Cambridge International Examinations
Cambridge Pre-U Certificate

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

PHYSICS **9792/02**

Paper 2 Part A Written Paper **May/June 2014**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
You are advised to spend about 1 hour 30 minutes on this section.

Section B
Answer the **one** question.
You are advised to spend about 30 minutes on this section.
The question is based on the material in the Insert.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
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8	
9	
10	
Total	

This document consists of **22** printed pages, **2** blank pages and **1** insert.

DC (NH/SW) 82332/3

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Data

gravitational field strength close to Earth's surface	$g = 9.81\ \mathrm{N\,kg^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
speed of light in vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$
electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
molar gas constant	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
	$s = \left(\frac{u+v}{2}\right)t$
heating	$\Delta E = mc\Delta\theta$
change of state	$\Delta E = mL$
refraction	$n = \frac{\sin\theta_1}{\sin\theta_2}$
	$n = \frac{v_1}{v_2}$

diffraction			
single slit, minima	$n\lambda$	=	$b \sin\theta$
grating, maxima	$n\lambda$	=	$d \sin\theta$
double slit interference	λ	=	$\dfrac{ax}{D}$
Rayleigh criterion	θ	≈	$\dfrac{\lambda}{b}$
photon energy	E	=	hf
de Broglie wavelength	λ	=	$\dfrac{h}{p}$
simple harmonic motion	x	=	$A \cos\omega t$
	v	=	$-A\omega \sin\omega t$
	a	=	$-A\omega^2 \cos\omega t$
	F	=	$-m\omega^2 x$
	E	=	$\frac{1}{2}mA^2\omega^2$
energy stored in a capacitor	W	=	$\frac{1}{2}QV$
electric force	F	=	$\dfrac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$
electrostatic potential energy	W	=	$\dfrac{Q_1Q_2}{4\pi\varepsilon_0 r}$
gravitational force	F	=	$-\dfrac{Gm_1m_2}{r^2}$
gravitational potential energy	E	=	$-\dfrac{Gm_1m_2}{r}$
magnetic force	F	=	$BIl \sin\theta$
	F	=	$BQv \sin\theta$

electromagnetic induction	E	=	$-\dfrac{d(N\Phi)}{dt}$
Hall effect	V	=	Bvd
time dilation	t'	=	$\dfrac{t}{\sqrt{1-\dfrac{v^2}{c^2}}}$
kinetic theory	$\frac{1}{2}m\langle c^2\rangle$	=	$\frac{3}{2}kT$
work done on/by a gas	W	=	$p\Delta V$
radioactive decay	$\dfrac{dN}{dt}$	=	$-\lambda N$
	N	=	$N_0 e^{-\lambda t}$
	$t_{\frac{1}{2}}$	=	$\dfrac{\ln 2}{\lambda}$
attenuation losses	I	=	$I_0 e^{-\mu x}$
mass-energy equivalence	ΔE	=	$c^2\Delta m$
hydrogen energy levels	E_n	=	$\dfrac{-13.6\,\text{eV}}{n^2}$
Heisenberg uncertainty principle	$\Delta p\Delta x$	⩾	$\dfrac{h}{2\pi}$
	$\Delta E\Delta t$	⩾	$\dfrac{h}{2\pi}$
Wien's displacement law	λ_{max}	∝	$\dfrac{1}{T}$
Stefan's law	L	=	$4\pi\sigma r^2T^4$
electromagnetic radiation from a moving source	$\dfrac{\Delta\lambda}{\lambda}$	≈	$\dfrac{\Delta f}{f} \approx \dfrac{v}{c}$

Section A

You are advised to spend 1 hour 30 minutes answering the questions in this section.

1 A diver of height 1.80 m has his centre of gravity (C of G) 1.00 m above his feet when standing on the springboard. Fig. 1.1 illustrates the diver leaving the springboard, moving upwards and then entering the water.

