Class	Index Number	Name
21S		

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

PHYSICS, Higher 2 **9749/01**

Paper 1 Multiple Choice

16th September 2022
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, index number and Civics Group on the Answer Sheet in the spaces provided.

There are **thirty** questions in this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Total	**/ 30**

This document consists of **14** 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	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ 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	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/{}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
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	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{1/2}}$

Answer all questions.

1 The table below shows estimates of some physical quantities.

Which quantity is **not** a reasonable estimate?

	quantity	estimate
A	electric current in a heater	12 A
B	mass of an adult person	70 kg
C	maximum speed of an Olympic sprinter	$10\ m\ s^{-1}$
D	water pressure at the bottom of a swimming pool	10^7 Pa

2 The energy E stored in a certain electronic component is given by

$$E = \frac{Q^n}{2k}$$

where Q is the total charge in the component, n is an unknown integer and k is a physical quantity with SI base units $A^2\ s^4\ kg^{-1}\ m^{-2}$.

What is the value of n?

A -2 **B** -1 **C** 1 **D** 2

3 A micrometer is used to measure the diameters of two cylinders.

diameter of first cylinder = (12.78 ± 0.02) mm
diameter of second cylinder = (16.24 ± 0.03) mm

The difference in the diameters is calculated.

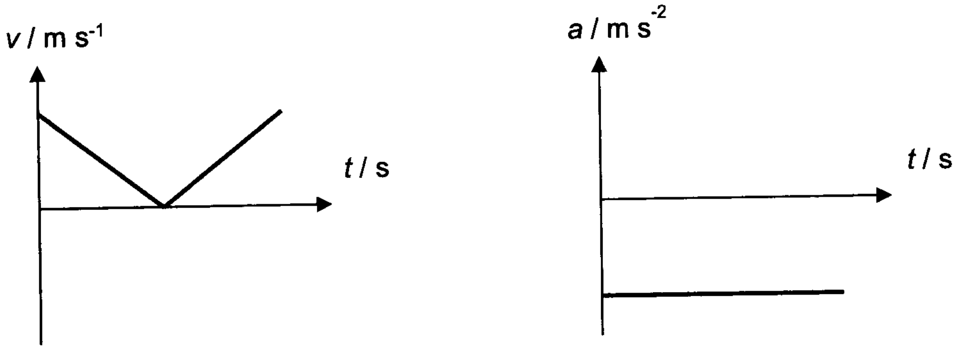
What is the percentage uncertainty in this difference?

A 0.29 **B** 0.58 **C** 0.87 **D** 1.4

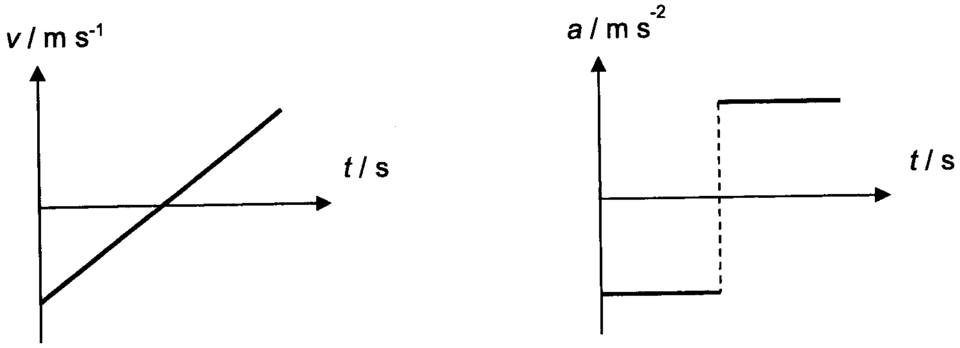
4 A driver decelerates uniformly to a stop as he approaches a junction, turns around immediately, and accelerates at the same rate that he decelerated earlier.

Which of the following velocity-time and acceleration-time graphs best represents this motion?

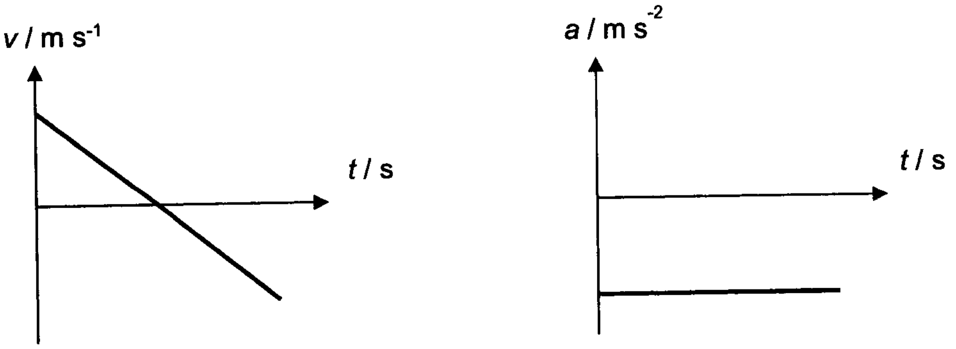
A



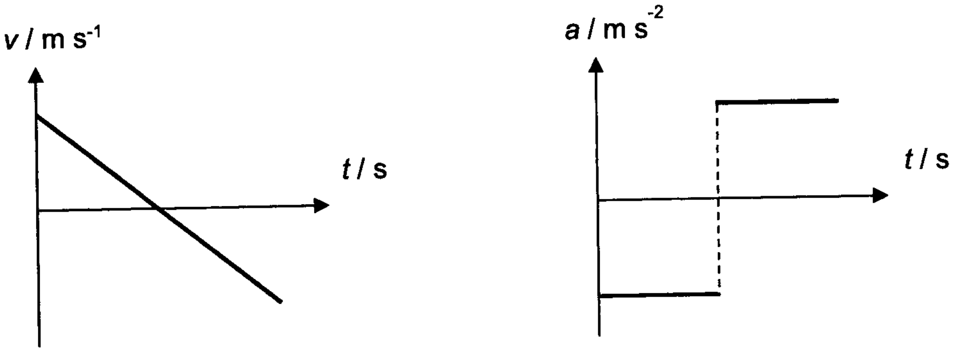
B



C



D

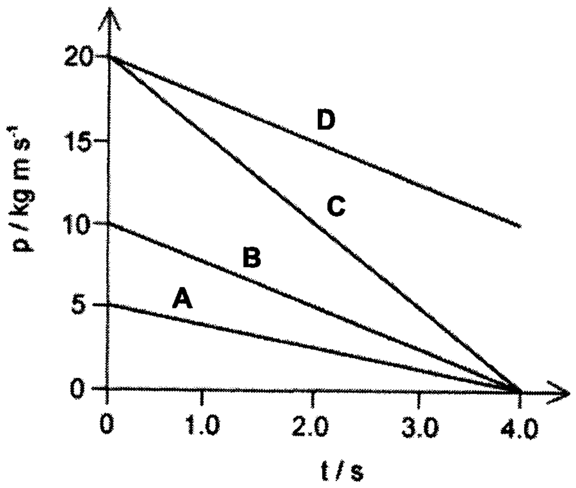


5 Mass M has the same kinetic energy as mass m. What is the ratio of their momenta $\frac{p_M}{p_m}$?

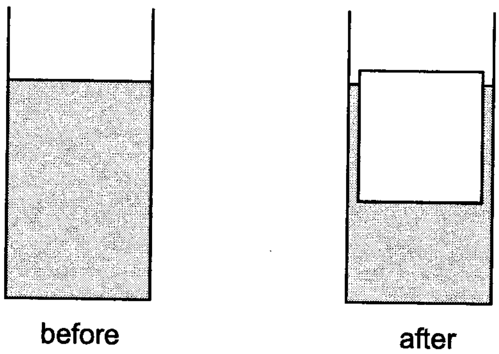
A $\frac{M+m}{M}$ **B** $\frac{M}{M+m}$ **C** $\sqrt{\frac{M}{m}}$ **D** $\sqrt{\frac{m}{M}}$

6 A resultant force of 5 N acts on a body for a time of 4.0 s.

Which graph could show the variation with time t of the momentum p of the body?



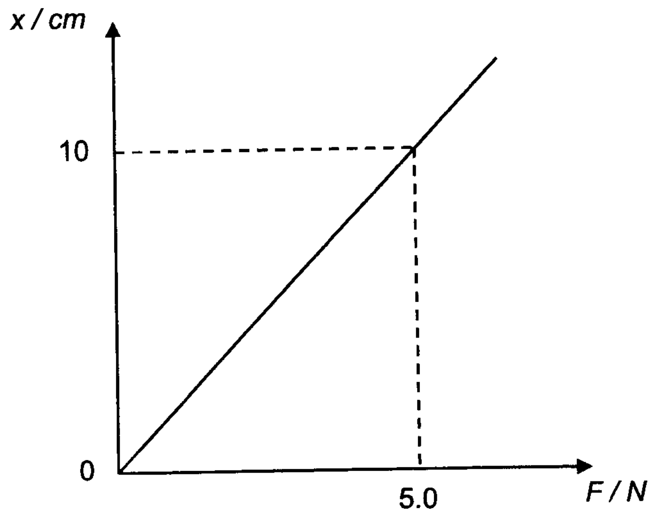
7 A cup contains 100 g of water. The pressure at the bottom of the cup is P.



50 g of water is removed from the cup, frozen into ice, and added back to the cup, as shown above. 10% of the volume of the ice is above the surface of the water.
What is the new pressure at the bottom of the cup?

A 0.95P **B** P **C** 1.05P **D** 1.10P

8 The variation of the extension x of a light spring with the force F applied is shown below.



Slotted masses with a total weight of 3.0 N were initially hung on the spring.

What is the decrease in the elastic potential energy stored in the spring when a slotted mass weighing 0.5 N is removed from the system?

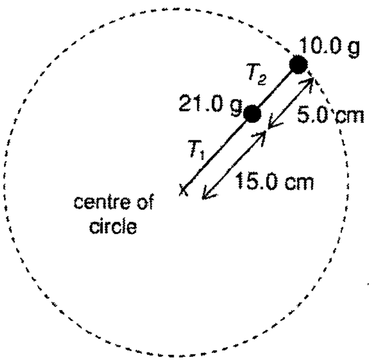
A 0.013 J **B** 0.015 J **C** 0.028 J **D** 0.056 J

9 A lorry of mass 2000 kg has an engine which can deliver a maximum power of 50 kW.

What is the minimum time in which the lorry can be accelerated from rest to a speed of 100 km h^{-1} on level ground?

A 11.3 s **B** 15.4 s **C** 30.9 s **D** 200 s

10 Two blocks of mass 10.0 g and 21.0 g are tied together and performing a uniform horizontal circular motion on a smooth table, at an angular speed of 6.28 rad s^{-1}, as shown below.



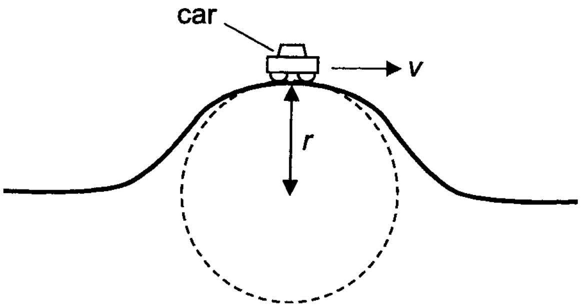
Tension T_1 is the tension in the string connecting the 21.0 g mass to the centre and T_2, the tension in the string connecting the 10.0 g mass to the 21.0 g mass.

What is the ratio T_1 to T_2?

A 1.0 **B** 1.6 **C** 2.1 **D** 2.6

11 A car of mass m moving at a constant speed v passes over a humpback bridge of radius of curvature r.

Given that the car remains in contact with the road, what is the normal reaction force R experienced by the car when it is at the top of the bridge?



