Class	Index Number	Name
21S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2022
Preliminary Examination

PHYSICS, Higher 2 **9749/02**

Paper 2 Structured Questions **12th September 2022**
2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 9
2	/ 9
3	/ 11
4	/ 10
5	/ 7
6	/12
7	/ 22
Total	/ 80

This document consists of **21** printed pages including this page.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = u t + \frac{1}{2} a t^2$
	$v^2 = u^2 + 2 a s$
work done on/by a gas	$W = p \Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -\dfrac{Gm}{r}$
temperature	T / K $= T$ / °C + 273.15
pressure of an ideal gas	$p = \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \dfrac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$v = \pm \omega \sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire	$B = \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \dfrac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{1/2}}$

Answer **all** the questions in the space provided.

1 **(a)** Fig. 1.1 shows a block of mass 0.30 kg released from rest at a height of 0.10 m above a light spring of force constant 80 N m^{-1}. The block lands on the light board and compresses a vertical spring before rebounding. The spring obeys Hooke's law. Assume that all the energy the block loses becomes elastic potential energy in the spring.

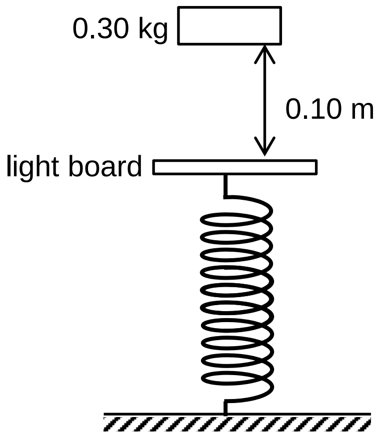


Fig. 1.1

(i) Calculate the maximum compression of the spring.

maximum compression = …………………. m [2]

(ii) When the spring is compressed, the block attains a maximum kinetic energy before coming to a momentary stop. At the position where the block has maximum kinetic energy,

1. show that the compression of the spring is 0.037 m, and

[1]

2. determine the maximum kinetic energy attained by the block using energy considerations.

maximum kinetic energy = ……………………… J [3]

(iii) On Fig. 1.2, show the variation with position of the block of the kinetic energy (label this KE), gravitational potential energy (label this GPE) and elastic potential energy (label this EPE) of the block-spring system.

Take the gravitational potential energy to be zero when the spring is at maximum compression.

There is no need to indicate numerical values.

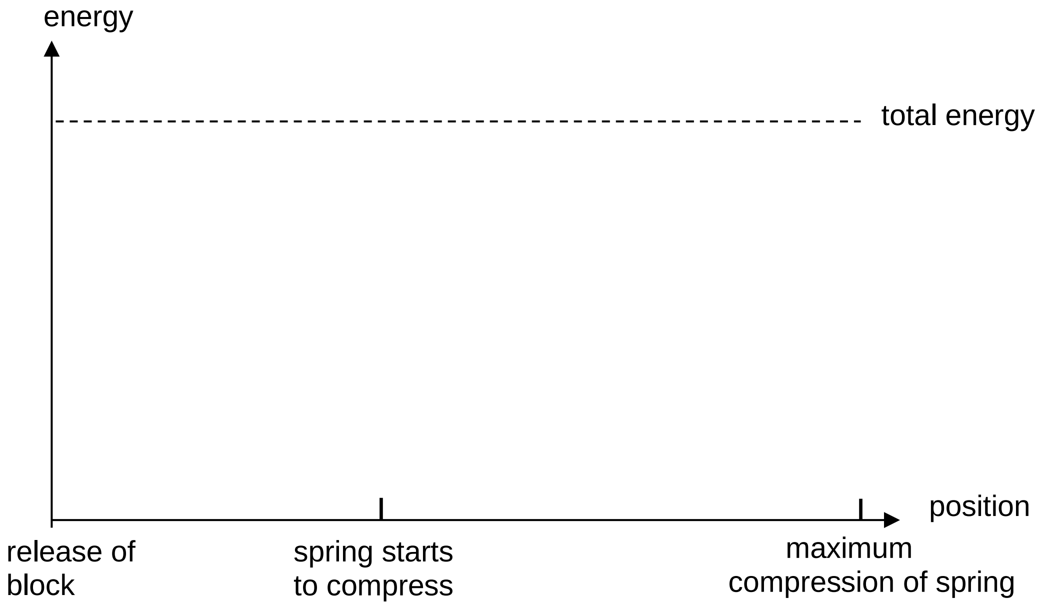


Fig. 1.2

[3]

2 **(a)** A satellite is orbiting the Earth in a circular orbit with a period of 24 hours.

(i) State two conditions under which the orbit of this satellite is geostationary.

1. ……………………………………………………………………………………………..

……………………………………………………………………………………………………

2. ……………………………………………………………………………………………..

……………………………………………………………………………………………………
[2]

(ii) Suggest one advantage of a geostationary satellite used for communiation.