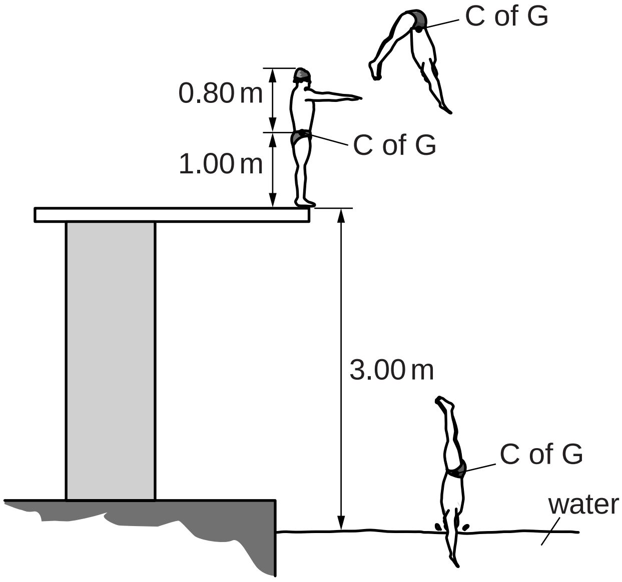

Fig. 1.1 (not to scale)

The diver leaves the springboard with an upward velocity of 5.6 m s^{-1}. The take-off point on the board is 3.00 m above the water.

Assume that the centre of gravity (C of G) of the diver remains at the same position within the diver throughout the dive and ignore air resistance.

(a) Determine the maximum height of his centre of gravity above the water.

height = ... m [2]

(b) Determine the speed at which the diver's head reaches the water.

speed = ... m s^{-1} [2]

(c) Determine the time the diver is in the air, between leaving the springboard and his head reaching the water.

time = ... s [2]

[Total: 6]

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2 **(a)** Define the term *gravitational field strength.*

....

....[1]

(b) When describing the movement of an astronaut during a launch, comments such as "*The astronaut experiences a force of 5g*" are frequently made.

Explain why this expression is incorrect.

....

....[1]

(c) At blast-off from the Earth, an astronaut of mass 76 kg has an area of contact with his seat of 0.095 m^2.

Calculate the average pressure on the seat when the upward acceleration of the rocket is 47 $m\,s^{-2}$.

pressure = ... Pa [3]

[Total: 5]

3 **(a)** A rock climber of mass 68 kg uses a safety rope as shown in Fig. 3.1.

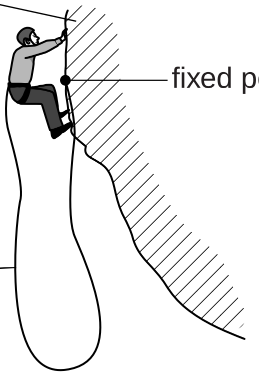

Fig. 3.1 (not to scale)

The available rope has an unstretched length of 16.0 m. The rope can extend 4.0 m before it breaks at a maximum tensile force of 9.0 kN.

(i) Calculate the maximum elastic energy stored in the rope before it breaks. Assume that the tensile force in the rope is proportional to its extension until it breaks.

maximum elastic energy = ... J [2]

(ii) The climber falls and comes to rest after falling 19.39 m.

Calculate his loss of gravitational potential energy.

gravitational potential energy = ... J [2]

(iii) State what has happened to the energy calculated in **(ii)** when the climber has fallen 19.39 m. Support your answer with a relevant calculation.

....

....

....[3]

(b) The climber is concerned about the safety margin in his choice of rope. Discuss whether or not the length of rope affects the safety margin.

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....[3]

[Total: 10]