A $R = mg + \frac{mv^2}{r}$

B $R = mg - \frac{mv^2}{r}$

C $R = \frac{mv^2}{r} - mg$

D $R = \frac{mv^2}{r}$

12 The acceleration of free fall on the surface of the Earth is 6 times its value on the surface of the Moon. The mean density of the Earth is $\frac{5}{3}$ times the mean density of the Moon.

If r_E is the radius of the Earth and r_M the radius of the Moon, what is the value of $\frac{r_E}{r_M}$?

A 2.4 **B** 3.6 **C** 4.8 **D** 6.0

13 A car tyre, initially at 25^0 C, has been inflated to a pressure of 200 kPa as indicated by the pressure gauge. This means that the pressure in the tyre is 200 kPa above atmospheric pressure of 100 kPa. After driving on hot roads, the temperature of the air in the tyre is 50^0 C.

What is the percentage increase in the pressure gauge reading?

A 8.4 % **B** 12.5 % **C** 100 % **D** 150 %

14 A liquid is maintained at its boiling point by means of an electric heater.
The constant rate at which the liquid boils away is measured for two different powers of the heater as shown.

Power of heater	Rate of loss of mass of liquid
P_1	m_1
P_2	m_2

For each power of the heater, P_1 or P_2, the rate of heat loss h to the environment is the same.

Which expression is correct for the specific latent heat of vaporization of the liquid?

A $\frac{P_1}{m_1}$ **B** $\frac{1}{2}\left(\frac{P_1}{m_1}+\frac{P_2}{m_2}\right)$ **C** $\frac{P_1 - P_2}{m_1 - m_2}$ **D** $\frac{P_1 + P_2}{m_1 + m_2}$

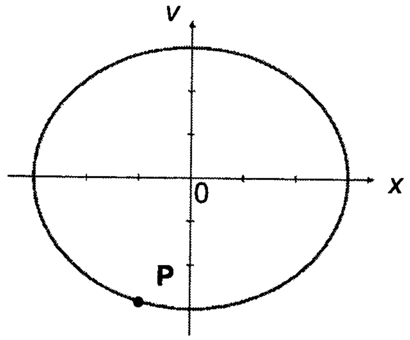
15 A system absorbs 80 J through heating while doing 100 J of external work.

What is the change in the internal energy of the system?

A -100 J **B** -20 J **C** +80 J **D** +180 J

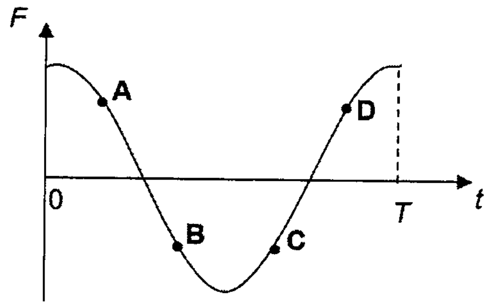
16 An object undergoes simple harmonic motion.

The variation with displacement x of the velocity v of the object is as shown. **P** is a position during the oscillation.



The variation with time t of the net force F acting on the object is as shown below. T is the period of the oscillation.

Which point on the graph corresponds to the state of motion at position **P**?



17 An object placed on a horizontal platform is oscillating vertically in simple harmonic motion with a frequency of 1.5 Hz.

What is the maximum amplitude of oscillation that will allow the object to remain in contact with the platform throughout the motion?

A 0.11 m **B** 1.0 m **C** 6.5 m **D** 9.0 m

18 A sound wave is emitted from a point source. At a distance r from the source, the amplitude of the wave is $8X$.

What is the amplitude at a distance $2r$ from the source?

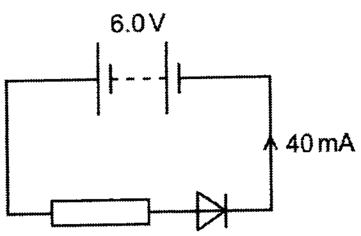
A 8X **B** 4X **C** 2X **D** X

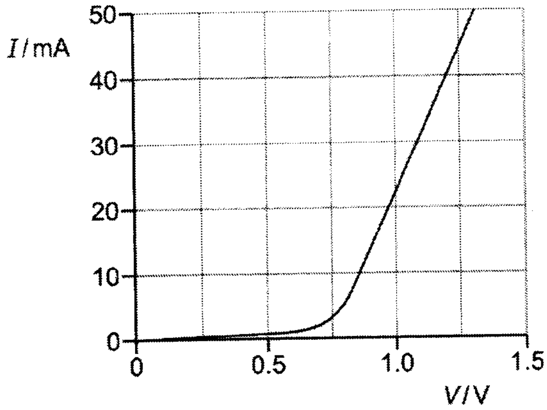
19 A beam of monochromatic light of wavelength 600 nm is incident normally on a diffraction grating that has 3.0×10^5 lines per metre.

What is the total number of images produced by light transmitted through this grating?

A 5 **B** 8 **C** 9 **D** 11

20 A fixed resistor and a diode are connected in series to a battery of electromotive force 6.0 V and negligible internal resistance. The graph shows the variation with potential difference V of the current I for the diode.





The current in the diode is 40 mA.

What is the resistance of the fixed resistor?

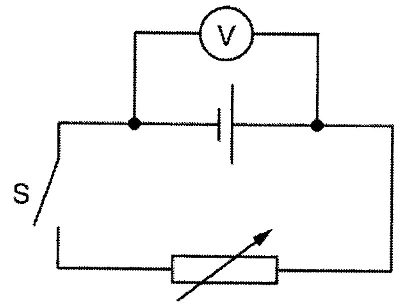
A 30 Ω **B** 120 Ω **C** 150 Ω **D** 180 Ω

21 An electrical cable consists of seven strands of copper wire, each of diameter 0.30 mm, connected in parallel. The resistivity of copper is 1.72×10^{-8} Ω m. The current in the cable is 13 A.

What is the potential difference between two points on the cable a distance of 1.0 m apart?

A 0.0045 V **B** 0.11 V **C** 0.45 V **D** 3.2 V

22 A cell that has internal resistance is connected to a switch S and a variable resistor. A voltmeter is connected between the terminals of the cell, as shown.



When switch S is open, the variable resistor is adjusted to have a value of 8.0 Ω, the voltmeter reads 1.5 V.

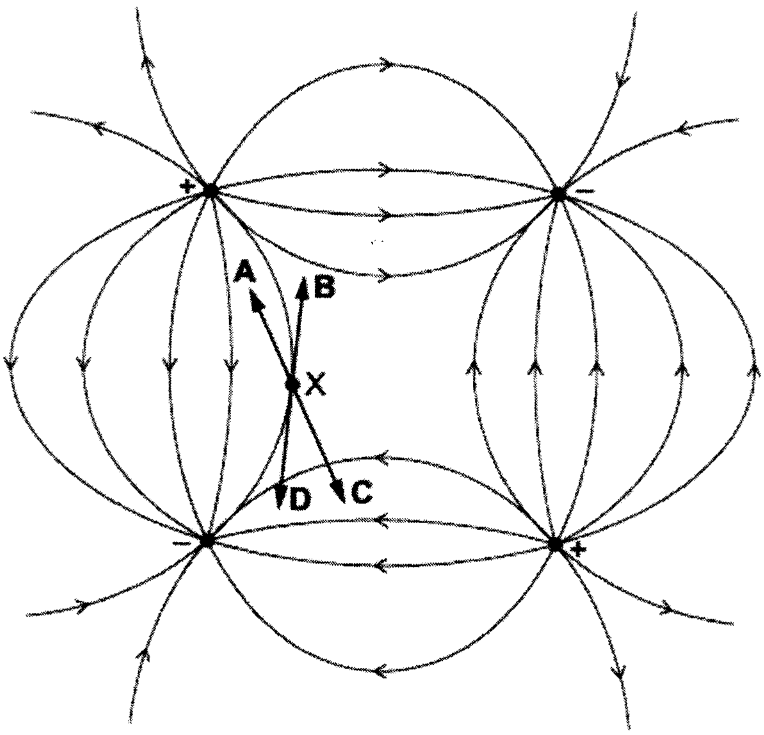
The switch is then closed and the variable resistor is adjusted to have a resistance of 4.0 Ω. The voltmeter now reads 0.75 V.

What is the internal resistance of the cell?

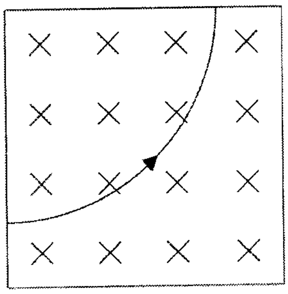
A 1.0Ω **B** 2.0Ω **C** 4.0Ω **D** 8.0Ω

23 The diagram shows an electric field pattern caused by two positive and two negative point charges of equal magnitude placed at the four corners of a square.

In which direction does the force act on an electron at point X?



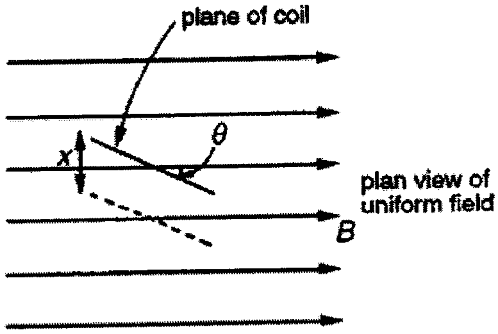
24 A particle is in a region of uniform magnetic field. The field is directed into the plane of the page. The path of this particle is shown in the figure below.



What is this particle and what is the direction of the electric field for it to pass through with no deflection?

	This particle is	Direction of electric field is
A	a positive ion	upwards
B	a positive ion	downwards
C	an electron	upwards
D	an electron	downwards

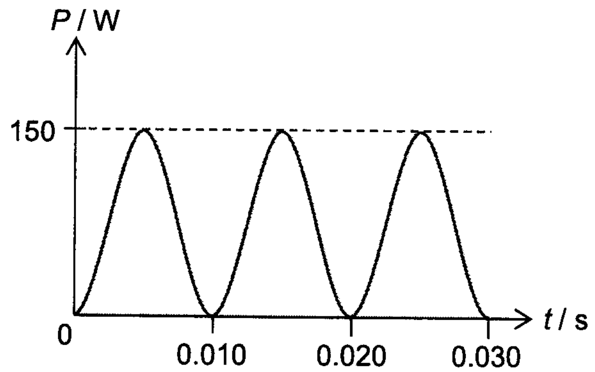
25 A plane coil of wire containing N turns each of area A is placed so that the plane of the coil makes an angle θ with the direction of the uniform magnetic field of flux density B. The coil is now moved through a distance x in time t to the position shown dotted.



What is the e.m.f. induced in the coil?

A zero **B** $NAB\frac{x}{t}$ **C** $NABx\frac{\cos\theta}{t}$ **D** $NABx\frac{\sin\theta}{t}$

26 The graph shows the variation with time t of the power P dissipated in a resistor of resistance 6.0 Ω when it is connected to an alternating supply.



Which equation represents the sinusoidal alternating current through the resistor?

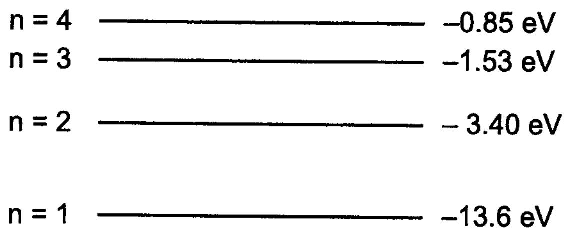
A $I = 5.0 \sin 100\pi t$

B $I = 5.0 \sin 200\pi t$

C $I = 25 \sin 100\pi t$

D $I = 25 \sin 300\pi t$

27 The figure shows the four lowest energy levels of a hydrogen atom. It is known that the wavelength of visible light ranges from 400 nm to 700 nm.