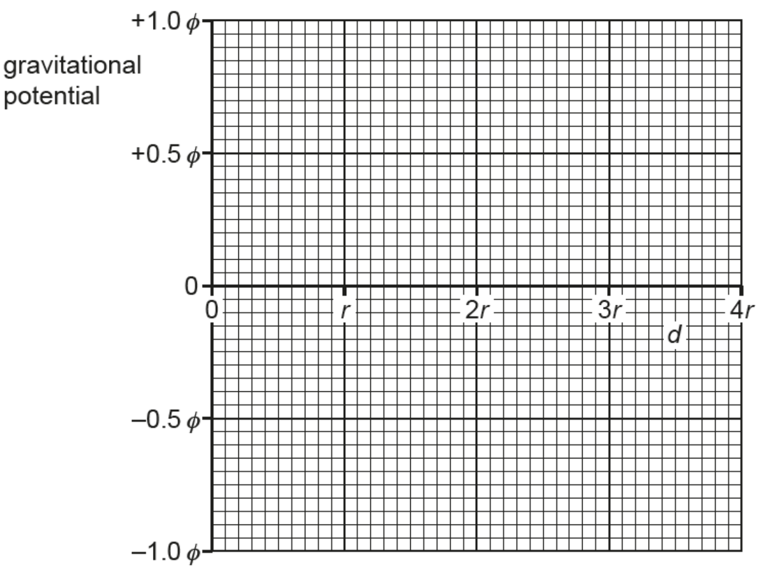
……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(b) **(i)** An isolated solid sphere of radius *r* may be assumed to have its mass M concentrated at its centre. The magnitude of the gravitational potential at the surface of the sphere is ϕ. On Fig. 2.1, show the variation of the gravitational potential with distance *d* from the centre of the sphere for values of *d* from $d = r$ to $d = 4r$.



[2]

Fig. 2.1

(ii) The sphere in **(b)(i)** is a planet with radius r of 6.4×10^6 m and mass M of 6.0×10^{24} kg. The planet has no atmosphere. A rock of mass 3.4×10^3 kg moves directly towards the planet. Its distance from the centre of the planet changes from $4r$ to $3r$.

Calculate the change in gravitational potential energy of the rock.

change = ... J [2]

(iii) Explain whether the rock's speed increases, decreases or stays the same as it moves towards the planet.

....

....

....[2]

3 **(a)** A double-slit interference experiment is set up using coherent red light as illustrated in Fig. 3.1.

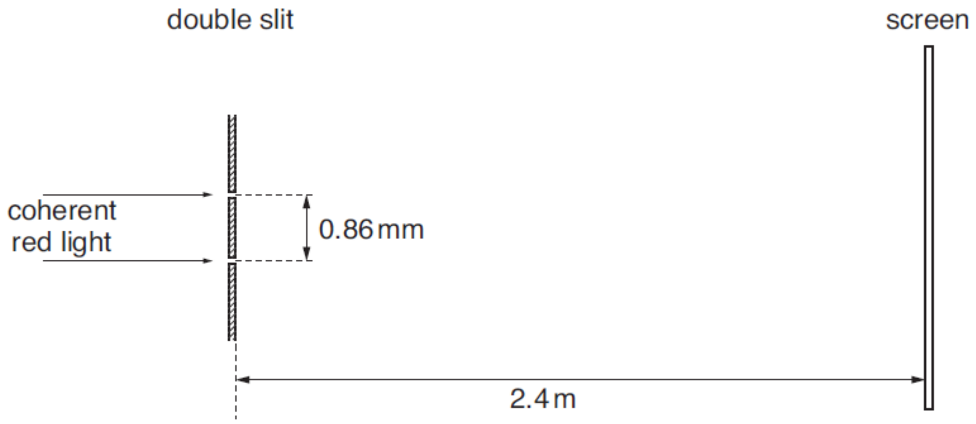


Fig. 3.1 (not to scale)

The separation of the slits is 0.86 mm. The distance of the screen from the double slit is 2.4 m. A series of light and dark fringes is observed on the screen.

(i) State what is meant by *coherent* light.

....

....

....[1]

(ii) Estimate the separation of the dark fringes on the screen.

separation = ………………mm [3]

(iii) Initially, the light passing through each slit has the same intensity. The source is adjusted so that the intensity of the light passing through one of the two slits is reduced.

State and explain the effect, if any, on the dark fringes observed on the screen.

....

....

....

....[3]

(b) Microwave ovens cook food by generating electromagnetic radiation that gets absorbed and converted into the internal energy of the atoms and molecules of the food. A device called a magnetron emits electromagnetic radiation of frequency 2.45 GHz from one side of the microwave oven as shown in Fig. 3.2. Standing waves are produced in the oven's interior.

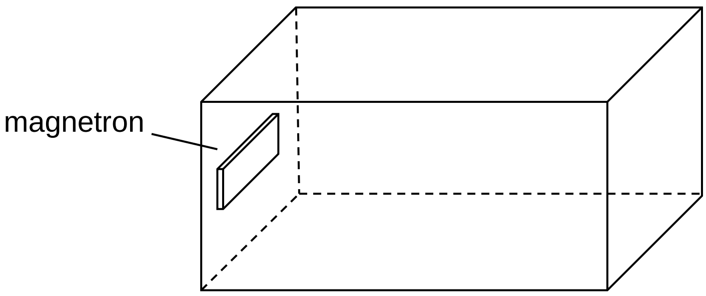


Fig 3.2

(i) Calculate the wavelength of the electromagnetic radiation produced.

wavelength = ………………..m [2]

(ii) The standing wave set up in the microwave is as shown in Fig. 3.3. Label three points P, Q and R on the standing wave that oscillate in phase with the same amplitude.

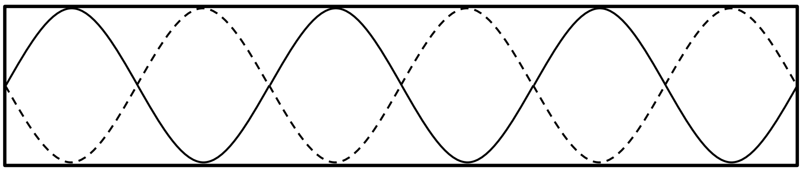


Fig 3.3 [2]

4 **(a)** Fig. 4.1 shows a section through a loudspeaker.

