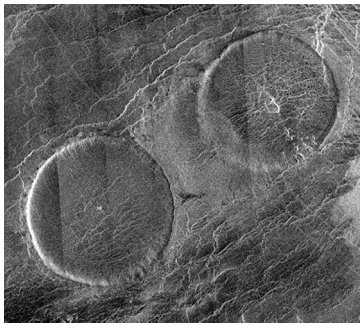
(Total for Question 11 = 11 marks)

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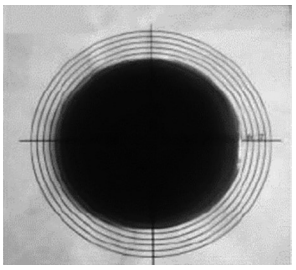
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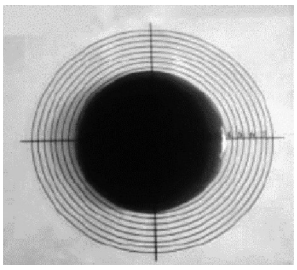
12 The photograph shows an image of two "pancake" volcanoes on the surface of the planet Venus. Scientists believe these types of volcano are formed from lava spreading out in all directions onto a flat landscape.



A student investigated the formation of pancake volcanoes. She observed the flow of a viscous liquid at two different temperatures as it spread out from a central spot. The photographs below show the liquid at both temperatures after it had been flowing for the same length of time.



High temperature test



Low temperature test

(a) Scientists believe that the high temperature of lava when it erupts is one factor that allows the lava to spread out over a large area.

Explain how the student's investigation supports this idea.

(2)

The experiment shows the liquid flows faster (spreads further in the same time) at the higher temperature, because it has a lower viscosity.

So if lava behaves similarly, hot lava will flow a long way and cover a large area in a given time before it cools and solidifies.

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(b) The student carried out an experiment to determine the viscosity of the liquid at room temperature. She observed a steel sphere falling through the liquid.

She had the following equipment:

- a long, wide cylindrical tube
- two steel spheres with diameters 7.0 mm and 22.0 mm
- video camera
- metre rule

The student observed the sphere with a diameter of 7.0 mm falling through the liquid. The sphere fell 0.80 m in 5.3 s at a constant velocity.

The viscosity η of the liquid can be calculated using the equation

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

providing Stokes' law applies.

(i) Calculate the viscosity of the liquid.

density of liquid $\rho_l = 1430\,\text{kg m}^{-3}$

density of steel $\rho_s = 7800\,\text{kg m}^{-3}$

(4)

$v = s/t = 0.80\ m \div 5.3\ s = 0.151\ m\ s^{-1}$

$V = (4/3)\pi r^3 = (4/3)\pi(3.5 \times 10^{-3}\ m)^3 = 1.80 \times 10^{-7}\ m^3$

$\eta = Vg(\rho_s - \rho_l) / 6\pi rv$

$\eta = 1.80 \times 10^{-7} \times 9.81 \times (7800 - 1430) \div (6\pi \times 3.5 \times 10^{-3} \times 0.151)$

$\eta = 1.1\ Pa\ s$

Viscosity of liquid = 1.1 Pa s

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(ii) If the student had used the larger sphere, the equation would not have produced the correct answer.

Explain why.

(2)

With the larger sphere the (terminal) speed would be much greater, so Stokes' law would not apply, because the flow of liquid around the sphere would be turbulent and not laminar.

(iii) The student used the video camera to record the sphere falling through the liquid.

State **one** benefit of using the video camera to record the motion of the sphere.

(1)

The video can be played back frame by frame, which eliminates human reaction time, so the time is measured more accurately.