If electrons having kinetic energy of 12.5 eV are used to bombard cool hydrogen gas, how many spectral lines in the visible region can be obtained subsequently?

A 0

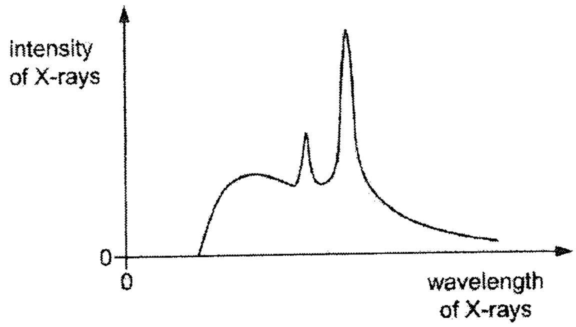
B 1

C 2

D 3

28 X-rays are produced when high speed electrons collide with a metal target. To attain the high speed, electrons are accelerated over a potential difference.

The graph illustrates how the intensity of X-rays varies with their wavelength when the target is tungsten.



The electrons are subsequently accelerated across a higher potential difference.

Which statement is correct?

A The minimum wavelength will decrease.
B The minimum wavelength will increase.
C The number of peaks will increase.
D The position of the peaks will move towards shorter wavelengths.

29 Nuclei of atoms can exist in excited states. When an excited nucleus returns to its state of lowest energy (the ground state), a γ-ray photon may be emitted.

The mass of a nucleus in its ground state is 59.9308 u. The energy of the photon emitted when this nucleus returns from an excited state to the ground state is 2.13×10^{-13} J.

What is the mass of the nucleus in the excited state?

A 59.9208 u **B** 59.9294 u **C** 59.9322 u **D** 59.9337 u

30 Antimony-124 undergoes radioactive decay, with a half-life of 60 days, to become tin-124. Tin-124 is stable.

Initially, a sample of antimony-124 contains no tin-124.

After what period of time will the ratio $\dfrac{\text{number of tin-124 nuclei}}{\text{number of antimony-124 nuclei}}$ equal 6?

A between 60 days and 120 days
B 120 days
C between 120 days and 180 days
D 180 days

[End of Paper]

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

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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}

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pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
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	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{1/2}}$

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.

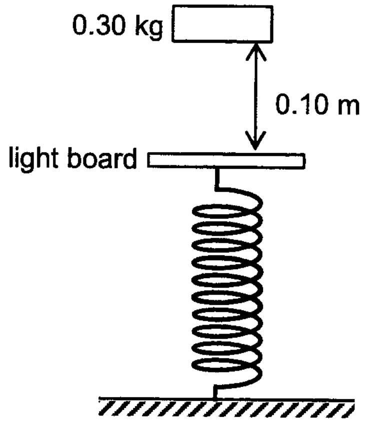


Fig. 1.1

(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.

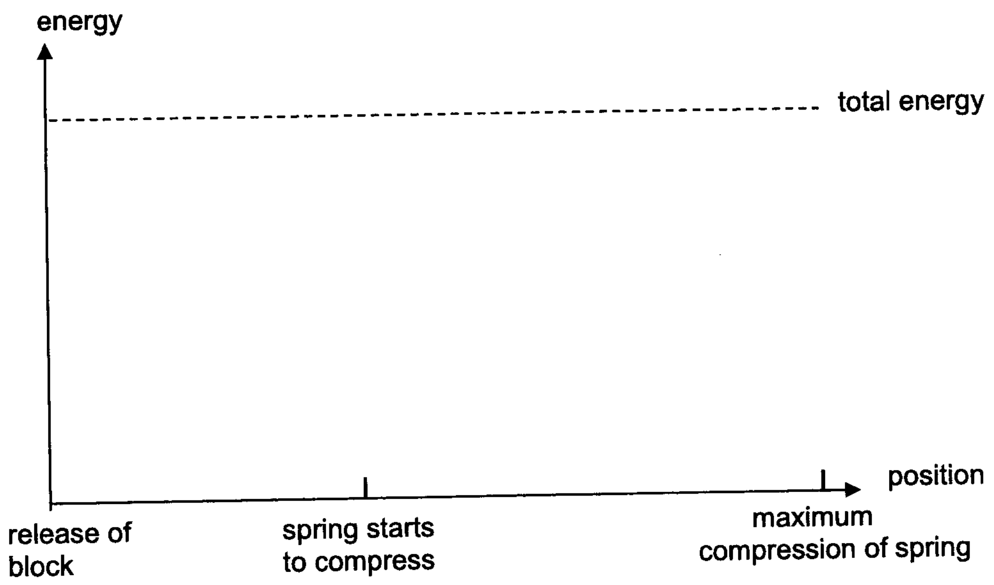


Fig. 1.2

[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.

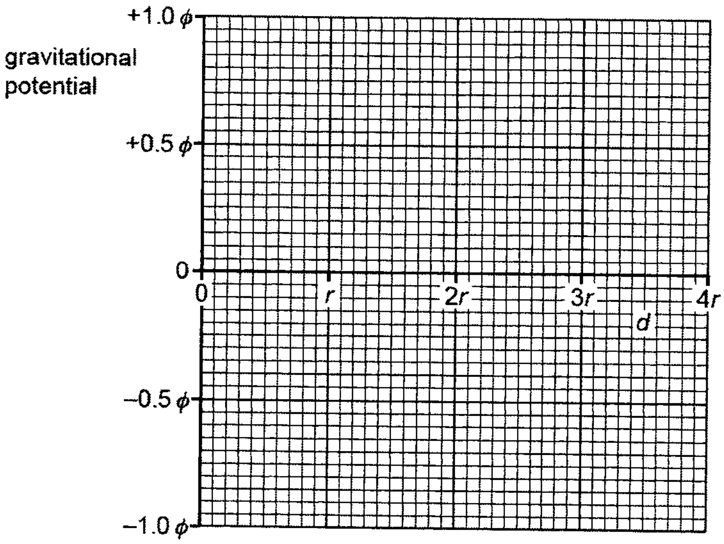
....

....

....

.... [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.

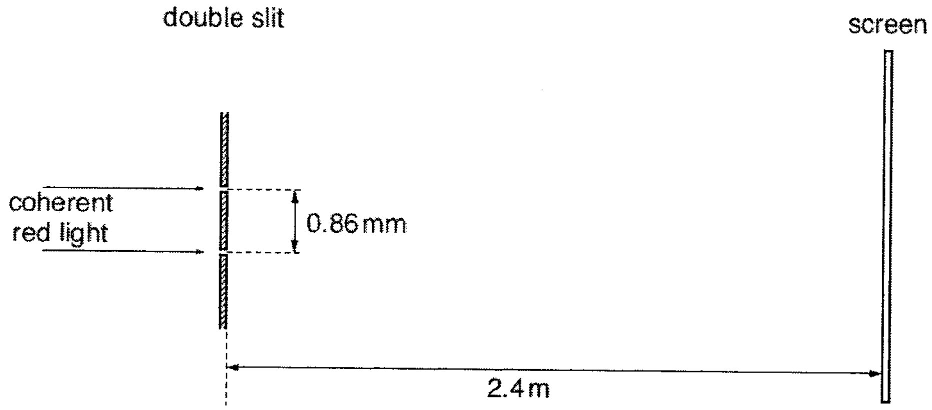


Fig. 3.1 (not to scale)

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.

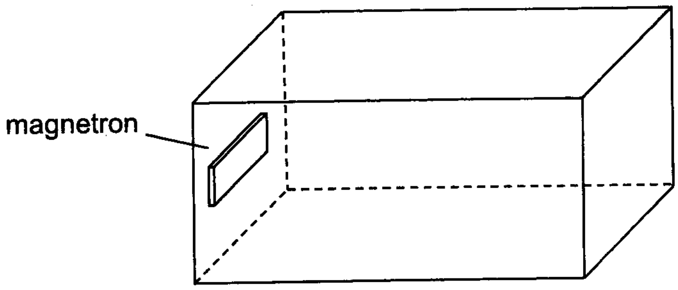


Fig 3.2

(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.

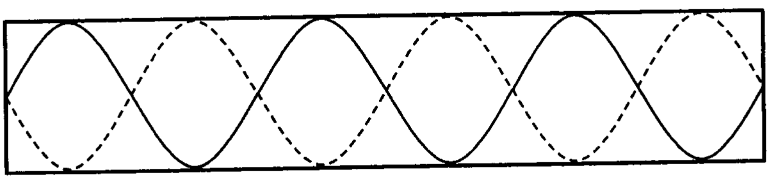


Fig 3.3 [2]

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

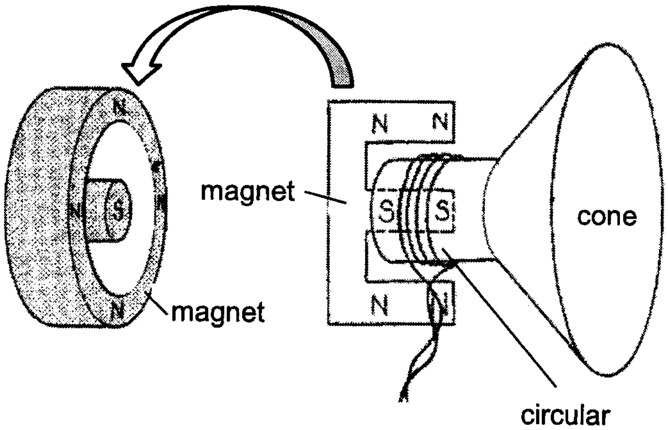


Fig. 4.1

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.

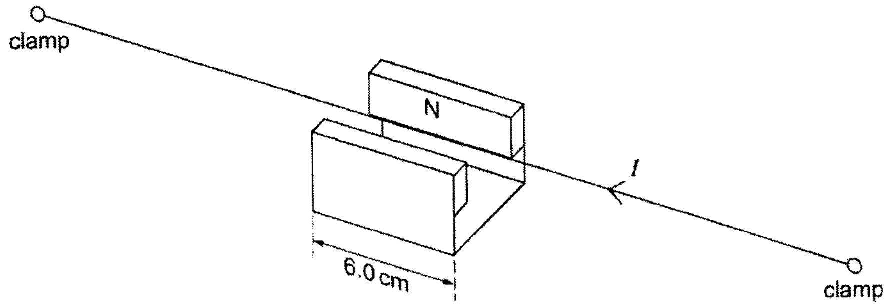


Fig. 4.2

(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.

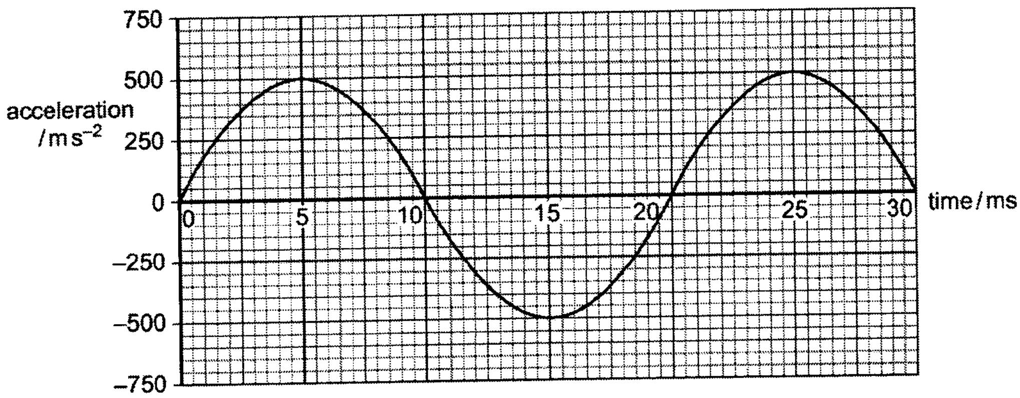


Fig. 4.3

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.