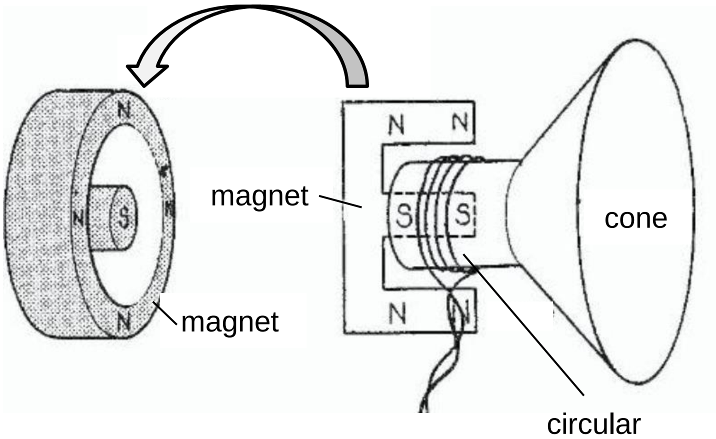


Fig. 4.1

The circular coil is free to move left and right in the space between the North and South poles of the magnet. The magnet is curved. The coil is connected to a d.c. supply of e.m.f. 1.5 V and of negligible internal resistance.

(i) The length of the wire in the coil is 24 m and its resistance is 8.0 Ω. The magnetic flux density of the magnetic field at the position of the coil is 1.2×10^{-2} T. Calculate the force experienced by the wire in the coil due to the radial magnetic field.

force = ………………. N [2]

(ii) Wire of the same length and material but half the diameter of the original wire is used to make a similar coil. State and explain the change to your answer in **(i)** when this coil is used in place of the original one.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(b) Fig. 4.2 shows a horizontal copper wire placed between the opposite poles of a permanent magnet. The wire is in a state of tension and is clamped at each end. The length of the wire in the field of flux density 0.032 T is 6.0 cm.

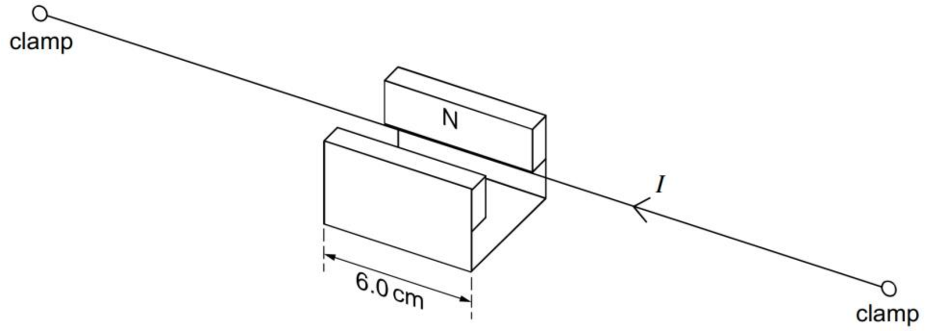


Fig. 4.2

(i) A direct current I is passed through the wire. On Fig. 4.2 draw and label an arrow **F** to indicate the direction of the force on the wire. [1]

(ii) The direct current is changed to an alternating current of constant amplitude and variable frequency, causing the wire to oscillate. Fig. 4.3 shows how the acceleration of the wire at the centre point between the poles varies with time when the frequency of the current is at the fundamental frequency of the wire.

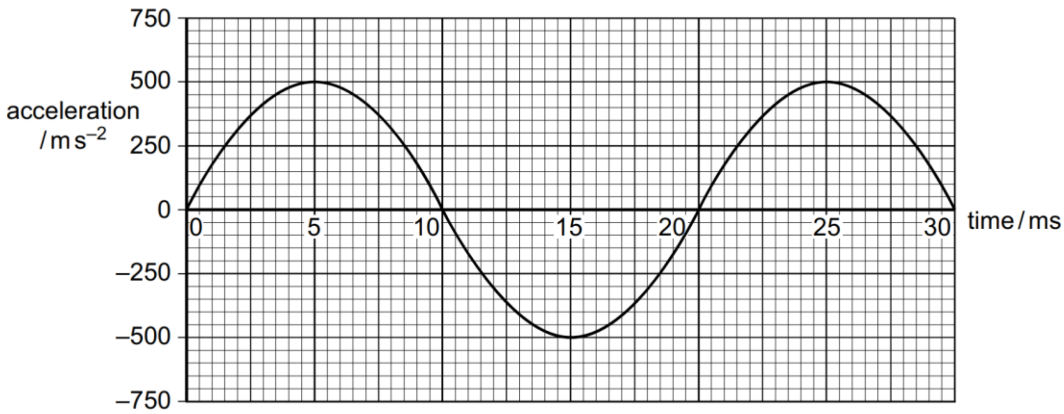


Fig. 4.3

The distance between the clamps is 75 cm. Calculate the speed of the wave in the wire.

speed = …………... m s^{-1} [2]

(iii) Explain whether the maximum acceleration of all points on the wire between the clamps is the same or not. A sketch may help your answer.

....

....

....

....

.... [3]

5 **(a)** In many distribution systems for electrical energy, the energy is transmitted using alternating current at high voltages.

Suggest and explain an advantage, one in each case, for the use of

(i) alternating voltages,

....

....

....[1]

(ii) high voltages.

....

....

....

....[2]

(b) A simple transformer is illustrated in Fig. 5.1.

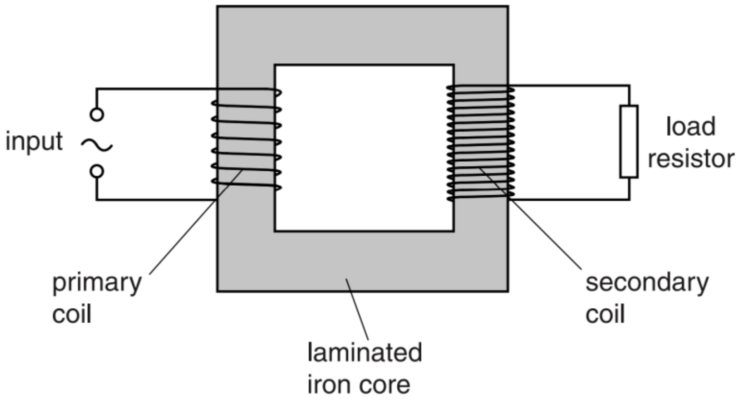


Fig. 5.1

Explain

(i) why the iron core is laminated,

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(ii) what is meant by an *ideal* transformer.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(c) An ideal transformer has 300 turns on the primary coil and 8100 turns on the secondary coil. The root-mean-square input voltage to the primary coil is 9.0 V.

