Cambridge Pre-U

Cambridge International Examinations
Cambridge Pre-U Certificate

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

9651429999

PHYSICS (PRINCIPAL) **9792/02**

Paper 2 Written Paper **May/June 2016**

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

Section 2
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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4	
5	
6	
7	
8	
9	
Total	

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **25** printed pages, **3** blank pages and **1** insert.

CAMBRIDGE
International Examinations

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

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

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

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

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 $\lambda = \frac{ax}{D}$

Rayleigh criterion $\theta \approx \frac{\lambda}{b}$

photon energy $E = hf$

de Broglie wavelength $\lambda = \frac{h}{p}$

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 $W = \frac{1}{2}QV$

capacitor discharge $Q = Q_0 e^{-\frac{t}{RC}}$

electric force $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$

electrostatic potential energy $W = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r}$

gravitational force $F = -\frac{Gm_1 m_2}{r^2}$

gravitational potential energy $E = -\frac{Gm_1 m_2}{r}$

magnetic force $F = BIl\sin\theta$

$F = BQv\sin\theta$

electromagnetic induction $E = -\frac{\mathrm{d}(N\Phi)}{\mathrm{d}t}$

Hall effect $V = Bvd$

time dilation $t' = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}}$

length contraction $l' = l\sqrt{1 - \frac{v^2}{c^2}}$

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 $\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$

$N = N_0 e^{-\lambda t}$

$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$

attenuation losses $I = I_0 e^{-\mu x}$

mass-energy equivalence $\Delta E = c^2\Delta m$

hydrogen energy levels $E_n = \frac{-13.6\,\text{eV}}{n^2}$

Heisenberg uncertainty principle $\Delta p\Delta x \geqslant \frac{h}{2\pi}$

Wien's displacement law $\lambda_{max} \propto \frac{1}{T}$

Stefan's law $L = 4\pi\sigma r^2 T^4$

electromagnetic radiation from a moving source $\frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$

Section 1

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

1 (a) A column of liquid has a depth h and a uniform cross-sectional area A. Fig. 1.1 shows the column.

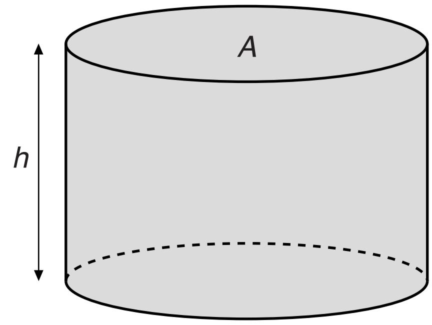

Fig. 1.1

The liquid has a density ρ. The gravitational field strength is g.

(i) Determine an expression for the weight of the column of liquid.

[2]

(ii) Show that the pressure p on the lower surface of the column due to the weight of the liquid is given by

$$p = h\rho g.$$

[1]

(b) Investigations on board a research ship in the Pacific Ocean, above the Marianas Trench, determine the density of the seawater.
The value obtained is $1.03 \times 10^3\,\text{kg}\,\text{m}^{-3}$.
Divers descend to a depth of 10.9 m in this seawater.

(i) Calculate the pressure due to this depth of seawater.

pressure = ... Pa [1]

(ii) The pressure is measured at a depth of 10900 m below sea level in the Marianas Trench. This depth is exactly 1000 times greater than the depth to which the divers descend.

The pressure, however, is not exactly 1000 times greater than the value obtained in **(b)(i)**.

State and explain two possible reasons why the pressure at this depth is not exactly 1000 times greater than the value obtained in **(b)(i)**.

....

....

....

....

....

....[4]

[Total: 8]

2 **(a)** Show that the kinetic energy of an object of mass m travelling with speed v is given by the equation

$$\text{kinetic energy} = \tfrac{1}{2}mv^2.$$

[3]

(b) A car of mass 1040 kg is travelling along a straight, horizontal road at a constant speed of 28 m s^{-1}. The output power of the engine is 36.0 kW.

(i) Calculate

1. the kinetic energy of the car,

kinetic energy = ... J [1]

2. the total resistive force on the car.

force = ... N [2]

(ii) The car then travels at the same speed up a hill. The hill has a gradient of 1.00 m rise for a distance along the road of 17.0 m.