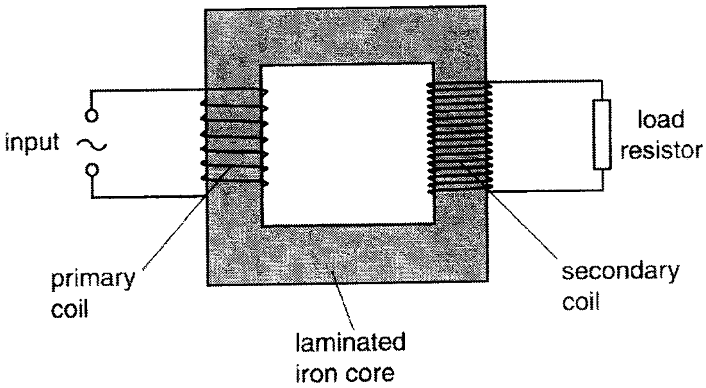


Fig. 5.1

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.

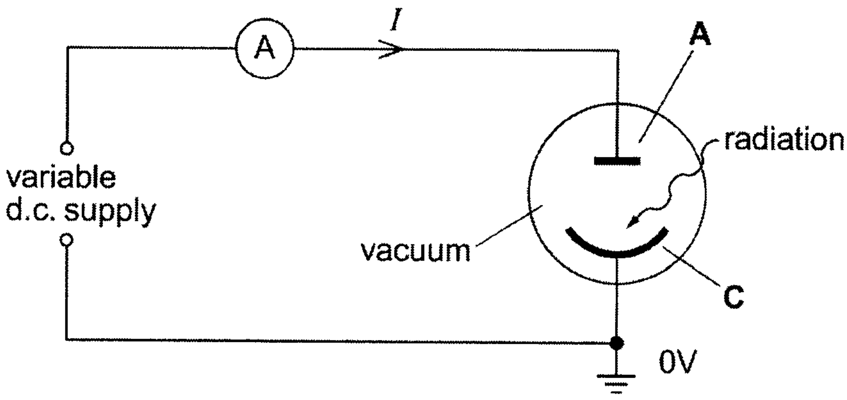


Fig. 6.1

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**.

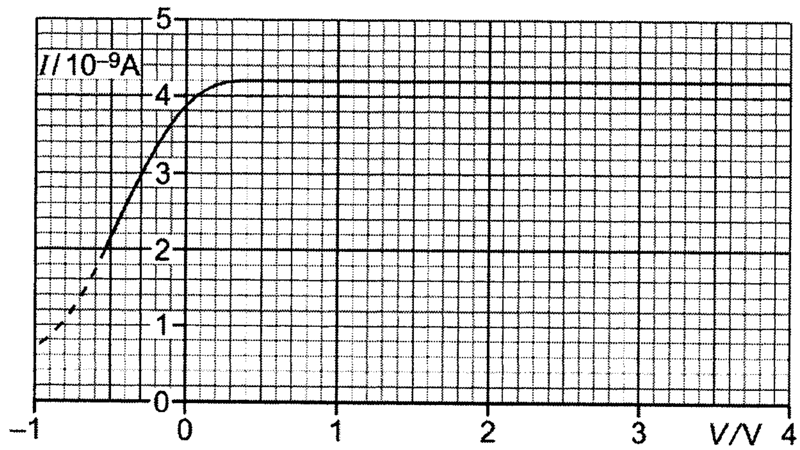


Fig. 6.2

(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.

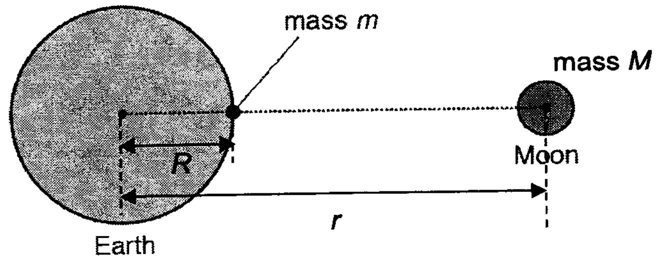


Fig. 7.1 (not to scale)

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.

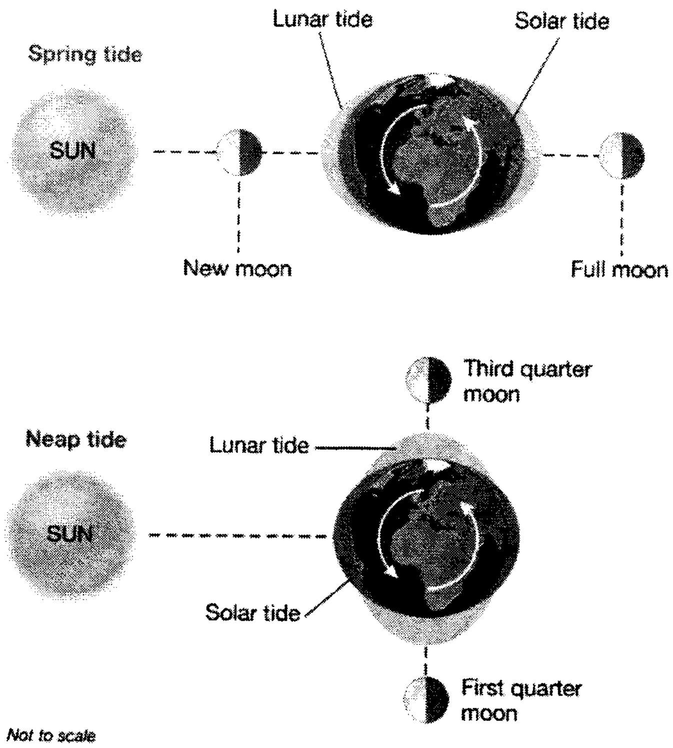


Fig. 7.2

(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.

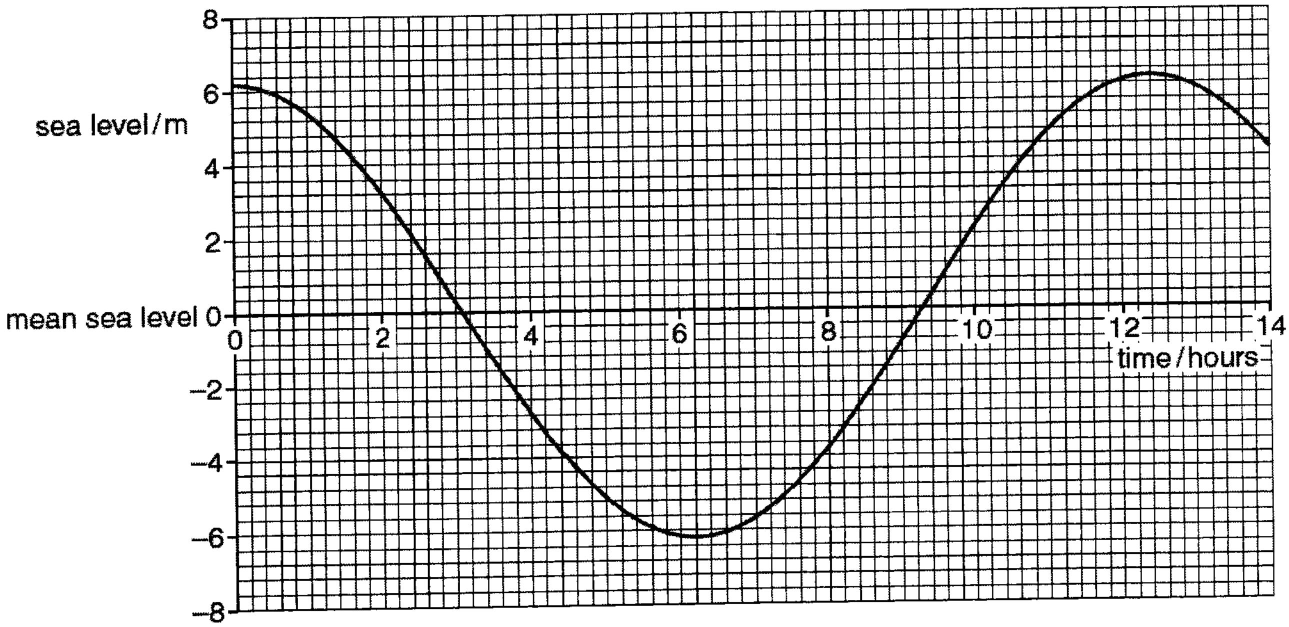


Fig. 7.3

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 x 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]

Class	Index Number	Name
21S		

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

PHYSICS, Higher 2 **9749/03**

Paper 3 Longer Structured Questions **15th 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.

Section **A**
Answer **all** questions.

Section **B**
Answer **one** question only.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

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

For Examiner's Use	
Section A	
1	/ 9
2	/ 8
3	/ 11
4	/ 8
5	/ 6
6	/ 7
7	/ 11
Section B	
8	/ 20
9	/ 20
Total	/ 80

This document consists of **24** 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	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ 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	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\phi = -\dfrac{Gm}{r}$
temperature	$T/\text{K} = T/^{\circ}\text{C} + 273.15$
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.	$x = x_0 \sin \omega t$
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	$x = x_0 \sin \omega t$
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	$B = \dfrac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{1/2}}$

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

1 **(a)** **(i)** State the principle of moments.

....

....

....[1]

(ii) Fig. 1.1 shows an arrangement used to demonstrate the principle of moments.

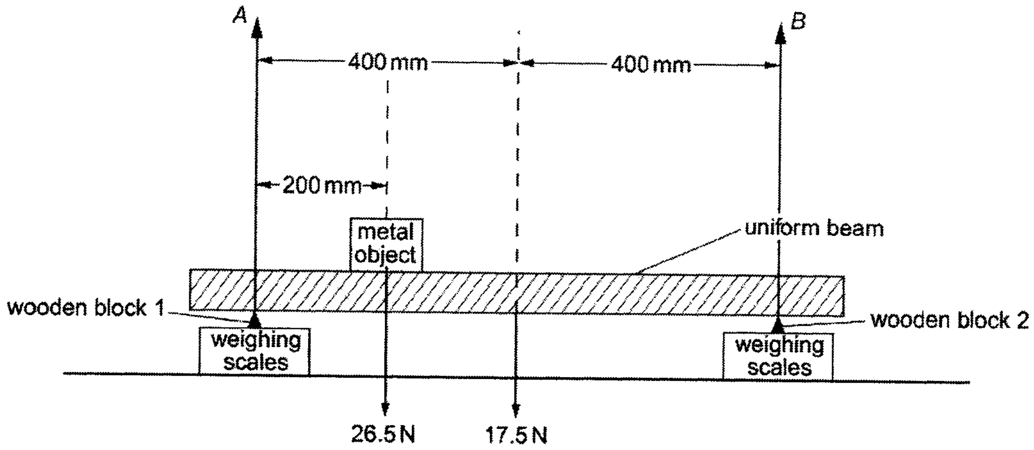


Fig. 1.1

A uniform beam is supported on the edges of two triangular shaped wooden blocks placed on two weighing scales. The weight of the beam is 17.5 N and the distance between the wooden blocks is 800 mm. A metal object of weight 26.5 N is placed 200 mm from one of the blocks. The blocks exert upward forces *A* and *B* on the beam.

Calculate the force *B*.

B = ... N [2]

(iii) State the magnitude of the sum of the two forces *A* and *B* and explain your answer.