Calculate the peak voltage across the load resistor connected to the secondary coil.

peak voltage = ……………………………………… V [1]

6 **(a)** Fig. 6.1. shows an electrical circuit, which includes a photocell.

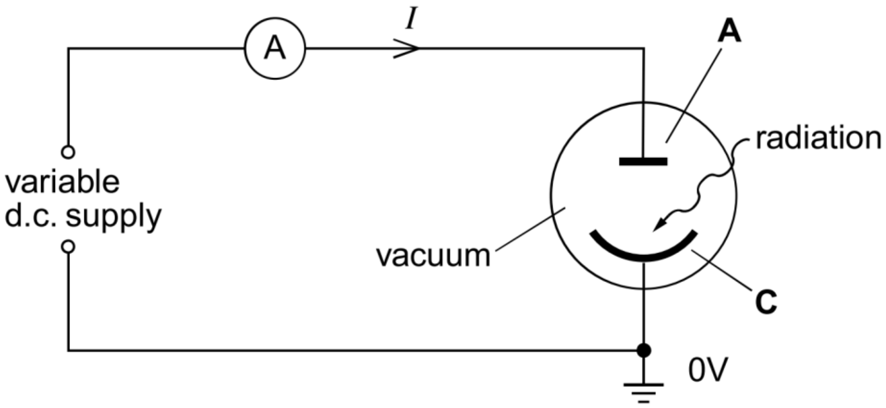


Fig. 6.1

The photocell consists of a metal plate **C** that is exposed to electromagnetic radiation. The photoelectrons emitted travel towards the electrode **A**. A sensitive ammeter measures the current in the circuit.

The plate **C** is illuminated with ultraviolet radiation of constant intensity and of wavelength 2.5×10^{-7} m. Fig. 6.2 shows how the photoelectric current I in the circuit varies with the potential difference V between **A** and **C**.

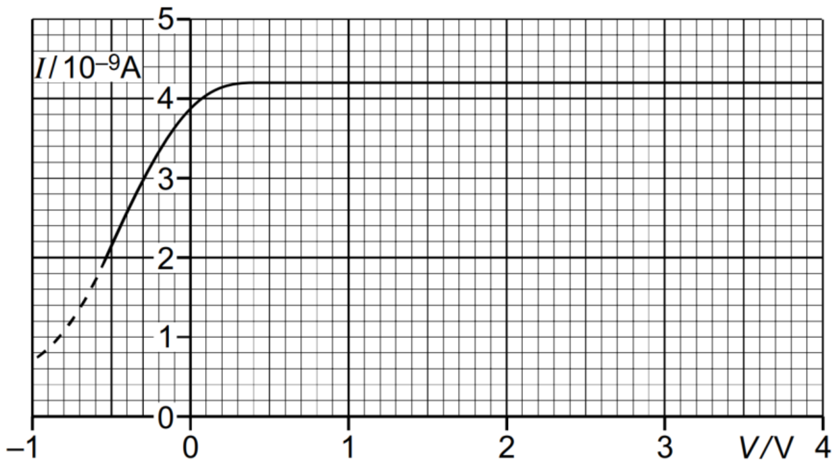


Fig. 6.2

(i) When the potential difference V is 2.0 V, determine the number of electrons per second reaching electrode A.

number of electrons per second = ………………… s^{-1}[2]

(ii) The intensity of the incident ultraviolet radiation is increased.

1. State how the maximum energy of the photoelectrons emitted from plate **C** is changed.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

2. State and explain how the photoelectric current is changed.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(b) The table below shows the work function energies of some metals.

metal	work function energy (eV)
beryllium	5.0
magnesium	3.7
potassium	2.3
silver	4.7
zinc	4.3

(i) Define the *work function energy* of a metal.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(ii) State and explain which metal has the lowest threshold frequency.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(iii) A plate made of magnesium is illuminated with electromagnetic radiation of wavelength 3.2×10^{-7} m. Determine the maximum kinetic energy of the electrons emitted from the surface of the magnesium plate.

maximum kinetic energy = …………………. J [2]

(iv) Calculate the de Broglie wavelength of an electron emitted with the maximum kinetic energy.

wavelength = ……………………. m [2]

7 Read the passage below and answer the questions that follow.

Most sources of energy originate directly or indirectly from the Sun, including fossil fuels, conventional hydroelectric, wind, biofuels, wave power and solar. Unlike these, tidal power is the only source of energy which is drawn directly from the relative motions of the Earth-Moon system. The gravitational forces produced by the Moon and the Sun, in combination with the Earth's rotation, are responsible for the generation of the tides. Periodic changes of water levels and associated tidal currents are due to the gravitational attraction by the Sun and Moon. Tidal power is practically inexhaustible and classified as a renewable energy source. A tidal energy generator uses this phenomenon to generate energy.

Currently, although the technology required to harness tidal energy is well established, tidal power is expensive, and there is only one major tidal generating station in operation. This is the La Rance on the northern coast of France. It has 24 turbines rated at 10 MW each with a total capacity of 240 MW.