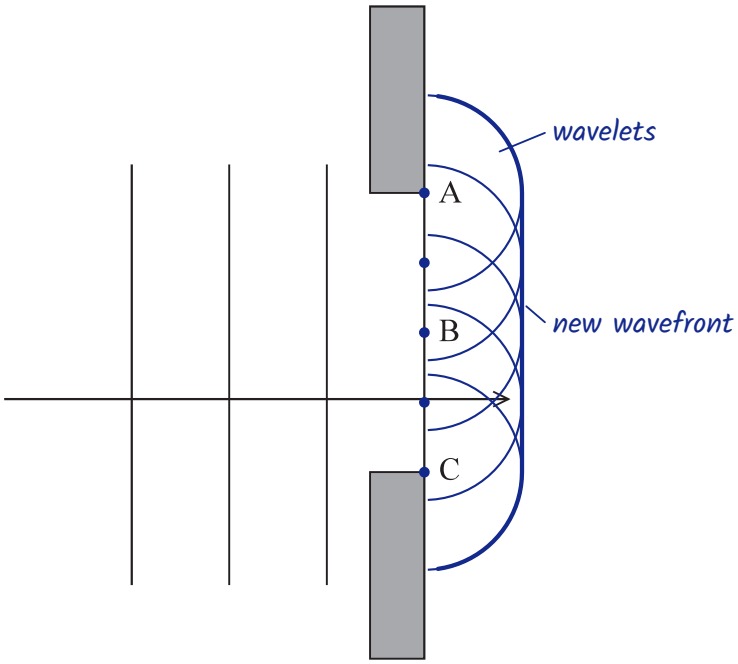
(Total for Question 12 = 9 marks)

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13 The diffraction of light provides evidence for the wave theory of light.

(a) The diagram represents wavefronts of light, incident at a single slit. The points labelled A, B and C are points on the wavefront that has just passed through the gap.



(i) Describe what is meant by a wavefront.

(1)

A wavefront is a line (surface) along which all the points are in phase.

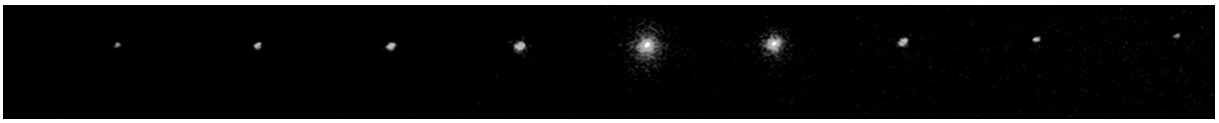
(ii) Add to the diagram to show how Huygens' construction can be used to determine the shape of the next wavefront, after the wave has passed through the gap.

(3)

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(b) A student carried out an investigation to determine the wavelength of the light emitted from a laser pen.

He shone the light from the laser pen so that it was incident perpendicularly on a diffraction grating. The diffraction grating had 200 lines per mm. He observed the diffraction pattern on a screen 3.00 m away from the grating. The pattern consisted of a series of bright dots.



(i) Give a reason why a laser is a suitable source of light to produce a diffraction pattern.

(1)

A laser is monochromatic (a single wavelength) and coherent, so the pattern has sharp, clear maxima.

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(ii) The student measured a distance of 102 cm between the central maximum and the centre of a third order maximum.

The table shows the range of wavelengths for each colour of the visible spectrum.

Colour	Range of wavelength / nm
violet	380–450
blue	450–495
green	495–570
yellow	570–590
orange	590–620
red	620–750

Deduce the colour of the light emitted from the laser pen.

(5)

$d = 1/200\ mm^{-1} = 0.005\ mm = 5.0 \times 10^{-6}\ m$

$\tan \theta = 1.02\ m \div 3.00\ m$, so $\theta = 18.8°$

$n\lambda = d \sin \theta$ with $n = 3$

$\lambda = (5.0 \times 10^{-6}\ m \times \sin 18.8°) \div 3 = 5.4 \times 10^{-7}\ m = 537\ nm$

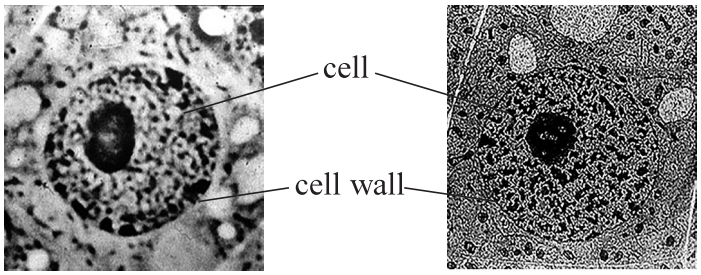
537 nm lies in the range 495 to 570 nm, so the laser light is green.