....

....

....[2]

(iv) Describe what happens to the forces *A* and *B* as the metal object is gradually moved to the centre of the beam.

....

....

....

....[2]

(b) Fig. 1.2 shows a girl supported by two elastic ropes. She is in equilibrium. Her weight is 392 N.

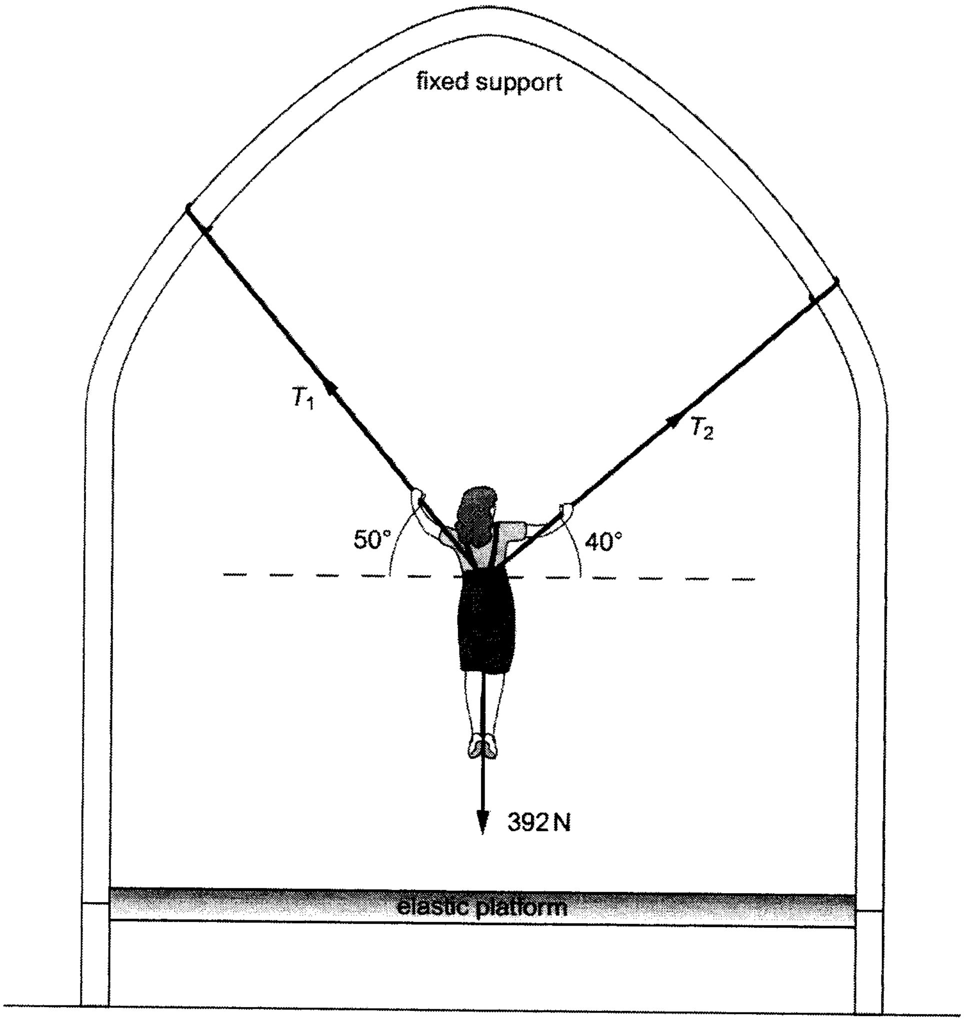


Fig. 1.2

Determine the tensions T_1 and T_2 in the two ropes.

tension T_1 = ... N

tension T_2= .... N [2]

2 (a) One mole of hydrogen at a temperature of 420 K is mixed with one mole of oxygen at 320 K. After a short period of time the mixture is in *thermal equilibrium*.

(i) Explain what is meant by *thermal equilibrium*.

....[1]

(ii) The kinetic theory of gases leads to the derivation of the equation

$$pV = \frac{1}{3}Nm < c^2 > .$$

Using the formula above and the ideal gas equation, derive an expression for the mean kinetic energy of an ideal gas molecule in terms of the Boltzmann constant, *k*, and the temperature *T*.

[2]

(iii) Hence determine the average kinetic energy of a hydrogen molecule *before* the two gases are mixed.

kinetic energy = ...J [1]

(b) **(i)** Two different gases at the same temperature have molecules with different mean square speeds. Explain why this is so.

....

....

....[2]

(ii) Explain why in the earth's atmosphere, there is hardly any hydrogen, compared to oxygen molecules.

....

....

....

....

....[2]

3 (a) A mass undergoes simple harmonic motion. For a displacement x that is measured from its equilibrium position, the acceleration a of the mass m is given by the expression

$$a = -\frac{16}{m}x$$

(i) Explain how the expression leads to the conclusion that the mass is performing simple harmonic motion.

....

....

....

....

....[3]

(ii) Fig. 3.1 shows the variation of the potential energy of the mass with time.

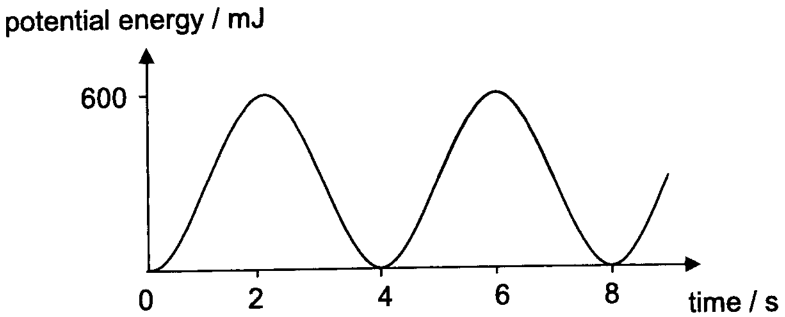


Fig. 3.1

Calculate

1. the frequency for the oscillations of the mass,

frequency = ... Hz [1]

2. the mass,

mass = ... kg [2]

3. the amplitude of the oscillations.

amplitude = ... m [2]

4. Mark a point on Fig. 3.1 between 0 and 4 s and mark it as Z when the mass is exactly mid-way between the equilibrium position and amplitude position. [1]

(b) On Fig. 3.2, sketch a labelled graph of the variation of the velocity with time of the mass for 2 periods.

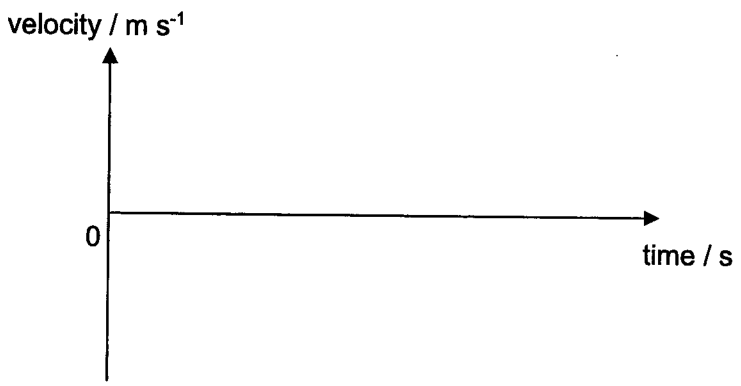


Fig. 3.2

[2]

4 (a) A fire alarm on a wall produces a loud sound during a fire drill in SAJC. The speed and frequency of the sound waves are 330 m s^{-1} and 5000 Hz respectively.

(i) Determine the phase difference between any two air molecules which are 3.3 cm apart in the direction of propagation.

phase difference = ...rad [2]

Hence state whether they are oscillating *in phase* or *in anti-phase*.

....[1]

(ii) The surface area of a human eardrum is approximately 5.5×10^{-5} m^2. Calculate the energy received at a person's eardrum given he is at 24 m away from the alarm for 15 s and the average sound intensity at the eardrum is 3.0×10^{-2} W m^{-2}.

energy = ...J [2]

(iii) State the assumption that you have made.

....

....[1]

(b) Distinguish between a *polarised* wave and an *unpolarised* wave.

....

....

....[2]

5 (a) A d.c. supply is connected across a variable resistor. The resistance of the variable resistor is changed. Fig. 5.1 shows the variation of the power P dissipated in the resistance R of the variable resistor.

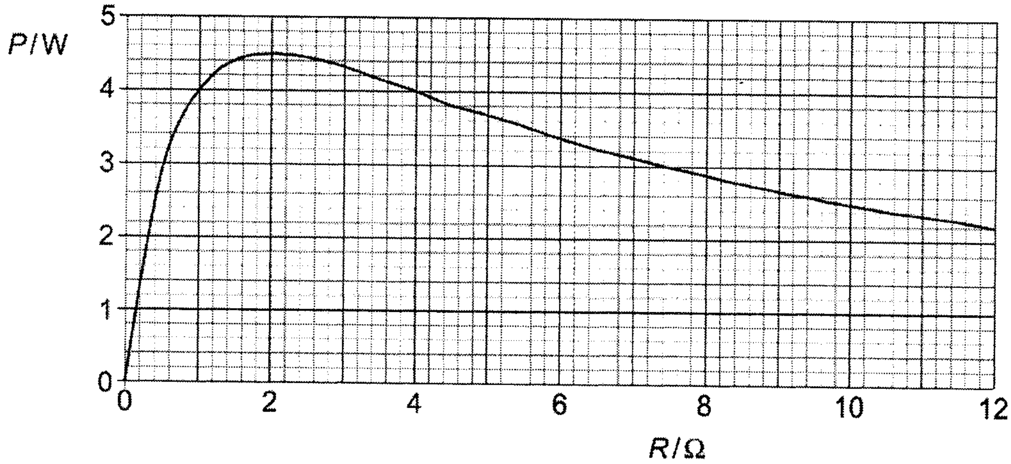


Fig. 5.1

(i) Use Fig. 5.1 to determine the potential difference across the variable resistor when it dissipates maximum power.

potential difference = ... V [2]

(ii) Explain why your answer in **(i)** is not equal to the e.m.f. of the supply.

....

....

....[1]

(b) Fig. 5.2 shows a circuit. The battery has negligible internal resistance.

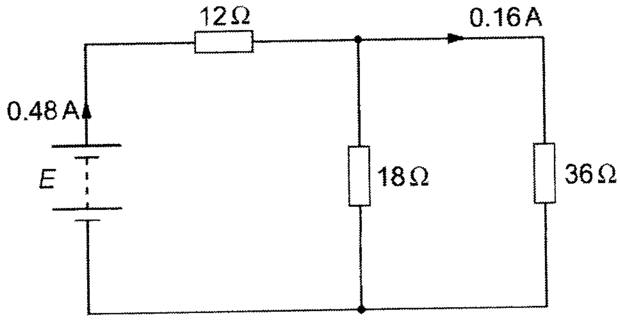


Fig. 5.2

(i) Determine the number of electrons passing through the battery in a time of 150 s.

number = ... [1]

(ii) Determine the e.m.f. *E* of the battery.

e.m.f. = ... V [2]

6 **(a)** State Faraday's law of electromagnetic induction.

....