Tidal energy is like most other forms of renewable energy in that it cannot be relied upon 100% of the time, so the value quoted above will never be generated in a year. A value of capacity factor C_F is used to estimate the percentage of the maximum that will actually be generated in a year.

$$C_F = \frac{\text{electrical energy actually generated}}{\text{theoretical maximum electrical energy output from generators}}$$

The high and low tides that generate tidal energy are caused by the Moon. Consider the gravitational force exerted on the Earth by the Moon. The tidal force is the small difference between the actual force exerted on a piece of Earth matter at the Earth's surface and the force exerted on the same piece if it were placed at the Earth's centre.

We can write down an equation for the tidal force exerted by the Moon (of mass *M* at a distance *r* from *Earth*) on a body (of mass *m*) placed along the line joining the Earth (of radius *R*) to the Moon as shown in Fig. 7.1.

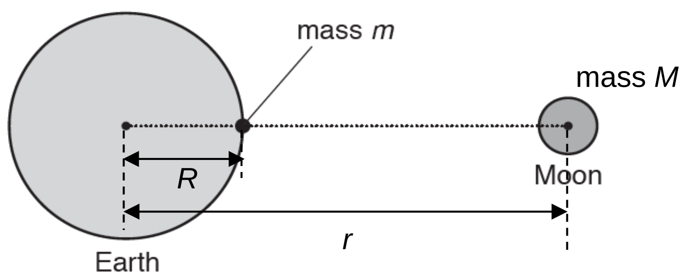


Fig. 7.1 (not to scale)

Assuming *R* is much smaller than *r*, the Moon's tidal force F_M directed away from the Earth's centre has magnitude

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

The tidal force due to the Moon causes the Earth—and its water—to bulge out on the side closest to the Moon and the side farthest from the Moon. These bulges of water are high tides.

The Sun causes tides just like the Moon does, although they are somewhat smaller. When the Earth, Moon, and Sun line up—which happens at times of full moon or new moon—the lunar and solar tides reinforce each other, leading to more extreme tides, called spring tides. When lunar and solar tides act against each other, the result is unusually small tides, called neap tides. The spring and neap tides are illustrated in Fig. 7.2.

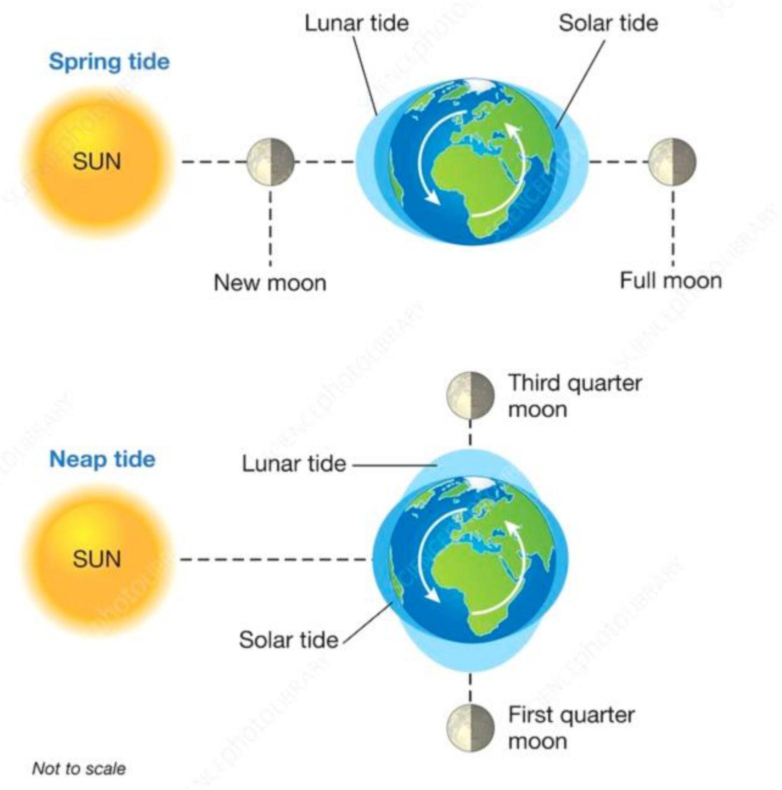


Fig. 7.2

(a) **(i)** Suggest the process in the Sun responsible for providing the energy for fossil fuels, wind energy, biofuels, wave power and solar energy.

....

.... [1]

(ii) The energy source for the La Rance power station is not the Sun. Describe two origins of the energy source for the La Rance power station.

1...

....

2 ....

....

[2]

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

(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]

(c) The variation in sea level is measured at the La Rance. Fig. 7.3 shows how sea level varies with time on a specific day after the largest high tide of the year.