The total resistive force remains unchanged.

Calculate the new output power of the engine.

power = ... W [3]

(c) A lorry of mass 40 000 kg is travelling along a straight, horizontal road. The brakes are applied. The brakes lock and the wheels stop rotating, causing the lorry to slide along the road.

The coefficient of kinetic friction μ_k between the lorry and the road is 0.35.

Calculate the magnitude of the frictional force that acts on the lorry.

force = ... N [3]

[Total: 12]

3 An α-particle X has mass m and a speed of $1.30 \times 10^7\,\mathrm{m\,s^{-1}}$. It collides elastically with a stationary helium nucleus Y, which also has a mass m.
Fig. 3.1 is a representation of the collision.

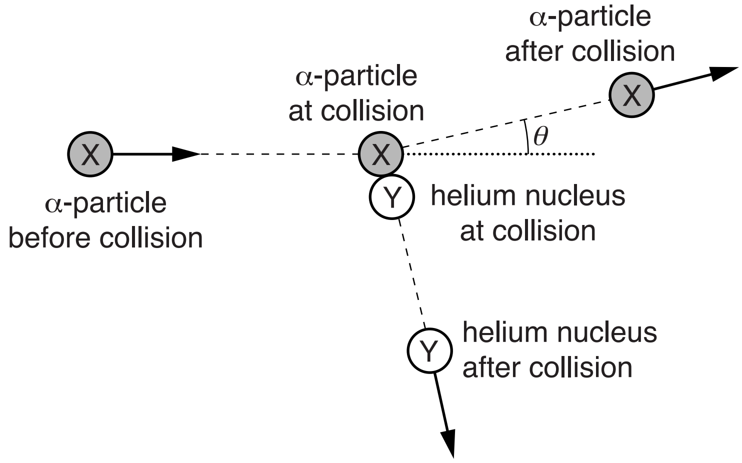

Fig. 3.1

After the collision, the velocity of X is $1.20 \times 10^7\,\mathrm{m\,s^{-1}}$ at an angle θ to its original direction. The velocity v of Y is in a direction at 90° to the direction in which X is moving.

(a) Without making any calculations, sketch in the space below Fig. 3.1 a vector triangle to show conservation of momentum. Label the triangle with the initial momentum p_1 of X, the final momentum p_2 of X, and the final momentum p_3 of Y.

[2]

(b) (i) Write an expression for the final kinetic energy E_3 of Y, in terms of the initial kinetic energy E_1 and the final kinetic energy E_2 of X.

[1]

(ii) Determine the speed of Y after the collision.

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

(c) Show that, whatever the size of the angle θ, the angle between the final velocity of X and the final velocity of Y is always 90°.

[2]

[Total: 7]

4 A 12.0V, 24.0W immersion heater is connected to a 12.0V supply of negligible internal resistance.

(a) Calculate the resistance of the heater.

resistance = ... Ω [2]

(b) The heater is connected into a circuit. Fig. 4.1 is the circuit diagram.

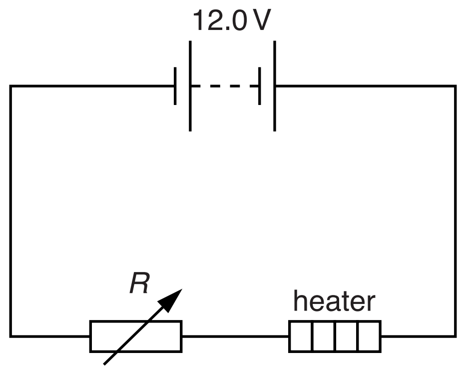

Fig. 4.1

The resistance of the heater is constant.

The resistance of the variable resistor is *R*. The output power of the heater is varied by varying *R* from 0 to 15.0 Ω.

(i) Complete the table by determining values for the total resistance of the circuit, the current in the circuit and the output power of the heater, for different values of *R*.