.... [1]

(b) The diameter of the cross-section of a long solenoid with 15 turns is 3.2 cm, as shown in Fig. 6.1

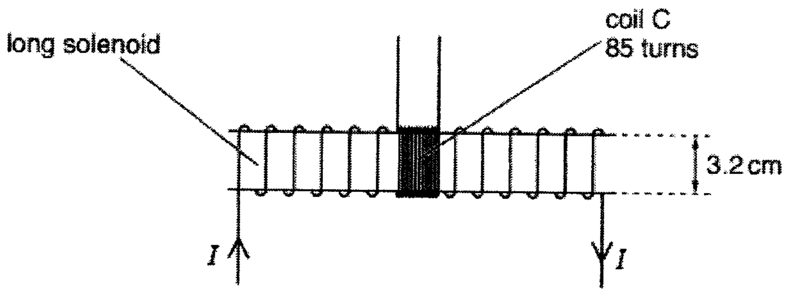


Fig. 6.1

A coil **C**, with 85 turns of wire, is wound tightly around the centre region of the solenoid. The magnetic flux density B, in tesla, at the centre of the solenoid is given by the expression

$$B = \pi \times 10^{-3} \times I$$

where I is the current in the solenoid in ampere.

(i) Calculate, for a current I of 2.8 A in the solenoid, the magnetic flux linkage of the coil **C**.

magnetic flux linkage = ... Wb [1]

(ii) The current I in the solenoid in **(b)(i)** is reversed in 0.30 s. Calculate the mean e.m.f. induced in coil **C**.

e.m.f. induced = ... V [2]

(iii) The current I in the solenoid in **(b)(i)** is now varied with time t as shown in Fig. 6.2.

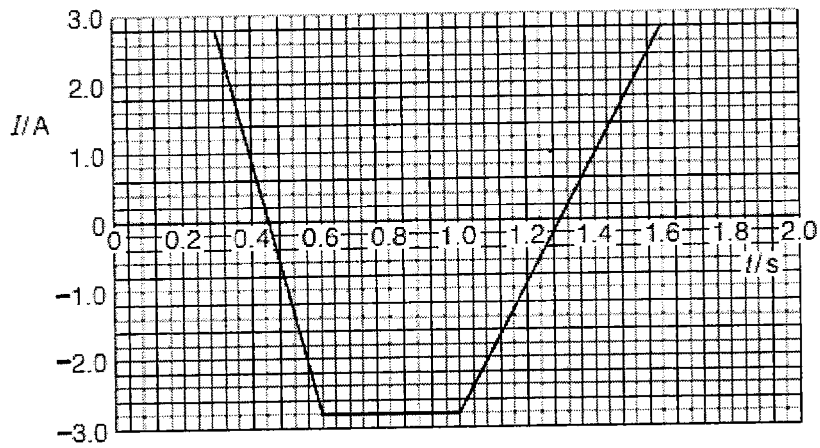


Fig. 6.2

Use your answer to **(b)(ii)** to show, on Fig. 6.3, the variation with time t of the e.m.f. E induced in coil **C**. [3]

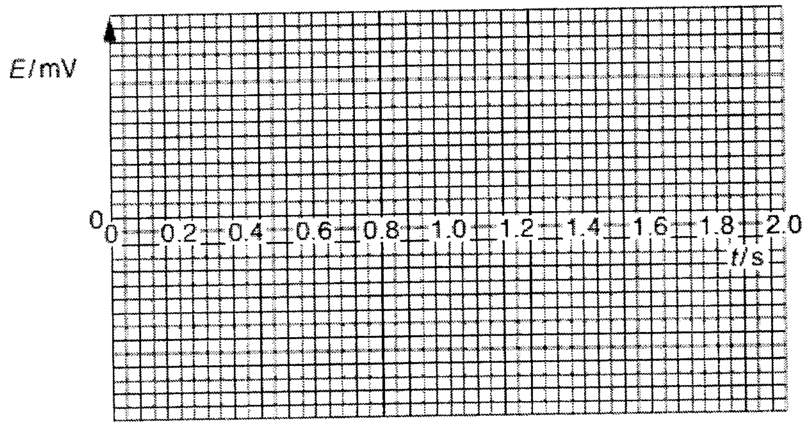


Fig. 6.3

7 **(a)** The β-decay of nuclei of tungsten-185 is spontaneous and random.

State what is meant by

(i) *spontaneous* decay,

....

....[1]

(ii) *random* decay.

....

....

....[2]

(b) A nuclear reaction between two helium nuclei produces a second isotope of helium, two protons and 13.8 MeV of energy. The reaction is represented by the following equation.

$$^{3}_{2}\text{He} + {}^{3}_{2}\text{He} \rightarrow {}^{\cdots}_{\cdots}\text{He} + 2\,{}^{\cdots}_{\cdots}\text{p} + 13.8\ \text{MeV}$$

(i) Complete the nuclear equation. [1]

(ii) Radiation is produced in this nuclear reaction.
State

1. a possible type of radiation that may be produced,

.... [1]

2. why the energy of this radiation is less than the 13.8 MeV given in the equation.

....

....[1]

(iii) Calculate the minimum number of these reactions needed per second to produce a power of 60 W.

number = ...s^{-1} [2]

(c) Using the data below, calculate in MeV, the energy released in the following reaction.

$$^{2}_{1}\text{H} + ^{3}_{1}H \rightarrow ^{4}_{2}\text{He} + ^{1}_{0}n$$

The binding energy per nucleon of

- deuterium $^{2}_{1}\text{H}$ is 1.11 MeV
- tritium $^{3}_{1}H$ is 2.66 MeV
- helium $^{4}_{2}\text{He}$ is 7.20 MeV

energy released = ...MeV [3]

Section B

Answer **one** question from this Section in the spaces provided.

8 Fig. 8.1 shows an M777 howitzer secured to the ground firing a projectile at an angle of 50° to the horizontal. The projectile exits the muzzle at a speed of 800 m s^{-1}.

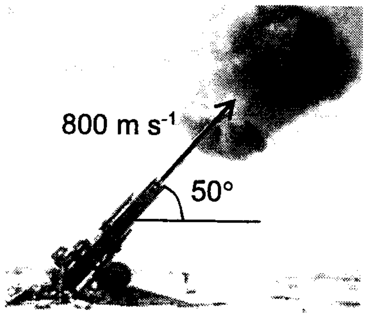


Fig. 8.1

(a) **(i)** Calculate the vertical component of the projectile's initial velocity.

vertical component = ... m s^{-1} [1]

(ii) Neglecting air resistance and the height of the howitzer, determine the horizontal range of this projectile.

range = ... km [3]

(iii) It can be proven that launching the projectile at 40° will achieve the same horizontal range. Suggest one advantage of launching the projectile at this smaller angle.

....

.... [1]

(b) The howitzer is set up to destroy an enemy tank by aiming its projectile to land at the expected position of the moving tank.

The enemy tank, initially stationary, is 3.0 km away from the landing point of the howitzer's projectile as shown in Fig. 8.2.

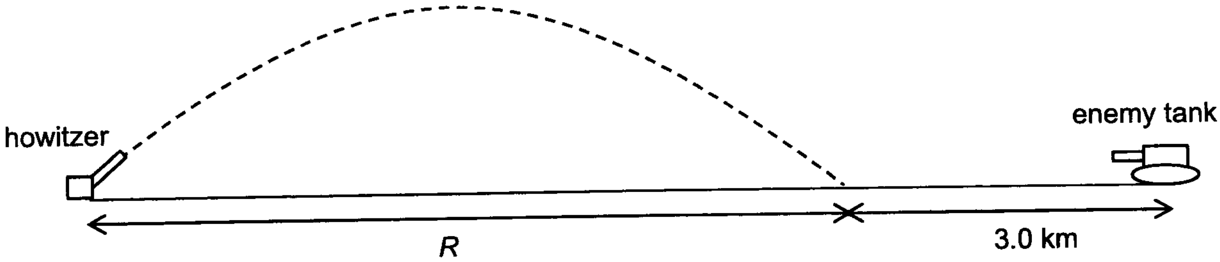


Fig. 8.2

The tank has a maximum speed of 60 km h^{-1} and a maximum acceleration of 1.0 m s^{-2}.

(i) Calculate the minimum time required for the tank to reach the landing point of the howitzer's projectile.

time = ... s [4]

(ii) Determine the time the howitzer should start firing after the tank starts moving so that the projectile will hit the tank.

time = ... s [1]

(c) In reality, the projectile experiences a large magnitude of air resistance.

(i) In Fig. 8.3(a) and 8.3(b), draw and label the forces acting on the projectile as it is moving up and as it is moving down. [2]

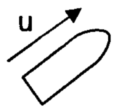


Fig. 8.3(a) Projectile moving up

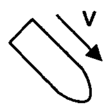
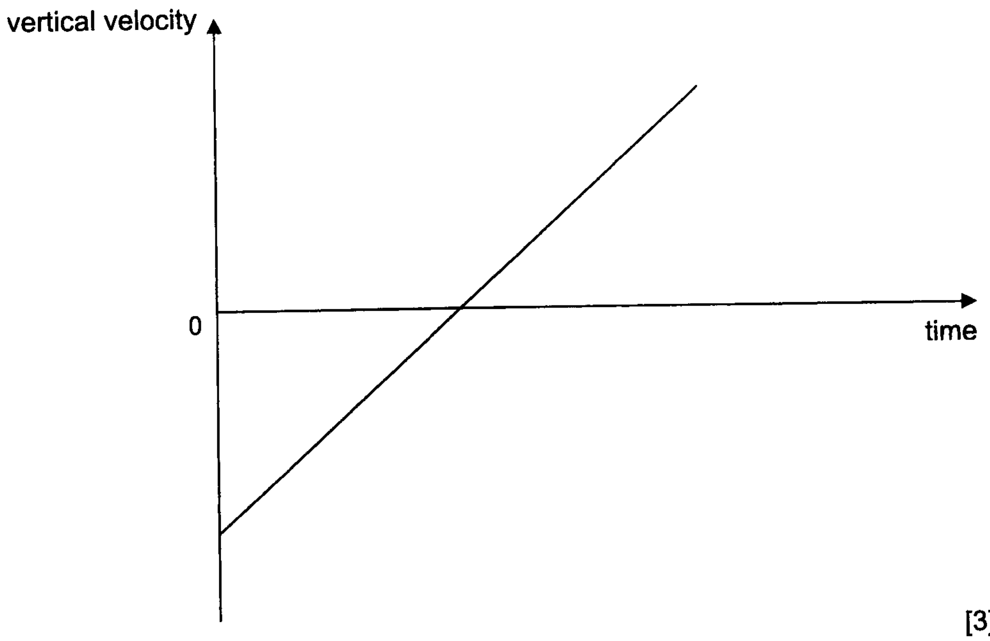


Fig. 8.3(b) Projectile moving down

(ii) Fig 8.4 shows the variation with time of the vertical velocity of the projectile when the air resistance is negligible from the time it is fired to when it reaches the ground.

On Fig. 8.4, draw a line to show the variation with time of the vertical velocity of the projectile when air resistance is not negligible.



[3]

Fig. 8.4

(iii) Label a point **P** on your line when the projectile's vertical acceleration is equal to the acceleration of free fall. [1]

(d) **(i)** State the *principle of conservation of linear momentum*.

....

....

.... [2]

(ii) If the howitzer and the projectile are considered as a system, explain whether the principle of conservation of momentum could be applied to this system during the firing process.

....

....

.... [2]

9 (a) Two parallel metal plates in a vacuum are separated by a distance of 15 mm, as shown in Fig. 9.1.

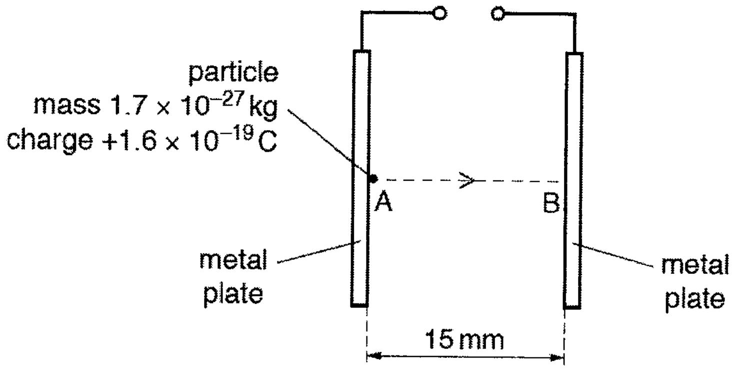


Fig 9.1

A uniform electric field is produced between the plates by applying a potential difference between them.