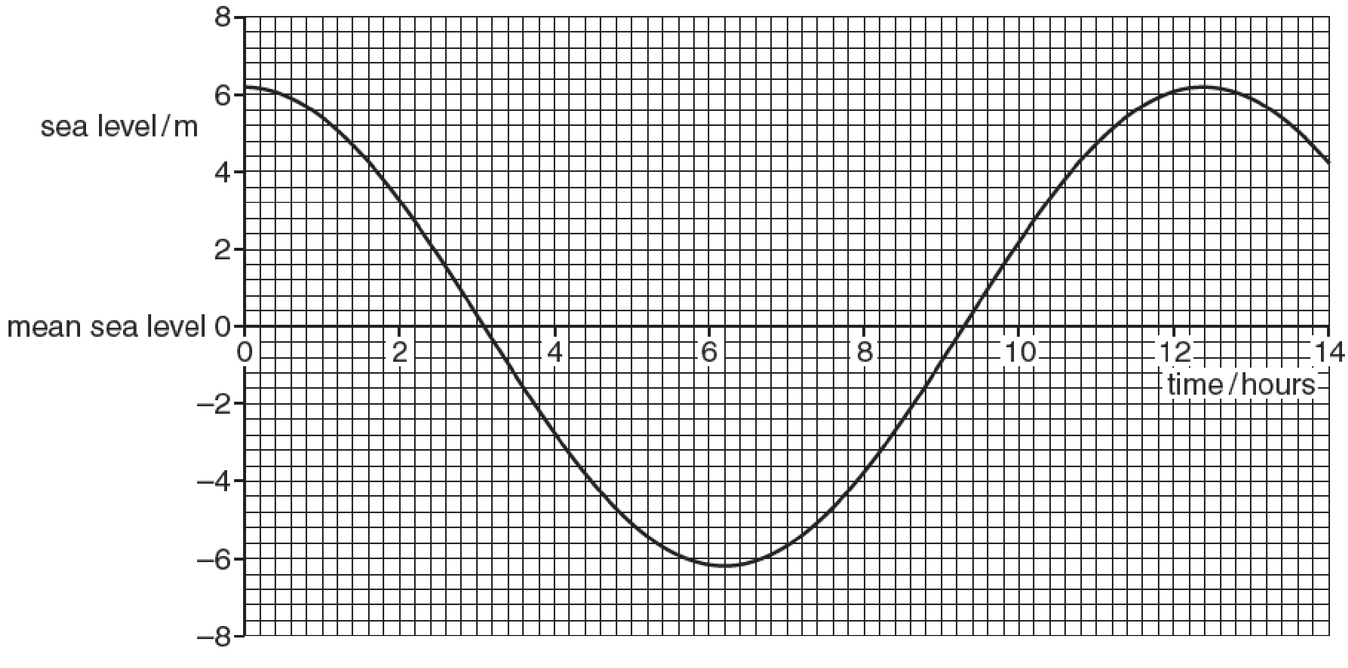


Fig. 7.3

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 1.03×10^3 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 90.5%. Calculate the output power 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 [2]

(d) At the La Rance, the actual annual output of energy is 5.4×10^8 kWh.

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

capacity factor = ………………… [3]

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

....

.... [1]

(e) **(i)** The table gives data for the Earth, Moon and Sun.

radius of Moon's orbit around the Earth	3.84×10^8 m
radius of Earth	6.38×10^6 m
radius of Earth's orbit around the Sun	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. 7.1.

F_M = ... N [2]

2. When the Earth, Moon and Sun are in a straight line the Sun's tidal force on 1.00 kg of seawater in Fig. 7.1 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]

(ii) State in terms of tidal forces, when and how spring tides are formed.

………..

....

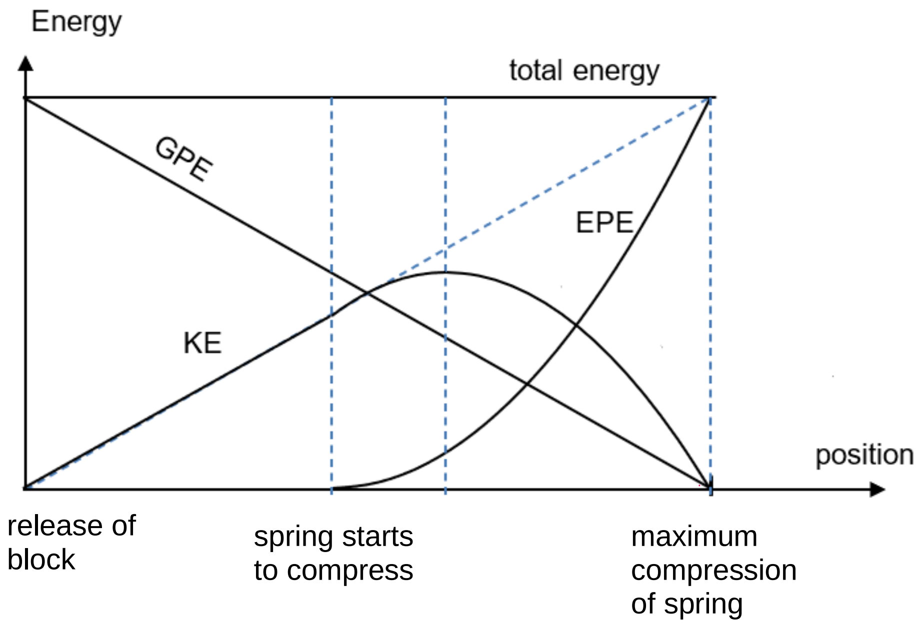
....

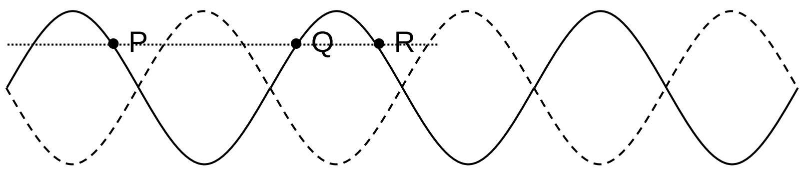
.... [2]

[End of Paper]