(Total for Question 13 = 10 marks)

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14 An optical microscope uses a beam of visible light. An electron microscope uses a beam of electrons.

A biologist looked at an animal cell using both microscopes. The two images are shown; both have the same magnification.



using optical microscope using electron microscope

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(a) An electron in the beam of the electron microscope has a velocity of 2% of the speed of light.

Calculate the de Broglie wavelength of the electron.

(3)

$p = mv = 9.11 \times 10^{-31}\ kg \times (0.02 \times 3.00 \times 10^{8}\ m\ s^{-1}) = 5.47 \times 10^{-24}\ kg\ m\ s^{-1}$

$\lambda = h/p = 6.63 \times 10^{-34}\ J\ s \div 5.47 \times 10^{-24}\ kg\ m\ s^{-1}$

$\lambda = 1.2 \times 10^{-10}\ m$

de Broglie wavelength = $1.2 \times 10^{-10}\ m$

(b) The image of the animal cell produced by the electron microscope is less blurred than the image produced by the optical microscope.

Explain why.

(2)

The wavelength of the electrons is much less than the wavelength of visible light (about 10^{-10} m compared with about 5×10^{-7} m).

So there is less diffraction with the electron beam, giving a less blurred image.

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(c) The biologist measured the diameter of the cell from one of the images. He recorded four measurements. The image had a magnification of ×800.

Diameter of image /cm			
2.4	2.5	1.1	2.2

Determine a value for the diameter of the actual cell.

(2)

Ignore the anomalous 1.1 cm: mean = (2.4 + 2.5 + 2.2)/3 = 2.4 cm = 0.024 m

magnification = image height/object height

diameter of cell = 0.024 m ÷ 800 = 3.0×10^{-5} m

Diameter of cell = 3.0×10^{-5} m

(Total for Question 14 = 7 marks)

TOTAL FOR SECTION A = 60 MARKS

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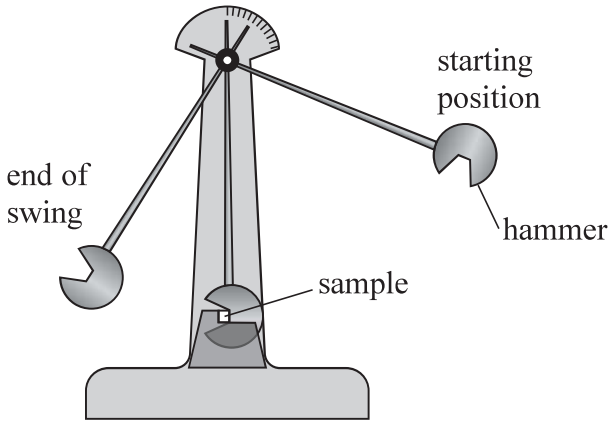
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SECTION B

Answer ALL questions.

15 Read the passage and answer the questions below.



(ref: Physics Review April 2015 p22)

The Charpy test is used by scientists to measure the fracture toughness of a material. A simple pendulum, with a hammer on the end, is held high and released so that it swings down and strikes the sample. The height from which the hammer is released is increased until the sample fractures. Some energy is absorbed by the sample in the impact but the hammer continues to move until it comes to rest at the top of its swing. Due to the law of conservation of energy the hammer will not swing up as high as its starting position. The difference in height between the start and end is proportional to the energy absorbed in the impact – the fracture toughness.

(a) "The difference in height between the start and end is proportional to the energy absorbed in the impact – the fracture toughness."

Justify this statement.

(2)

The energy absorbed in the impact is equal to the change in GPE of the hammer between the start and the end of the swing.

$\Delta E = mg\Delta h$, and m and g are constant, so $E \propto \Delta h$.

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(b) The hammer is released from a height of 13.0 cm above the lowest point of the swing.