4 Certain characteristics of two sound waves are illustrated in the displacement-time graph in Fig. 4.1.

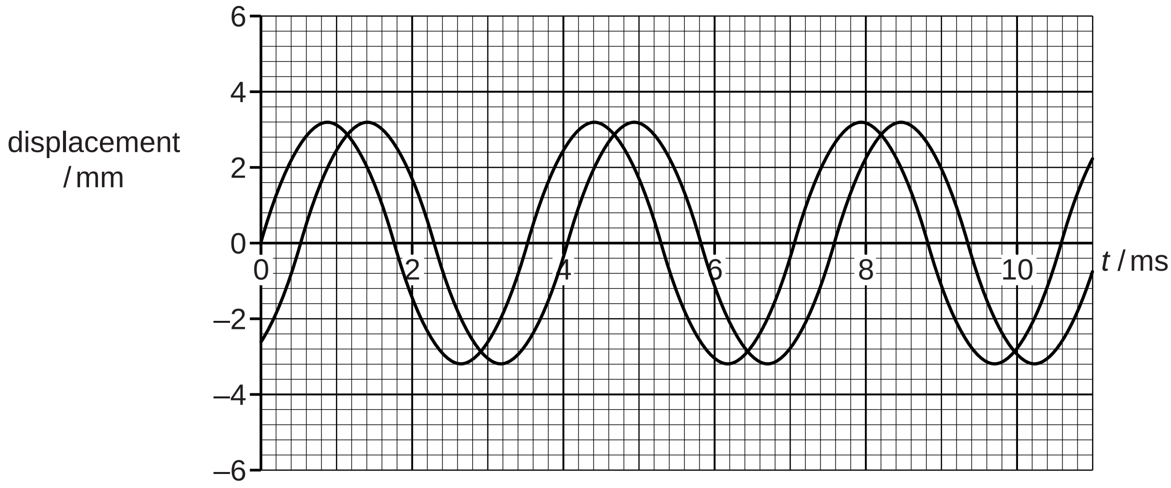


Fig. 4.1

(a) For the waves shown in Fig. 4.1 determine, with SI units, their

(i) amplitude,

amplitude .... unit .... [1]

(ii) period,

period .... unit .... [1]

(iii) frequency,

frequency .... unit .... [1]

(iv) phase difference.

phase difference .... unit .... [3]

(b) State the additional item of information that is required to determine the speed of these waves.

....[1]

(c) **(i)** On Fig. 4.1, sketch the shape of the resultant of the two waves. [2]

(ii) Estimate the amplitude of the resultant wave. Give the unit.

amplitude = ... unit .... [1]

[Total: 10]

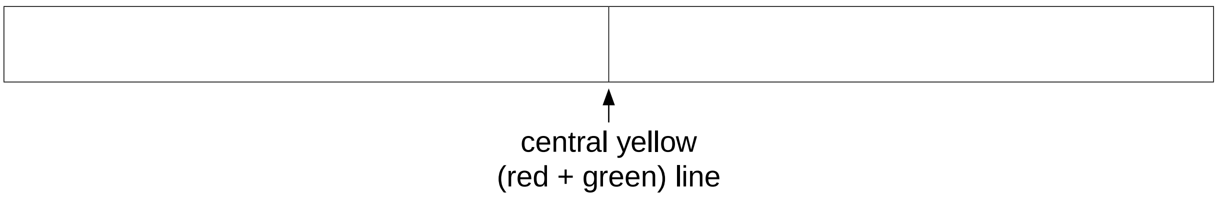
5 **(a)** Red and green light of wavelengths 640 nm and 520 nm, respectively, are simultaneously directed through a narrow slit on to a diffraction grating. The grating is at right angles to the light and has a line spacing of 1.60 μm.

(i) Complete the table by calculating the values for all the angles of maxima for both colours.

order, *n*	angle for red maximum / °	angle for green maximum / °
0	0	0
1		
2		
3	–	

[4]

(ii) On Fig. 5.1, sketch the approximate pattern that would be seen on a screen behind the diffraction grating. Label the red and green maxima with **R** and **G**, respectively.



[2]

Fig. 5.1

(b) The grating is replaced with a double slit of the same spacing. Describe how the new pattern produced differs from the one for the diffraction grating.

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....[3]

[Total: 9]

6 An electric kettle contains 1.50 kg of water at a temperature of 17 °C. The kettle is connected to a 230 V mains supply and there is a current of 12.5 A in the heating element.

specific heat capacity of water = 4190 J kg^{-1} K^{-1}
specific latent heat of water = 2.26 × 10^{6} J kg^{-1}

(a) Estimate the time taken to bring the water to its boiling point.

time = ... s [3]

(b) The kettle does not switch off automatically. Estimate the additional time taken to evaporate all of the water.

time = ... s [2]

(c) Give **two** reasons why the times calculated in **(a)** and **(b)** will be shorter than in practice.

....

....

....