A particle of mass 1.7 x 10^{-27} kg and charge +1.6 x 10^{-19} C is initially at rest at point A on one plate. The particle is moved by the electric field to point B on the other plate. The particle reaches point B with kinetic energy 2.4 x 10^{-16} J.

(i) Define electric field strength.

....

....

....[2]

(ii) 1. State whether A or B is at higher potential.

higher potential at .... [1]

2. Determine the work done by the electric field to move the particle from A to B.

work done = ... J [1]

3. Use your answer in **(a)(ii)2.** to determine the force on the particle.

force = ... N [2]

4. Determine the potential difference between the plates.

potential difference = ... V [3]

(iii) On Fig. 9.2, sketch a graph to show the variation of the kinetic energy of the particle with the distance x from point A along the line AB.

Numerical values for the kinetic energy are not required. [1]

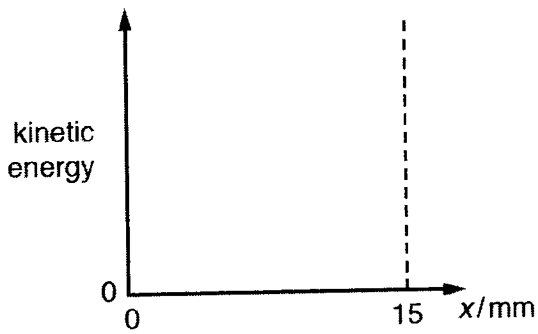


Fig. 9.2

(iv) An electron is placed at A and projected along the direction AB with a kinetic energy less than 2.4×10^{-16} J. Describe the motion of the electron.

....

....

....[2]

(b) A uniform magnetic field normal to the page is produced in the region PQRS. At point X, a gamma-ray photon interaction causes two particles to be formed. The paths of these particles are shown in Fig. 9.3.

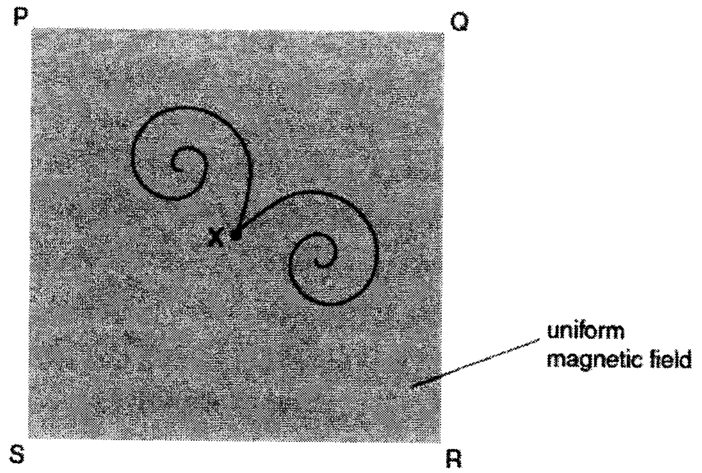


Fig. 9.3

(i) State the condition for a charged particle to experience a force in a magnetic field.

....

....

....

....[2]

(ii) Suggest with a reason, why each of the paths is a spiral, rather than the arc of a circle.

....

....

....

....[2]

(iii) State and explain what can be deduced from the paths about

1. the charges on the two particles

....

....

....

....[2]

2. the initial speeds of the two particles.

....

....

....

....[2]

[End of Paper]

Class	Index Number	Name
21S		

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

PHYSICS, Higher 2 **9749/04**

Paper 4 Practical

15 August 2022
2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

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.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
Give details of the practical shift and laboratory where appropriate in the boxes provided.

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.

Shift
Laboratory

For Examiner's Use	
1	/11
2	/11
3	/20
4	/13
Total	**/55**

This document consists of **20** printed pages and **2** blank pages.

1 In this experiment, you will investigate the centre of gravity of a suspended card shape.

(a) You have been provided with a card shape, as shown in Fig. 1.1.

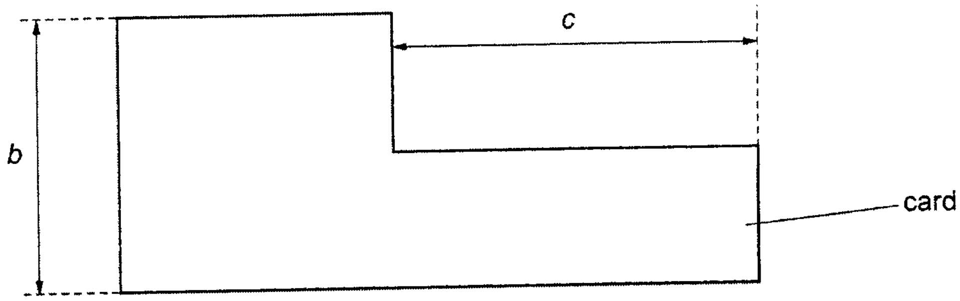


Fig. 1.1

Measure and record the lengths *b* and *c*.

b = ...

c = ...
[1]

(b) Use the pin to make two small holes in the card, as shown in Fig. 1.2.

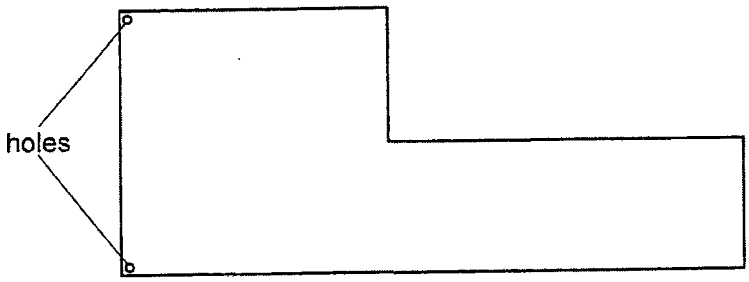


Fig. 1.2

Suspend the card as shown in Fig. 1.3. The pin should be held firmly in the clamp and the card should hang freely. The loop of string at the end of the pendulum should be attached to the pin.

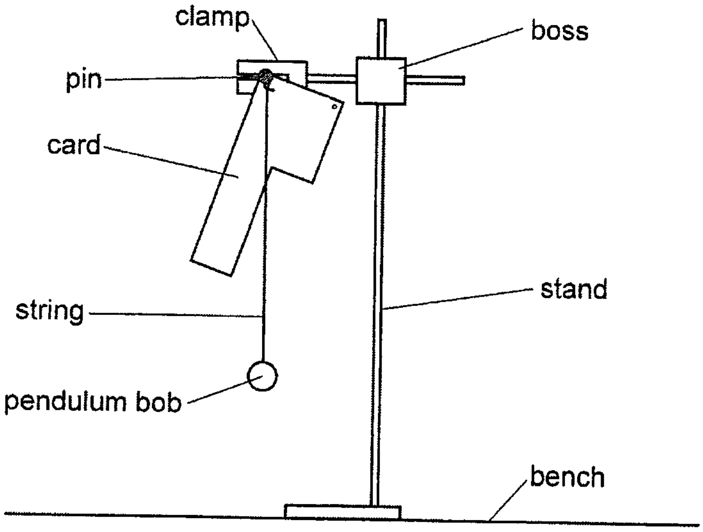


Fig. 1.3

Use the pencil to draw a line on the card along the path of the string in Fig.1.3, as shown in Fig.1.4.

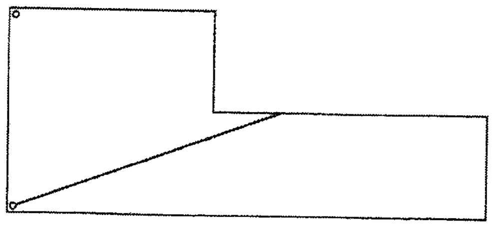


Fig. 1.4

Repeat the procedure using the other hole in the card. The two lines will cross at the centre of gravity G, a distance *y* above the longest edge of the card, as shown in Fig.1.5.

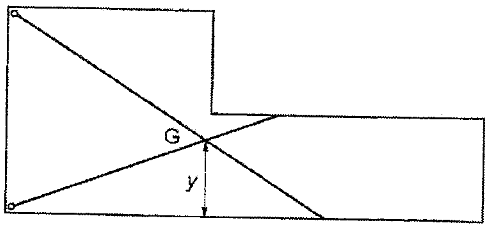


Fig. 1.5

Measure and record *y*.

y = ...[2]

(c) **(i)** Reduce c by 6 cm by cutting the card at right-angles to its longest edge.

Measure and record c.

c = ...[1]

(ii) Repeat the procedure from page 3.

y = ...[1]

(d) Theory suggests that

$$y = \frac{\frac{b^2}{2} + \frac{bc}{8}}{b + \frac{c}{2}}$$

where b remains constant.

(i) Calculate the value of y when c is reduced by another 6 cm.

y = ...[1]

(ii) The experiment is repeated for more values of c.

State the graph to plot to obtain a straight line assuming that the theory is correct.

....

....

....[1]

(iii) State expressions for the gradient and y-intercept of the line.

gradient = ...

y-intercept = ...[2]

(iv) Explain, without calculation, why the value of y is equal to 6 cm when $c = 0$.

....

....

....

....

....[2]

[Total: 11]

2 In this experiment, you will investigate an electrical circuit.

(a) Set up the circuit shown in Fig. 2.1.

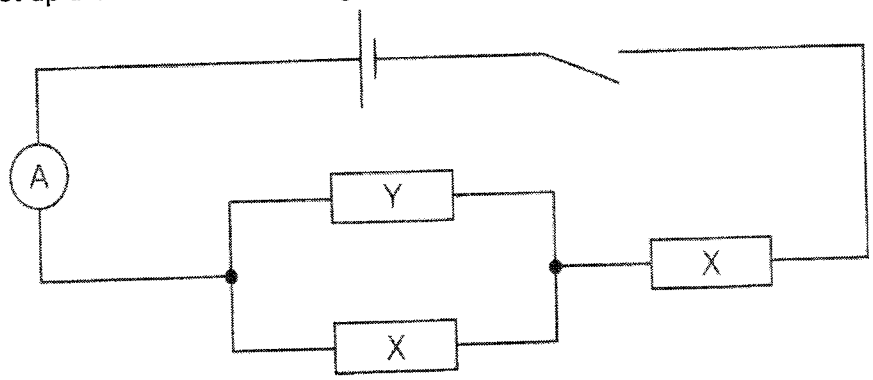


Fig. 2.1

The value of the resistance of Y is R_Y. Its value should be 10 Ω.

Record R_Y.

R_Y = ...

Close the switch.

Measure and record the ammeter reading I_1.

I_1 = ...

Open the switch.

Change the positions of the resistors Y and X, as shown in Fig. 2.2.

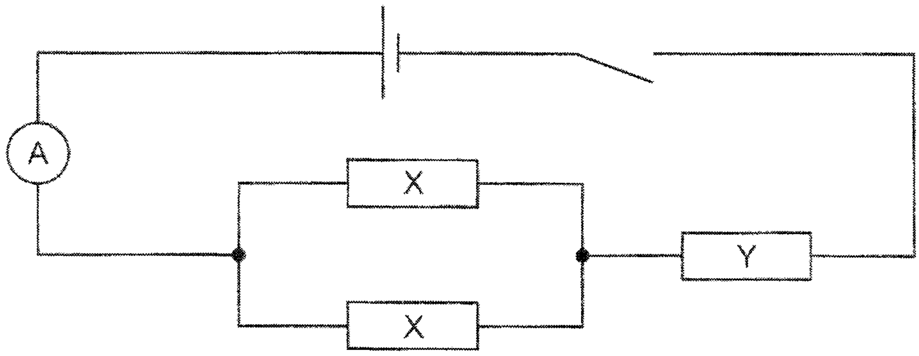


Fig. 2.2

Close the switch.