R / Ω	total resistance / Ω	current / A	output power / W
0			
3.0			
6.0			
9.0			
12.0			
15.0			

[3]

(ii) Fig. 4.2 and Fig. 4.3 represent two variable resistors.

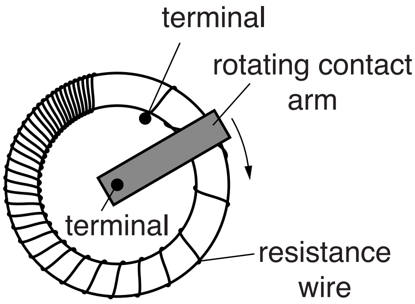

Fig. 4.2

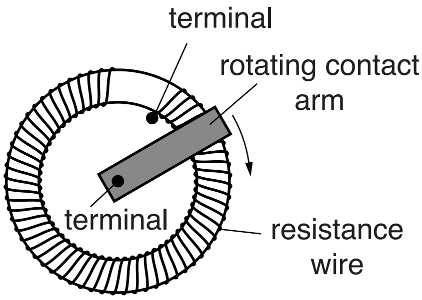

Fig. 4.3

Fig. 4.2 represents a variable resistor in which the turns of the resistance wire are not equally spaced. Fig. 4.3 represents a variable resistor in which the turns of the resistance wire are equally spaced.

The variable resistor used in the circuit in **(b)(i)** is represented in Fig. 4.2.

Using the completed table in **(b)(i)**, suggest and explain why the variable resistor represented in Fig. 4.2 is preferable for use in this circuit.

....

....

....

....

....[2]

[Total: 7]

5 **(a)** State an observation that shows that, in the same transparent material, visible light of different frequencies have different refractive indices.

....

....[1]

(b) Fig. 5.1 shows monochromatic light of a certain frequency incident on one end of an optical fibre. Some of the light enters the core of the fibre.

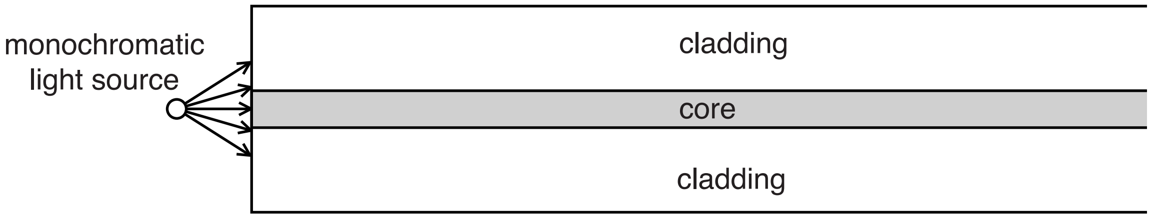

Fig. 5.1

(i) The refractive index of the core material is 1.59 and the refractive index of the cladding material is 1.52.

Some of the monochromatic light in the core strikes the boundary with the cladding.

Calculate the critical angle for the light in the core that strikes the boundary.

critical angle = ...° [2]

(ii) Calculate the speed of light in the core material.

speed of light = ... $m\,s^{-1}$ [1]

(c) There are many possible paths along the optical fibre in **(b)** that light can follow. Fig. 5.2 shows two of these paths. Light that travels along the centre of the core travels a shorter distance than light that is repeatedly reflected at an angle of incidence of 88°.

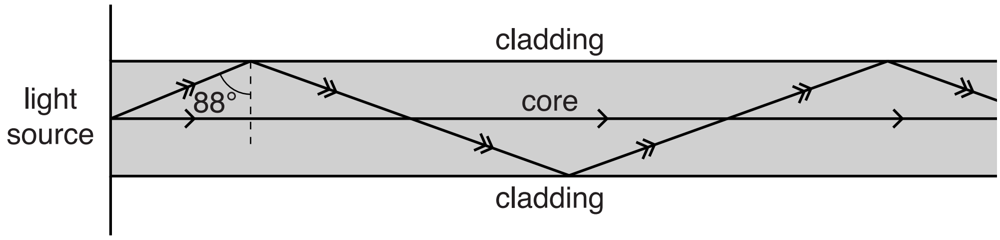

Fig. 5.2 (not to scale)

(i) The fibre is 50 km long. A signal is transmitted through the fibre.
Calculate the extra time taken by a signal that takes the longer path through the fibre.

extra time = ... s [4]

(ii) Fig. 5.3 shows an input signal and the corresponding output signal at the end of the fibre.