JC2 Prelim (H2 Physics) Paper 2 Solutions

1 (a)(i)	{Given: m = 0.3 kg; k = 80 N m^{-1}; obeys Hooke's law} At point of release: v = 0, KE = 0. Let GPE = 0 at the point of release. At point of **max compression**: v = 0,→ KE = 0 **Loss in GPE = Gain in elastic potential energy { + zero KE }** $mg\left(0.10+x_{max}\right)=\frac{1}{2}kx_{max}{}^{2}$ (A) $0.30(9.81)\left(0.10+x_{max}\right)=\frac{1}{2}(80)x_{max}{}^{2}$ $\rightarrow$ Max compression $x_{max}=0.13$ m	[1] [1]
(ii)1.	{As compression (ie x) increases, **upward** force exerted by spring increases **until it becomes = mg (downward);** hence, block **accelerates at a decreasing rate while increasing in speed**, as spring is being compressed under a **net force = mg - kx**. Hence kinetic energy increases **until F_{net} = 0**, (reaches a **max**) ie compression continues until (mg - kx) becomes 0.} At max ke: $mg=kx$ (A) {Explanation: since **F_{net} = 0**} ie 0.30 (9.81) = 80 x $x=\frac{mg}{k}=\frac{0.30(9.81)}{80}$ = 0.037 m (shown)	[1]
2.	Loss in GPE = mg (0.10 **+ 0 .037)** **Loss in GPE = Gain in EPE + Gain in KE** {using energy considerations} **$mg(0.10+0.037)=\frac{1}{2}k(0.037)^2+$ Gain in KE** $\rightarrow$ Gain in KE = Loss in GPE -- EPE $=(0.30)(9.81)(0.10+0.037)-\frac{1}{2}(80)(0.037)^2$ = 0.403 – 0.0547 = 0.35 J $\Rightarrow$ Maximum KE = 0.35 J (initial KE = 0 J)	[1] [1 - ecf] [1 -ecf]

(iii)		[3] {[1] for each correct graph}
2(a)(i)	• Satellite lies on equatorial plane of the Earth. • Rotates fr west to east.	[1] [1]
(a)(ii)	Any 1: • no tracking of the satellite required to receive signals from Earth • Since it's positioned at high altitude, it has a large spatial coverage • can monitor the same area consistently { ie can send & receive transmission from the area under observation without interruption}	[1]
(b)(i)	{Given: ϕ = potential at the surface of sphere of radius *r* . *Required: the potential fr d = r to d = 4r. For d < r: not required*} curve from r to 4r, with gradient of decreasing magnitude and starting at (r, ± ϕ), passing through (2r, ± **0.5ϕ**) and (4r, ± **0.25ϕ)** **according to** $\phi = -\dfrac{GM}{r}$. line (this must be a curve) showing potential is **negative throughout.**	[1] [1]
(ii)	GPE = - GMm/r change = GPE_{final} - $GPE_{initial}$ $= -\dfrac{6.67\times10^{-11}(6.0 \times 10^{24})(3.4 \times10^{3})}{(6.4 \times10^{6})}\left(\dfrac{1}{4}-\dfrac{1}{3}\right)$ **=** - 1.77 $\times$ 10^{10} J = - 1.8 $\times$ 10^{10} J	[1] [1]

(iii)	rock loses GPE, (so) KE increases {by PCE} or GPE converted to KE or since the net force is the attractive gravitational force, there is an acceleration so speed increases.	[1] [1]
3(a)(i)	Two waves are coherent if they have a **constant phase difference** {not zero phase difference} between them.	[1]
(ii)	estimated range of λ (for red light) = 700 nm (650 – 750 nm) Fringe separation $x = \frac{\lambda D}{a}$ where D = 2.4 m; a = 0.86 mm = 8.6 x 10^{-4} m For λ = 700 x 10^{-9} m, x = 1.95 mm {required unit in mm} For 650 nm: x = 1.81 mm; for 750 nm, x = 2.09 mm	[1] [1-ecf] [1-ecf]
(iii)	Dark fringes become **less dark, or, become brighter, or intensity increases.** {Accept**: no longer *completely* dark}** The **amplitudes** of the 2 waves that superpose at a dark fringe are **no longer equal**. (By the Principle of Superposition), the **resultant amplitude** (& hence, intensity), will **no longer be zero**, or , **completely destructive interference** no longer occurs.	[1] [1] [1]
(b)(i)	c = fλ, { where c = 3.00 x 10^8 m s^{-1} , f = 2.45 **G**Hz = 2.45 x 10^9 Hz } $\rightarrow \lambda$ = 0.122 m	[1] [1]
(ii)	 All 3 pts correct: award [2] ; 2 pts correct: [1]	[2]
4 (a)(i)	I = V/R = (1.5)/(8.0) = 0.188 A = 0.19 A F = BILsin90^0 = (1.2×10^{-2})(0.188)(24) = 0.054 N	[1] [1]
(a)(ii)	Resistance of wire increases by a factor of 4 (since R$\propto 1/A,\ A \propto d^2$) or, current decreases by a factor of 4 Hence, force decreases by a factor of 4 (since F $\propto I$)	[1] [1]

(b)(i)	F upwards *between the poles* (perpendicular to wire)	[1]
(b)(ii)	Deduce Period T = 20 ms = 20 x 10^{-3} s (fr Fig 4.3) $\rightarrow$ f = 1/T = 1/(20×10^{-3}) = 50 Hz **λ/2 = 0.75 m** (for **fundamental** frequency) $\rightarrow$ λ = 1.50 m v = f λ = (50)(1.50) = 75 m s^{-1}	[1] [1 – ecf]
(b)(iii)	A **stationary wave** (is formed on the wire between the clamps). {Drawing a diagram with a **single loop** betw the 2 clamps will be most helpful.} **Amplitude varies at every point.** {By drawing, show that the amplitudes at 2 different positions are different. No credit if discussion is on **nodes** and antinodes only because "all points on the wire "BETWEEN THE CLAMPS" means the **nodes are to be excluded from discussion.**} Since **$a = -\omega^2 x$,** (maximum) **acceleration is proportional to amplitude**; hence acceleration is different for different pts on the wire.	[1] [1] [1]
5(a)(i)	AC voltages can be **stepped up and stepped down using a transformer** for a more efficient transmission of power. {This is an advantage because with DC voltages, stepping them up & down is more difficult to achieve.}	[1]
(a)(ii)	For a **given amount of power generated**, electrical energy transmitted at high voltages would mean a **lower current** in the cables { P_{gen} = IV}, & thus, **less power loss** in cables, or **reduced heating** in cables, (or thinner cables can be used, leading to reduced cost).	[1] [1]
(b)(i)	Lamination **reduces** {not: prevents} **power loss in the core** due to **eddy currents.** {Accept "induced current"}	[1] [1]
(b)(ii)	**no power loss** in *transformer* (but not power loss in the wires or power loss in the core) or, **input power (to the primary) = output power (of the secondary)**	[1]
(c)	{ Given: N_P = 300, N_S = 8100 $V_{rms,\ primary}$ = 9.0 V } $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ $\frac{V_s}{9.0} = \frac{8100}{300}$ $\rightarrow$ $V_{rms,sec}$ = 243 V $\rightarrow$ peak $V_s = \sqrt{2} \times 243$ = 344 V = 340 V	 [1]