Calculate the momentum of the hammer when it strikes the sample.

mass of hammer = 31 kg

(3)

$mg\Delta h = \frac{1}{2}mv^2$, so $v = \sqrt{(2g\Delta h)}$

$v = \sqrt{(2 \times 9.81\ m\ s^{-2} \times 0.130\ m)} = 1.60\ m\ s^{-1}$

$p = mv = 31\ kg \times 1.60\ m\ s^{-1} = 49.6\ kg\ m\ s^{-1}$

$p = 50\ kg\ m\ s^{-1}$

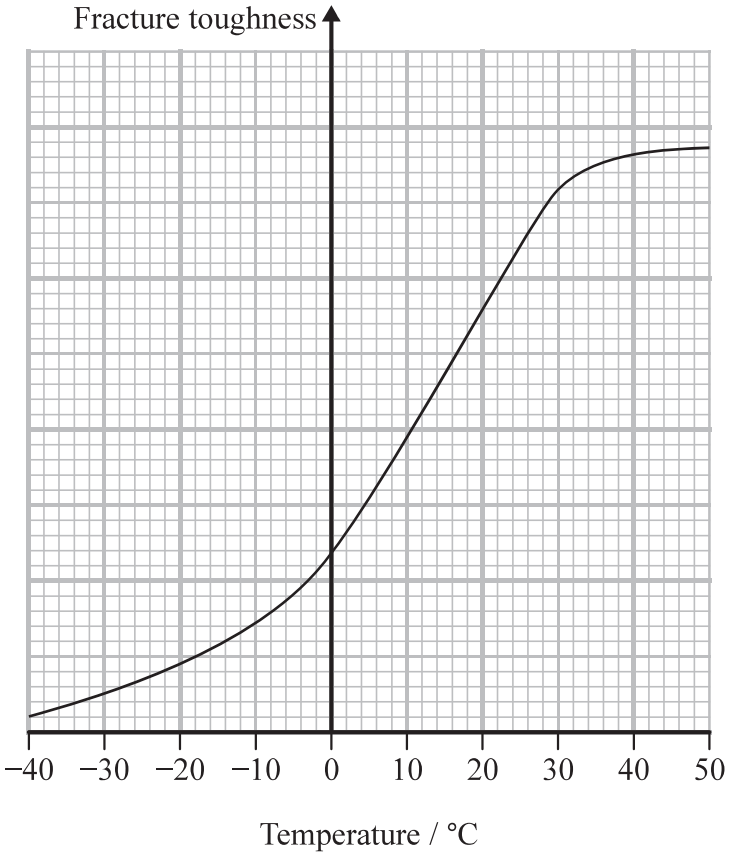
Momentum of hammer = $50\ kg\ m\ s^{-1}$

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(c) The sketch graph shows how the fracture toughness of a sample of steel varies with temperature.



A material with a low fracture toughness can absorb less energy before fracture than a material with high fracture toughness.

The ship *Titanic* sank in 1912 following a collision with an iceberg in the icy waters of the Atlantic. The steel hull of the ship was fractured by the impact.

Deduce why the steel was likely to have been fractured by the impact.

(3)

The icy water of the Atlantic was at a low temperature (about 0 °C or below), and the graph shows that the steel has a much lower fracture toughness at low temperature (at 0 °C it is less than half its value at 30 °C).

So at the low temperature the steel could absorb less energy before fracture.

The energy absorbed by the hull in the impact with the iceberg was sufficient to cause fracture.

(Total for Question 15 = 8 marks)

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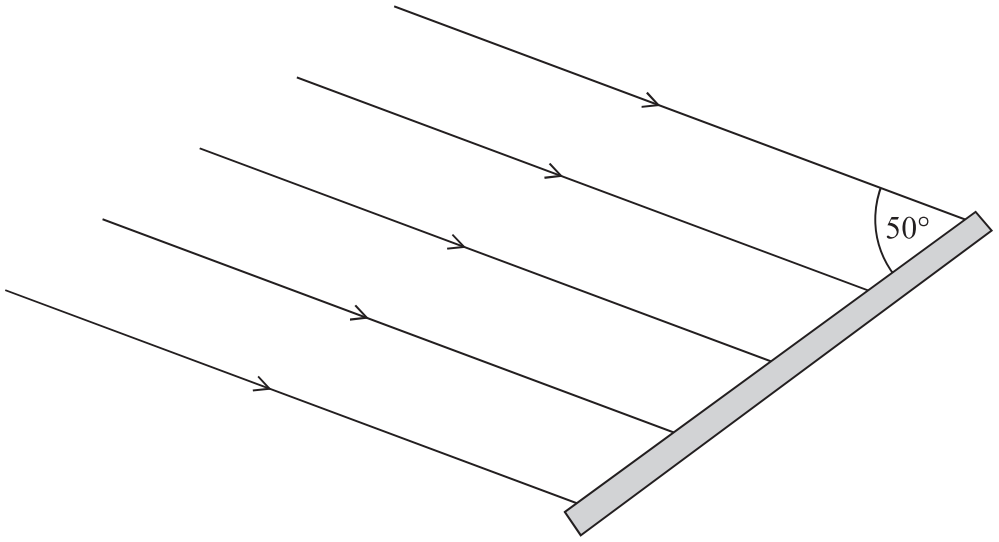
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16 A solar panel uses electromagnetic radiation from the Sun to generate electricity. In one installation a sensor in the solar panel measures the intensity of radiation arriving from different directions. A motor rotates the solar panel so that it always faces the brightest part of the sky.