Fig. 5.3

Suggest two reasons for the differences between the output signal and the input signal shown in Fig. 5.3.

1. ....

....

2. ....

....
[2]

(d) A world record was set when pulses of information lasting only 1.00×10^{-11} s were sent along a 50.0 km optical fibre. The time delay calculated in **(c)(i)** makes this seem impossible.

It is possible to make optical fibres in which the refractive index is not constant. The refractive index of such fibres is high at the centre, but decreases as the distance from the centre line increases.

(i) Explain how using an optical fibre of this design reduces the effect of time delays.

....

....

....

....[2]

(ii) Suggest one other design of optical fibre that makes sending pulses of this duration possible.

....

....[1]

[Total: 13]

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6 **(a)** Fig. 6.1 represents two waves travelling together through the same space.

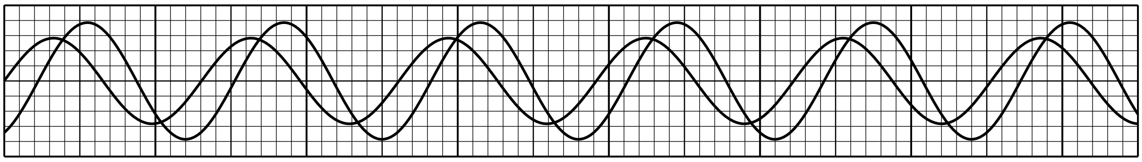

Fig. 6.1

(i) Use Fig. 6.1 to estimate the phase difference between the waves and state the unit for phase difference.

phase difference = ... unit .... [2]

(ii) State and explain whether or not the waves represented in Fig. 6.1 are coherent.

....

....[1]

(b) Microwaves of wavelength 5.00 mm pass through a single slit of width 14.0 mm. After passing through the slit, the microwaves form a pattern. The intensity of the microwaves varies with the angle measured from the incident direction.

(i) Determine two angles, of different magnitudes, at which destructive interference occurs.

angle 1 = ...

angle 2 = ...
[2]

(ii) Using the axes in Fig. 6.2, sketch a graph to show how the intensity of the microwaves varies with the angle measured from the incident direction.

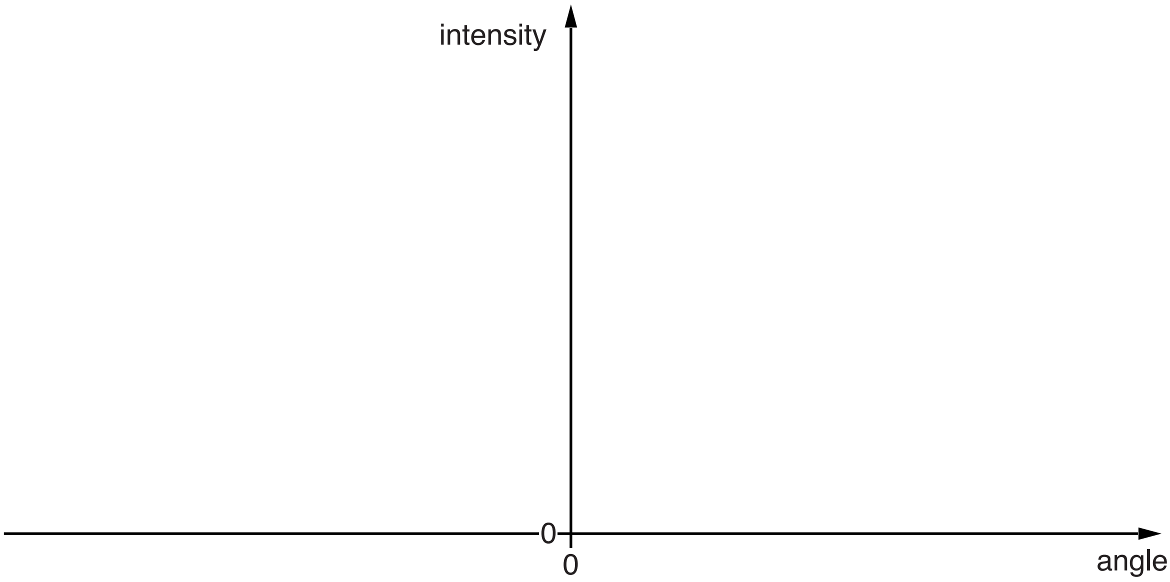

Fig. 6.2

[3]