....[2]

[Total: 7]

7 **(a)** Calculate the resistance of a copper wire of length 500 m and of diameter 0.914 mm. The resistivity of copper is $1.70 \times 10^{-8}\,\Omega\,m$.

resistance = ... Ω [3]

(b) A small heater H is marked 12 V, 20 W. Calculate its resistance.

resistance = ... Ω [1]

(c) The heater H is connected to a 12.0 V supply of negligible internal resistance using the copper wire in **(a)**. Fig. 7.1 shows the circuit.

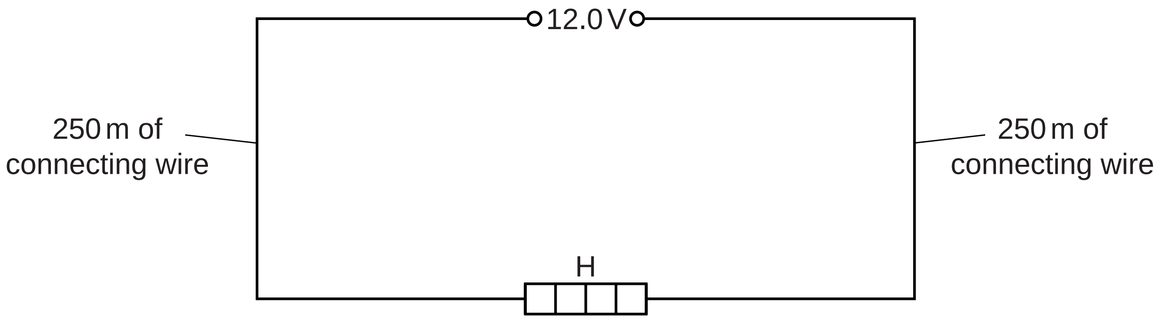

Fig. 7.1

Calculate the power the heater H supplies in this arrangement.

power = ... W [2]

(d) The same connecting wires are then used to connect a different heater P to a power supply of 100 V of negligible internal resistance, as shown in Fig. 7.2.

This heater is marked 100 V, 20 W.

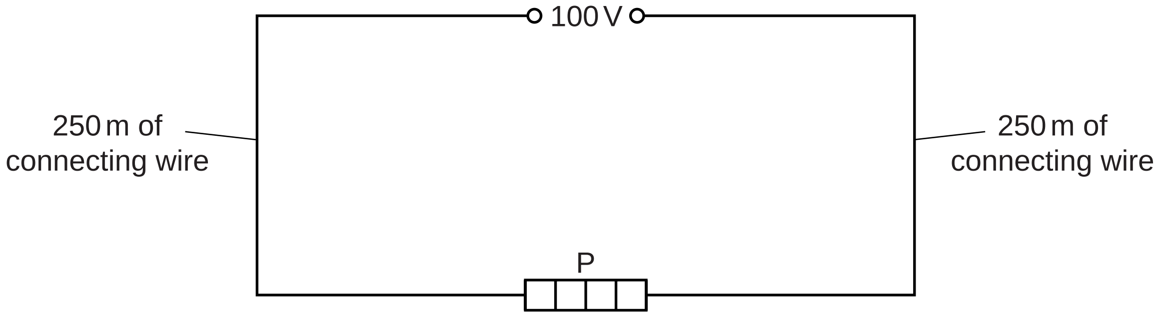

Fig. 7.2

Explain why less power is wasted in the connecting cables in this circuit compared to the circuit shown in Fig. 7.1. Space is provided for your calculations.

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....

....

....

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....[2]

[Total: 8]

8 **(a)** Nuclear decay is spontaneous and random. Explain what is meant by

(i) *spontaneous*,

....

....[1]

(ii) *random*.

....

....[1]

(b) In a nuclear reactor the main source of energy occurs as a result of a nuclear reaction. An incomplete transformation equation for this reaction is shown.

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow \qquad \rightarrow \qquad \text{Xe} + {}^{90}_{38}\text{Sr} + 3{}^{1}_{0}\text{n}$$

(i) Complete the transformation equation. [3]

(ii) The neutrons produced in the reaction enable a chain reaction to take place. Explain why this is possible.

....

....[2]

(iii) Suggest how the power output from a nuclear reactor may be varied.

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....

....