6 (a)(i)	Q = It $\rightarrow$Ne = It $\frac{N}{t} = \frac{I}{e}$ { I = 4.2 x 10^{-9} A from Fig 6.2 at V = 2.0 V} $= \frac{4.2 \times 10^{-9}}{1.6 \times 10^{-19}}$ = 2.63×10^{10} s^{-1}	[1] [1]
(a)(ii)1.	No change (Max energy is a function of freq & ϕ *since* $hf = \phi + \frac{1}{2} m_e v^2_{max}$)	[1]
(a)(ii)2.	{From line 1 p 14, candidates need to deduce the frequency is kept const as the intensity is increased} Increasing the intensity increases the **<u>rate</u>** (of incidence) of the <u>photons</u>, $\frac{n}{t}$. Hence the photoelectric <u>current increases</u> <u>since current increases when rate of emission of electrons increases.</u>	[1] [1]
(b)(i)	The <u>minimum</u> energy required to eject an electron (from a metal surface).	[1]
(b)(ii)	Since **<u>work function energy $\phi \propto f_0$</u>, or <u>$\phi = hf_0$</u>**, where f_0 is the threshold frequency, potassium has the lowest threshold frequency as **potassium has the lowest work function energy**.	[2]
(iii)	$hf = \phi + KE_{max}$ $h\frac{c}{\lambda} = \phi + KE_{max}$ $\left(\frac{6.63\times10^{-34}\times3\times10^{8}}{3.2\times10^{-7}}\right) = 3.7\times(1.6\times10^{-19}) + KE_{max}$ $KE_{max} = 2.96 \times 10^{-20}$ J	[1] [1]
(iv)	KE = $\frac{1}{2} m_e v^2$ $2.96 \times 10^{-20} = \frac{1}{2} (9.11\times10^{-31}) v^2$ $\rightarrow$ v = 2.549×10^{5} m s^{-1} $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times2.549\times10^{5}}$ = 2.86×10^{-9} m	[1 -ecf] [1 -ecf]

7(a)(i)	Nuclear fusion	[1]
(ii)	**Origin of the energy source**: 1. rotation (energy) of Earth 2. **gravitational forces** produced by the Moon and/or Sun **on the water**{see para 2 line 2 &3}	 [1] [1]
(b)(i)	from GPE to electrical (ignore intermediate kinetic energy) or **rotational** KE (of Earth) to electrical (ignore intermediate kinetic energy)	[1]
(ii)	Any two of: friction between water and pipe, viscosity within water, friction between moving parts, resistive heating in coils, cables eddy currents in transformer / generator	[2]
(c)(i)	Rate of loss of GPE = $mg\Delta h/ t = \rho(V/t)g\boldsymbol{\Delta h}$ $= 1.03 \times 10^3 \times 2100 \times 9.81 \times \mathbf{12.4}$ $= 2.63 \times 10^8$ J s^{-1}	 [1] [1-ecf for incorrect Δh]
(ii)	Output power, P = $(90.5/100) \times 2.63 \times 10^8$ $= 2.38 \times 10^8$ W = 238 MW	 [1-ecf]
(iii)	P = IV where V = 225 kV I = P/V $= 2.38 \times 10^8 / 225 \times 10^3$ $= 1.06 \times 10^3$ A	 [1-ecf] [1]
(d)(i)	(Given: **annual** energy output = 5.4×10^8 **kWh)** $= 5.4 \times 10^8 \times 10^3 \times 3600$ J C_F = actual energy generated / theoretical max electrical energy output Theoretical maximum electrical energy output from generators per annum = $240 \times 10^6 \times 365 \times 24$ Wh (para 2 line 3) {NOT: 238×10^6} $= 2.1 \times 10^{12}$ Wh , or 2.10×10^6 MWh or **2×10^9 kWh** $C_F = 5.4 \times 10^8$ (kWh) / 2×10^9 (kWh) = 0 .257 or 25.7 %	 [1] [1 - ecf for (c)(ii) value e.g 238 MW] [1 – ecf for (c)(ii) value e.g 238 MW]
(ii)	Any one of: (there are times when) generation is less than the maximum level due to energy loss , or, when water levels are not sufficiently different or water levels are equal	[1]

(e)(i)1.	$F_M = 2GMmR / r^3$ $= 2 \times (6.67 \times 10^{-11}) \times (7.35 \times 10^{22}) \times (1.00) \times (6.38 \times 10^6) \div (3.84 \times 10^8)^3$ $= 1.10 \times 10^{-6}$ N	 [1] [1]
2.	$F_M / F_S = (M_M/r_{earth\ orbit}{}^3) \div (M_S/r_{moon\ orbit}{}^3)$ $= 7.35 \times 10^{22} \times (1.50 \times 10^{11})^3 \div (1.99 \times 10^{30} \times (3.84 \times 10^8)^3)$ $= 2.20$ The effect of the Moon on the tides is more significant/2.2 times more than the effect of the Sun	 [1] [1] [1-ecf based on what their ans]
(ii)	Earth, Moon Sun line up/in straight line, (last para lines 2 & 3) (lunar and solar) tides/ tidal forces reinforce each other.	[1] [1]

End of solutions