[Total: 8]

7 A radiation detector consists of a detector (Geiger-Müller) tube connected to a counter. The detector is placed on a laboratory bench. The total count in one minute is recorded on five separate occasions.

The readings are:

25 22 22 27 24

A sample of radioactive material contains two radioactive isotopes A and B. Each isotope decays to an isotope that is stable. The radioactive properties of the sample are to be investigated.

The sample is placed on the bench and is moved close to the Geiger-Müller tube, as shown in Fig. 7.1.

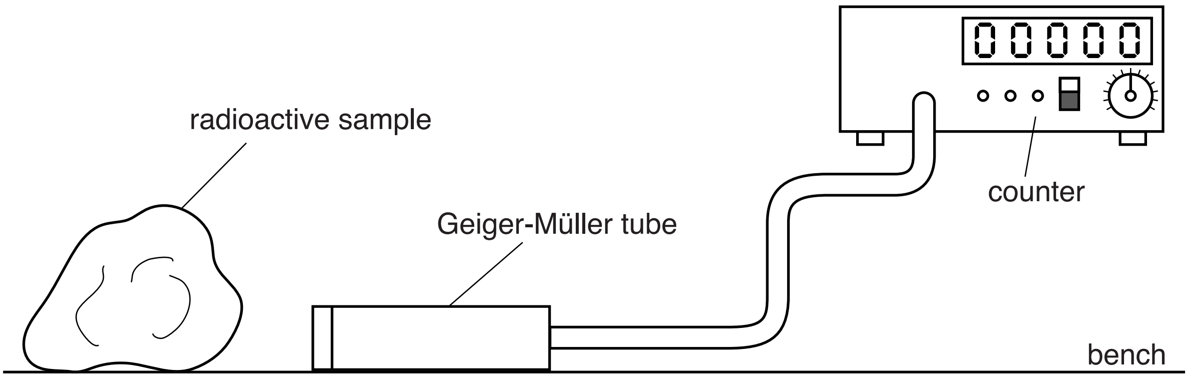

Fig. 7.1

The count rate and the corresponding time t are recorded every two hours for 18.0 hours.
The results are shown in the table.

t / hours	count rate / counts s^{-1}
0	236.4
2.0	146.6
4.0	97.9
6.0	71.9
8.0	56.2
10.0	47.7
12.0	43.5
14.0	40.4
16.0	40.8
18.0	40.2

Use the graph paper in Fig. 7.2 to plot an appropriate graph, and explain what can be deduced about the activity of the sample at $t = 0$ and the half-lives of the two isotopes in the sample.

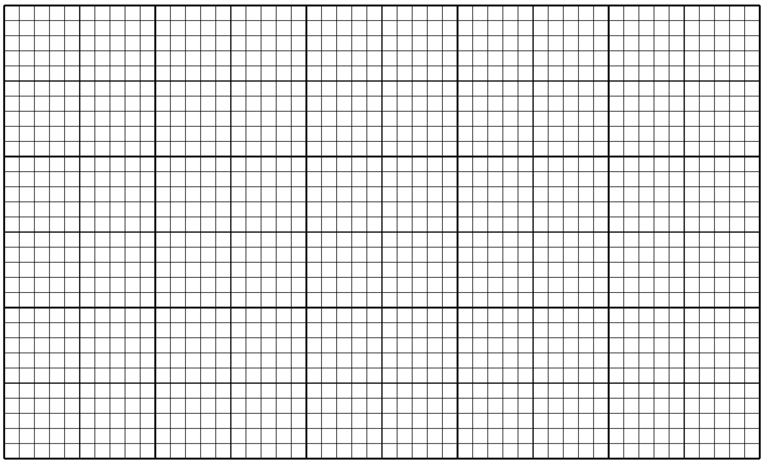

Fig. 7.2

[8]

[Total: 8]

8 Visible light of wavelength 380 nm is shone onto a metal target in a vacuum and photoelectrons are emitted. The maximum kinetic energy of the photoelectrons is 2.73×10^{-19} J.