Measure and record the ammeter reading I_2.

I_2 = ...

Open the switch. [1]

(b) Vary R_Y and repeat **(a)**.

Present your results clearly.

[3]

(c) I_1, I_2 and R_Y are related by the expression

$$\frac{I_1}{I_2} = \frac{R_Y}{2R_X} + \frac{1}{2}$$

where R_X is the resistance of resistor X.

Plot a graph and use the gradient to determine R_X.

R_x = ...

[5]

(d) By considering the value of $\frac{I_1}{I_2}$ when $R_Y = R_X$, describe another way in which the graph can be used to determine R_X.

....

....

....[1]

(e) The experiment is repeated with a larger value of R_X.

Sketch a line on your graph grid on page 9 to show the expected result.

Label this line W. [1]

[Total: 11]

3 In this experiment, you will observe the motion of two simple pendulums, and measure the interval between successive times at which the pendulums are moving together.

You will investigate how this time interval is affected when the length of one of the pendulums is changed.

(a) Set up two pendulums side by side as shown in Fig. 3.1, with each string clamped between two wooden blocks.

Set the length of pendulum A to about 0.65 m.

Pendulum A should be left at its set length throughout the experiment.

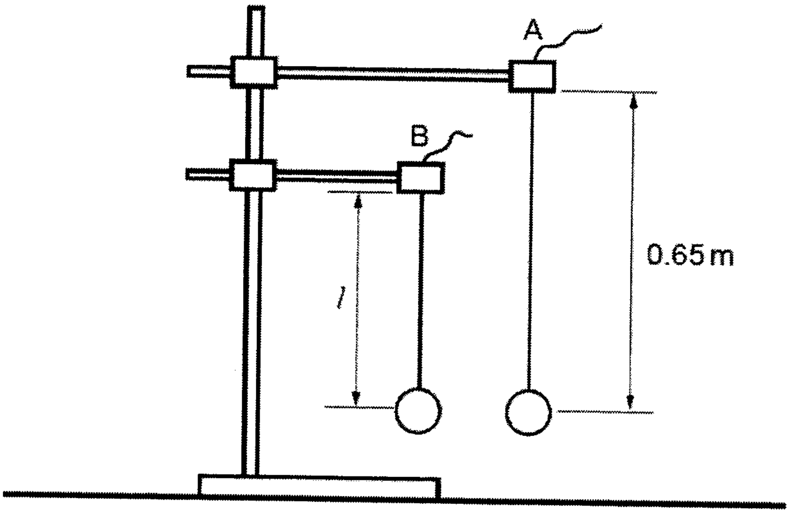


Fig. 3.1

(b) **(i)** Adjust pendulum B so that its length *l* is about 0.5 m.

Measure and record the value of *l*.

l = ... [1]

(ii) Estimate the percentage uncertainty of *l*

percentage uncertainty in *l* = ... [1]

(c) Set both pendulums into motion with small oscillations.

Start the stopwatch when the two pendulums are lined up as shown in Fig. 3.2 and are moving in the same direction.

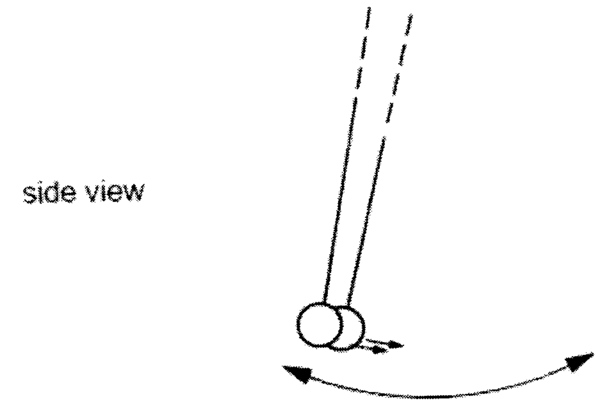


Fig. 3.2

(i) Determine the time *t* that elapses before the next occasion when the two pendulums are lined up and moving in the same direction.

t = ... [1]

(ii) Calculate the percentage uncertainty of *t*.

percentage uncertainty of *t* = ... [1]

(d) Change the length of l to about 0.4 m.

Repeat **b(i)** and **c(i)**.

l = ...

t = ... [2]

(e) It is suggested that

$$\frac{1}{t} = \frac{k}{\sqrt{l}}$$

where k is a constant

(i) Use your values from **(b)(i)** , **(c)(i)** and **(d)** to determine two values of k. Give your values of k to an appropriate number of significant figures

first value of k = ...

second value of k = ...

[1]

(ii) Justify the number of significant figures given in your values of k.

....

....

....

....[1]

(iii) State whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your values in **(b)(ii)** and **(c)(ii)**.

....

....

....

....[2]

(iv) Using the results obtained in **(e)(i)**, calculate the number of times pendulum B which is initially in phase will go out of phase and back in phase again in 1 minute when *l* is 10 cm.

number of times = ... [1]

(f) Describe a significant source of uncertainty or limitation of the procedure for this experiment.

....

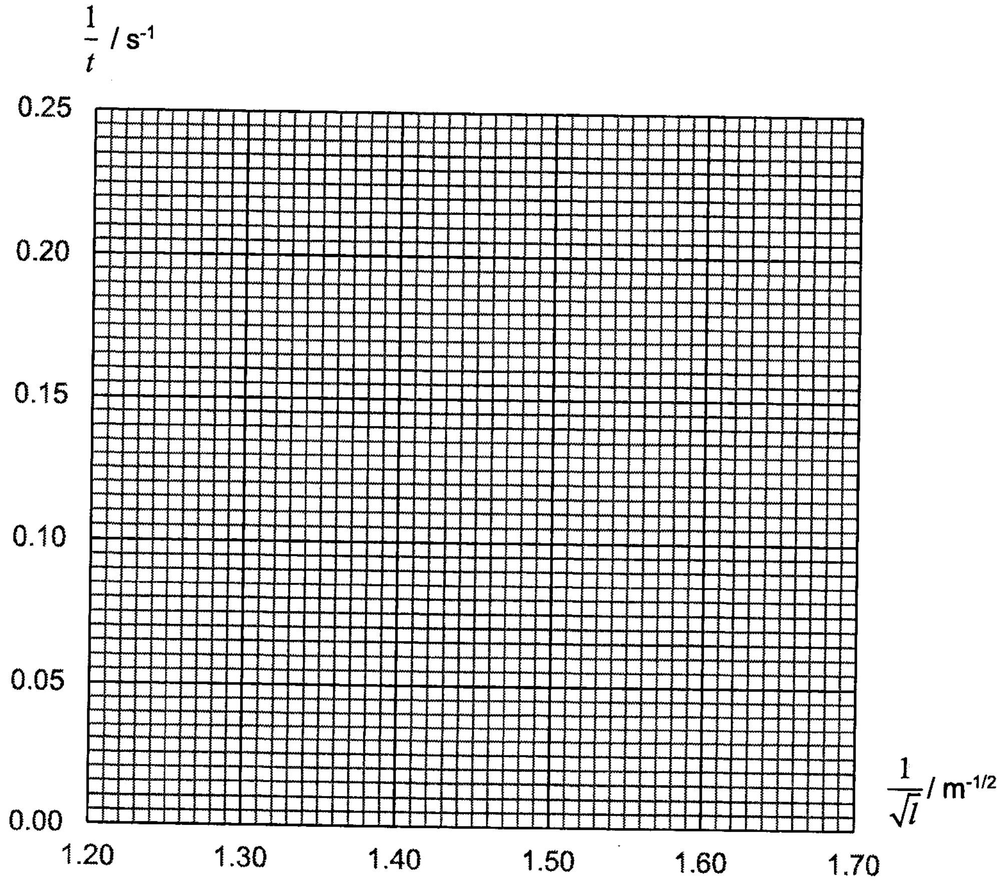
....

....[1]

(g) In a separate investigation, the length l of pendulum B was varied. The following results of $\frac{1}{t}$ and $\frac{1}{\sqrt{l}}$ were recorded.

$\frac{1}{t}$ / s^{-1}	0.03	0.05	0.08	0.13	0.18
$\frac{1}{\sqrt{l}}$ / $m^{-1/2}$	1.29	1.35	1.40	1.50	1.60

(i) Plot $\frac{1}{t}$ against $\frac{1}{\sqrt{l}}$ on the grid and draw the straight line of best fit. [2]



(ii) With reference to the graph in **(g)(i)**, make a conclusion on whether $\frac{1}{t}$ is directly proportional to $\frac{1}{\sqrt{l}}$.

....

....

....

....[3]

(h) The period T of a pendulum when it oscillates with small oscillations is said to be related to the length of the pendulum L as shown.

$$T = P\sqrt{L} \ ,$$

where P is a constant

Using the set up in **(a)** with a single pendulum, design an experiment to determine the value of constant P.

Your account should include:

- the equipment you would use
- the experimental procedure
- how you would use the results to determine P.

....

....

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....

....

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....

....

....

....

....

....

....[3]

[Total: 20]

4 Creep is the name given to the slow deformation of solid materials over an extended period of time when the material experiences stresses, which are below that required to reach the elastic limit. The *stress* exerted on a solid is defined as the applied force per unit cross-sectional area on the material and it is responsible for the elongation of the material along the axis of the force. Another measure of the deformation of an object is the *strain*, which is defined as the extension per unit length of the object. The ratio of stress to strain for a material is called the Young's Modulus of the material. It is a constant of the material.

An example of a situation where creep occurs is in the blades of a high temperature gas turbine. The operating temperature of the turbine is fairly close to the melting point of the material from which the blades are made. Therefore the blades are subject to creep and gradually become elongated as the turbine is used. This is illustrated in Fig. 4.1.

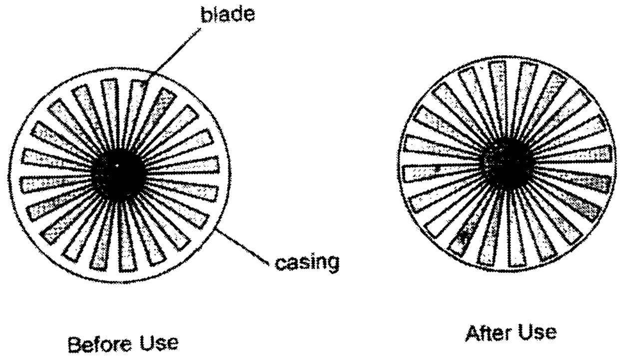

Fig. 4.1

The clearance between the blades and the casing is very small. This clearance decreases during the life of the turbine due to the creep in the blades. Therefore, it is important to engineers to have information about the creep process so that the life expectancy of the blades can be determined and damage to the engine can be prevented.

The length of a wire made of lead changes with time (i.e. creeps) as the temperature, T, of the wire and the load, m, which it supports are changed. The change in length, ΔL, is related to the temperature, T, of the wire and the load, m by the relationship

$$\Delta L = k\, T^p m^q$$

where k and p and q are constants.

You are provided with lead wires, a long box with toughened glass sides, some masses and an electrical heater.

Design an experiment to determine the values of p and q.

Draw a diagram to show the arrangement of your apparatus. Pay particular attention to:

- the equipment you would use
- the procedure to be followed
- the control of variables
- how the values of p and q are determined from your readings, and
- any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

....

....

....

....

....

....

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....

....

....

[Total: 13]

[End of Paper]