....[2]

[Total: 9]

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9 **(a)** Light of wavelength 470 nm strikes a thin film of an alkali metal. The work function of the metal is 2.06×10^{-19} J.

(i) Calculate the photon energy of light of wavelength 470 nm.

energy = ... J [2]

(ii) Calculate the maximum energy of a photoelectron emitted from the metal surface.

energy = ... J [1]

(b) Light of wavelength 470 nm is used in a device called a photomultiplier tube. A photomultiplier tube contains electrodes at increasing positive potentials. Fig. 9.1 shows a photomultiplier tube with six electrodes (labelled 1 to 6).

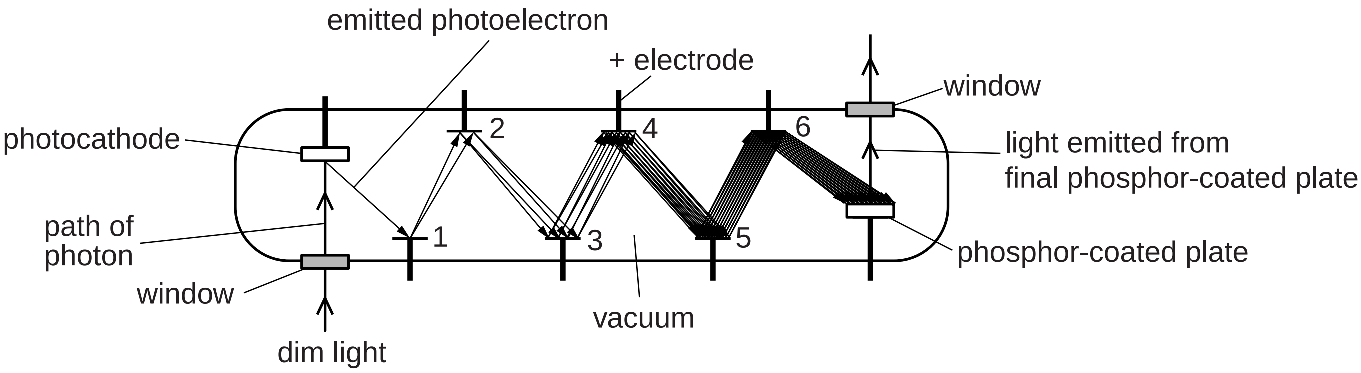

Fig. 9.1 (not to scale)

The light falls on a photocathode which emits photoelectrons. These electrons are attracted to an electrode at a higher potential and each arriving electron causes the emission of 15 electrons.

This process is repeated within the photomultiplier tube and as a result, a much larger current of electrons arrives at the phosphor-coated plate. The phosphor-coated plate emits light as a result of the arrival of the electrons.

(i) The rate of emission of electrons at the photocathode is 4 per second.

Calculate the number of electrons per second leaving the sixth electrode.

number of electrons per second = ... [2]

(ii) Calculate the current arriving at the phosphor-coated plate.

current = ... A [1]

(iii) Explain why the electrons arriving at the final electrode have more energy than the initial electrons.

....

....[2]

(c) Photomultiplier tubes, like the one shown in Fig. 9.1, can be used to make a night-vision camera. Give suggestions why such a night-vision camera can only give a black and white image even though the incident light may have many different wavelengths.

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....[3]

[Total: 11]

Section B

You are advised to spend about 30 minutes answering this section.
Your answers should, where possible, make use of any relevant Physics.

10 In recent years, seismology and an understanding of wave motion have produced many benefits. One consequence has been a much clearer picture of the internal structure of the Earth.

A large earthquake occurs near the surface of the Earth at a particular location and both seismic P-waves and S-waves are produced. The P-waves and S-waves travel through the Earth away from the epicentre of the earthquake.

(a) The average speed of the P-waves is $7.98\,\text{km}\,\text{s}^{-1}$ and the average speed of the S-waves is $4.75\,\text{km}\,\text{s}^{-1}$. A seismograph at a different location detects the arrival of the S-waves 2 minutes 50 seconds after the arrival of the P-waves.