(a) Calculate

(i) the energy of a photon of light of wavelength 380 nm,

energy = ... J [2]

(ii) the work function of the metal in joules,

work function = ... J [1]

(iii) the work function of the metal in electron-volts,

work function = ... eV [1]

(iv) the threshold frequency for the metal.

frequency = ... Hz [2]

(b) It is observed that a decrease in the intensity of the light does not affect the maximum kinetic energy of the photoelectrons.

Explain this observation and describe how it changes the way in which electromagnetic waves are understood.

....

....

....

....[3]

(c) **(i)** Explain why the photoelectrons do not all have the same energy.

....

....[1]

(ii) The experiment is repeated using a filament lamp that shines white light onto the metal target. The maximum kinetic energy of the photoelectrons is unchanged.

State and explain what this result shows about the radiation from the filament lamp.

....

....[2]

[Total: 12]

End of Section 1

Section 2

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

9 A tidal barrage across the La Rance estuary in Brittany is used to generate electricity.

On a particular day, this power station is operating and supplying energy to the French national grid.

(a) **(i)** State the useful energy change that occurs during this time.

....

....[1]

(ii) Suggest two mechanisms by which energy is wasted as thermal energy during the operation of the power station.

1. ....

....

2. ....

....

[2]

(b) The variation in sea level is measured at La Rance.

Fig. 9.1 shows how sea level varies with time after the largest high tide of the year.

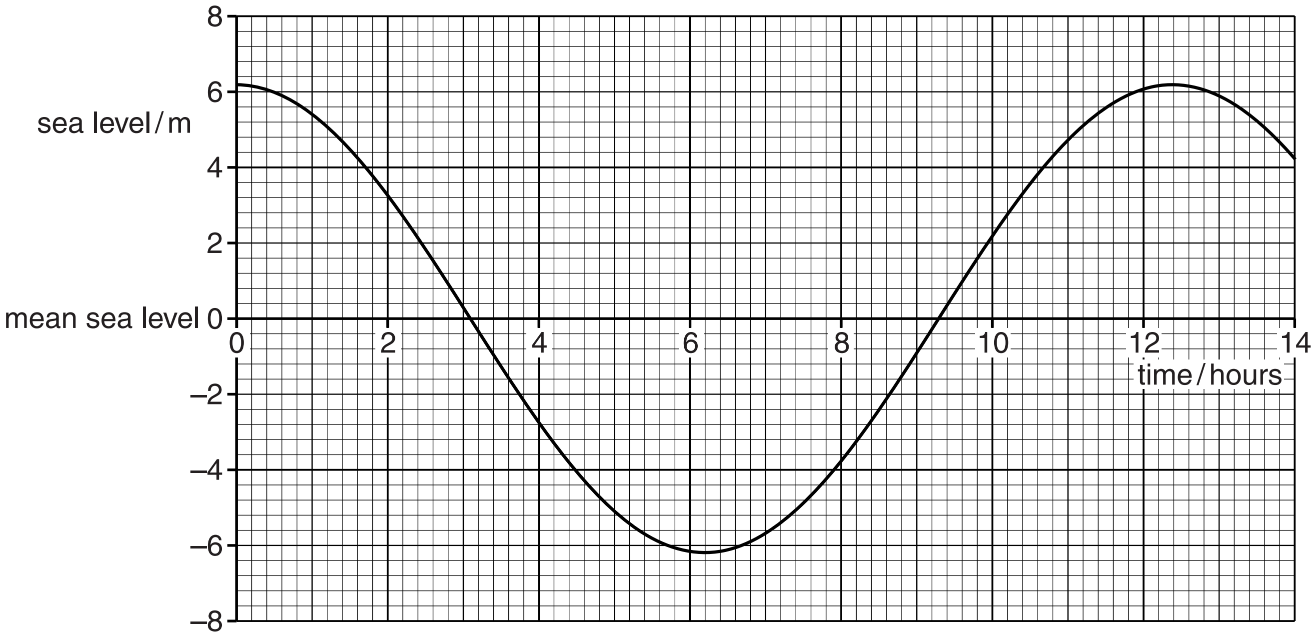

Fig. 9.1

At high tide, sluice gates are closed and water is trapped in the estuary.