(a) The intensity of the radiation incident at the surface of the Earth is 1100 W m^{-2}. A solar panel has an area of 2.4 m^2. Radiation is incident on the solar panel at an angle of 50° as shown. The efficiency of the solar panel is 20%.



Calculate the electrical power generated by the solar panel.

(3)

I = P/A, area perpendicular to the radiation = 2.4 m^2 × sin 50° = 1.84 m^2

power incident = 1100 W m^{-2} × 1.84 m^2 = 2020 W

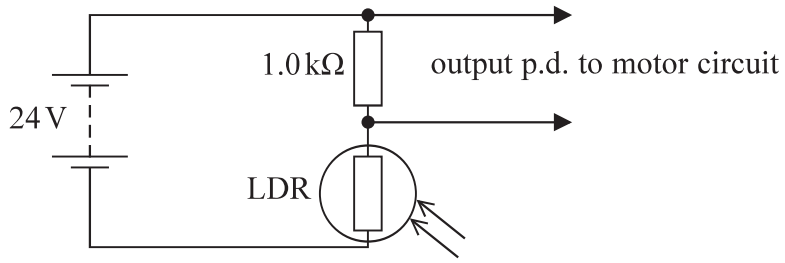
electrical power = 0.20 × 2020 W = 404 W = 400 W

Electrical power generated = *400 W*

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(b) The circuit diagram shows how a light dependent resistor (LDR) can be used to produce an output potential difference (p.d.) that is dependent on the intensity of light. This output p.d. is connected to a motor circuit that operates the movement of the solar panel.



Initially the motor is switched off. The light intensity increases and the resistance of the LDR decreases to 750 Ω.

The motor switches on when the output p.d. is above 13 V.

Deduce whether this change in light intensity causes the motor to switch on.

(3)

R_{total} = 1000 Ω + 750 Ω = 1750 Ω, so $I = V/R_{total}$ = 24 V ÷ 1750 Ω = 0.0137 A

output p.d. across 1.0 kΩ: $V = IR$ = 0.0137 A × 1000 Ω = 13.7 V

13.7 V is greater than 13 V, so the motor switches on.

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(c) When light is incident on an LDR, electrons move to a higher energy level where they become conduction electrons. This causes the resistance of the LDR to decrease.

A student suggests that this is an example of the photoelectric effect. The student is not correct.

Compare and contrast the photoelectric effect with the effect of radiation incident on an LDR.

(6)

Similarities: in both, an electron absorbs a single photon and gains energy from it, which is evidence for the particle (photon) model of light.

In both, the photon needs a minimum amount of energy, so the light must be above a certain (threshold) frequency.

In both, increasing the light intensity increases the number of electrons released (freed) per second.

Differences: in the photoelectric effect the electrons are released (emitted) from the surface of the material, but in the LDR the electrons remain within the LDR as conduction electrons.

The photoelectric effect occurs in metals, whereas the LDR is a semiconductor.

(Total for Question 16 = 12 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

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

$v = u + at$

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

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

Forces

$\Sigma F = ma$

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

$W = mg$

$moment\ of\ force = Fx$

Momentum

$p = mv$

Work, energy and power

$\Delta W = F\Delta s$

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

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

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

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

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

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

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

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

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

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

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

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

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