(i) Calculate the time taken, in minutes, for the S-waves to travel from the epicentre of the earthquake to the seismograph,

time = ... min [2]

(ii) Calculate the distance of the epicentre of the earthquake from the seismograph.

distance = ... km [1]

(b) **(i)** Explain what is meant by

1. a *longitudinal wave*,

....

....

2. a *transverse wave*.

....

....

[2]

(ii) Seismic waves produced by the earthquake are detected by seismographs in many different countries. In certain parts of the world, however, seismographs do not detect any of the S-waves produced by the earthquake.

State where, relative to the epicentre of the earthquake, these seismographs are located and explain why they do not detect the S-waves.

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....

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....[3]

(c) As the seismic waves travel through regions deeper within the mantle, the speeds of the waves change.

(i) Describe and explain this change in speed.

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....[3]

(ii) Describe the effect of this change in speed on the path taken through the mantle by the waves.

....

....

....[2]

(d) The P-waves produced by the earthquake have a speed of $13.7\,\text{km}\,\text{s}^{-1}$ in the mantle when they reach the boundary with the outer core.

Fig. 8.1 shows a P-wave travelling in the mantle as it strikes the boundary with the outer core at the grazing angle. Its direction of travel is perpendicular to the normal.

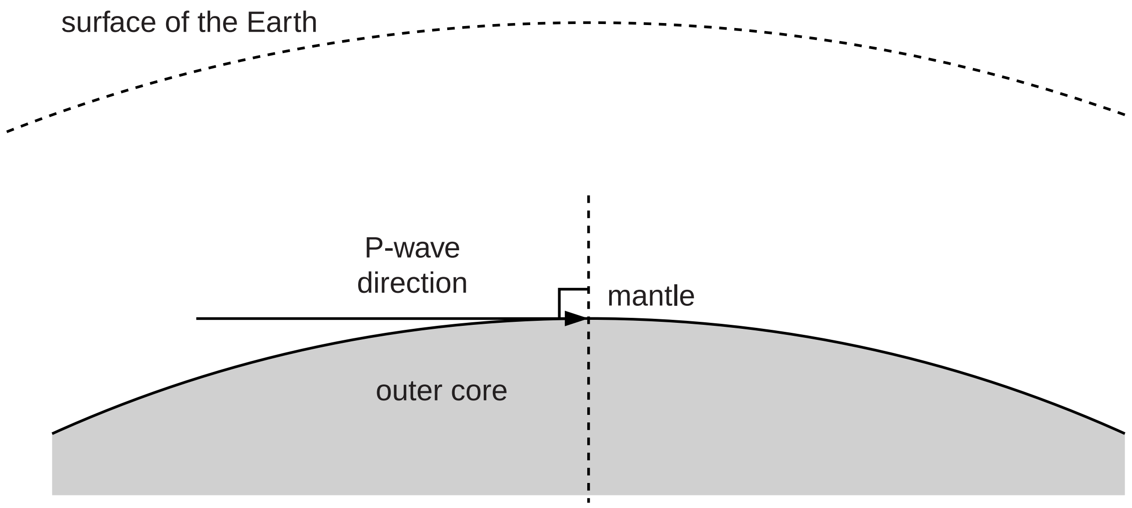

Fig. 8.1

The P-wave enters the outer core and begins its journey in the outer core at a speed of $8.25\,\text{km}\,\text{s}^{-1}$.

(i) On Fig. 8.1, sketch an arrow to indicate the direction of travel of the P-wave as it begins its journey in the outer core. [1]

(ii) Determine, by calculation, the exact direction of travel of the P-wave as it begins its journey in the outer core.

direction = ... ° [2]

(iii) Using your answer to **(d)(i)** or otherwise, explain why there are parts of the Earth's surface where it is not possible for seismographs to detect the P-waves produced by the earthquake. You may include a diagram to illustrate the explanation.

....

....

....[2]

Part (e) of this question continues on page 24.

(e) The temperatures and pressures within the Earth reach very high values within a few kilometres of the surface. It is difficult, therefore, to imagine that human beings will ever be able to reach regions further than a few kilometres from the surface.

Both public and private money are used to support the study of geophysics and seismology. Suggest why this expenditure is justified. You may use information from any of the extracts.

Your answer should concentrate on the social, technological and economic effects of such research.

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....[7]

[Total: 25]