At the next low tide, the gates are opened and seawater of density $1.03 \times 10^3\,kg\,m^{-3}$ flows through the generators at a rate of $2100\,m^3\,s^{-1}$.

(i) Calculate the rate at which the water loses gravitational potential energy.

rate = ... $J\,s^{-1}$ [2]

(ii) The power station operates with an efficiency of 0.905 (90.5%).

Calculate the output power (in megawatts) of the power station.

output power = ... MW [1]

(iii) The output power is supplied to the national grid at 225 kV.

Calculate the current supplied.

current = ... A [1]

(c) At La Rance, the annual output of energy is 540 000 000 kWh from 24 generators within the barrage, each of which is rated at 10 MW.

(i) Calculate the capacity factor C_F of the La Rance power station.

capacity factor = ...[3]

(ii) Suggest and explain one reason why it is not possible for the capacity factor of a tidal power station to be equal to 1.00.

....

....

....

....[2]

(d) The ultimate energy source for fossil fuel, biofuel, solar energy, wave energy and wind energy power stations is the thermonuclear fusion reaction taking place within the Sun. This is not the case for a tidal power station.

Discuss the origin of the energy transformed by the La Rance power station and explain the effect on the Earth of the power station.

....

....

....

....

....

....[3]

(e) The Moon's tidal force F_M is a factor that gives rise to the formation of tidal bulges on the surface of the Earth.

Fig. 9.2 shows a small mass of surface seawater positioned on the line joining the Earth to the Moon.

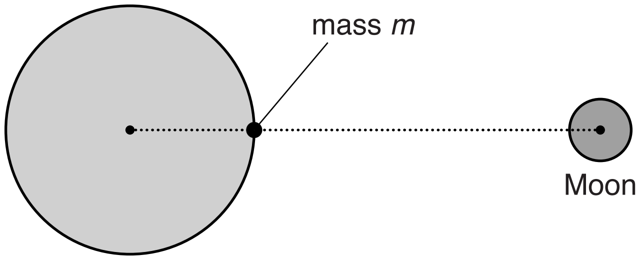

Fig. 9.2 (not to scale)

The tidal force F is the difference between the actual force exerted on the mass m on the surface of the Earth and the force that would be exerted on the same mass if it were placed at the Earth's centre.

(i) Show that the Moon's tidal force F_M on the small mass m is given by the equation

$$F_M = \frac{2GMmR}{r^3},$$

where G is the gravitational constant, M is the mass of the Moon, R is the radius of the Earth and r is the radius of the Moon's orbit.

[3]

(ii) The table gives data for the Earth, Moon and Sun.

radius of Moon's orbit	3.84×10^8 m
radius of Earth	6.38×10^6 m
radius of Earth's orbit	1.50×10^{11} m
mass of Sun	1.99×10^{30} kg
mass of Earth	5.97×10^{24} kg
mass of Moon	7.35×10^{22} kg

1. Calculate the magnitude of the Moon's tidal force F_M on 1.00 kg of seawater, at the position shown in Fig. 9.2.

F_M = ... N [2]

2. When the Earth, Moon and Sun are in a straight line the Sun's tidal force on the mass m in Fig. 9.2 is F_S.

Calculate the ratio $\frac{F_M}{F_S}$ and comment on the significance of your answer.

$\frac{F_M}{F_S}$ = ...

....

....

....
[3]

(iii) The gravitational forces of the Sun and of the Moon on the Earth give rise to spring and neap tides.

Describe, in terms of tidal forces, when and how spring tides are formed.

....

....

....

....[2]

[Total: 25]

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