Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **8866/02**
Higher 1

Paper 2 Structured Questions

19 September 2014

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

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

For Examiner's Use			
Section A			
1		/	8
2		/	8
3		/	8
4		/	6
5		/	10
Section B			
6		/	20
7		/	20
8		/	20
Total		/	80

This document consists of **25** printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

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,	$p = \rho gh$
resistors in series,	$R = R_1 + R_2 + ...$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + ...$

Section A

Answer **all** the questions in this section.

1 A ball is thrown with a velocity of 25 m s^{-1} vertically upwards from ground level. Air resistance is not negligible.

The variation with time *t* of the vertical velocity *v* of the ball is shown in Fig. 1.1.

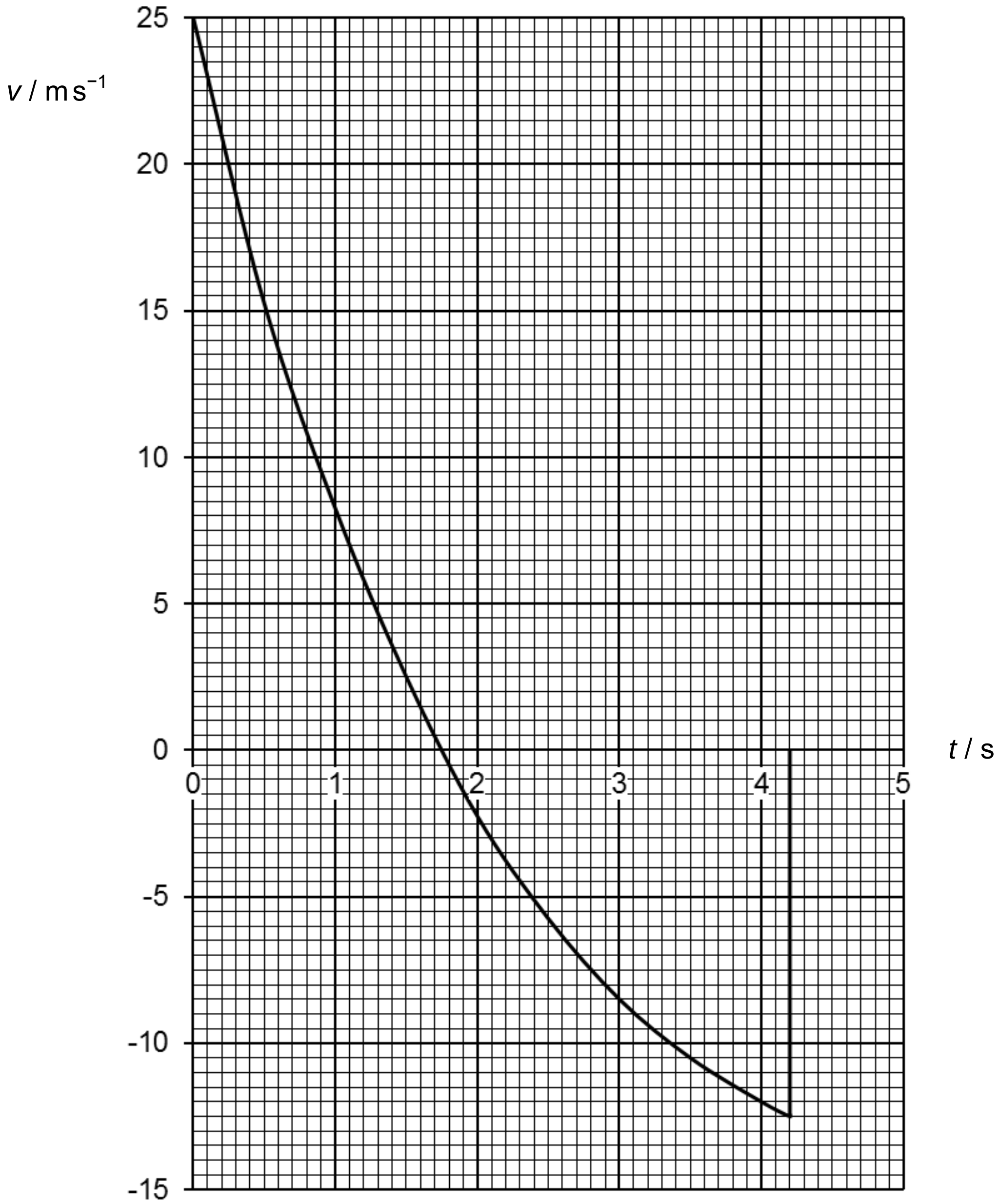


Fig. 1.1

(a) Use Fig. 1.1 to explain how it may be deduced that air resistance varies with speed.

....

....

.... [2]

(b) The mass of the ball is 350 g and that the maximum height reached by the ball is 19 m.

Use Fig. 1.1 to determine the ratio

$$\frac{\text{energy lost from the ball due to air resistance during the ball's upward motion}}{\text{energy lost from the ball due to air resistance during the ball's downward motion}}.$$

ratio = ... [3]

(c) **(i)** State the time at which the acceleration is *g*.

time = ... s [1]

(ii) On Fig. 1.1, sketch the graph to show the variation with time *t* of the velocity *v* of the ball if air resistance is negligible. [1]

(iii) Use your answer in **(ii)** to calculate the maximum height reached by the ball if air resistance is negligible.

height = ... m [1]

2 Fig. 2.1 shows two blocks, A and B, connected by a light, inextensible cord over a frictionless pulley. Block A of mass 2 kg rests on a horizontal smooth surface and is connected to a light spring of force constant 400 N m^{-1}. Block B of mass 10 kg is hung vertically by the cord. Initially, block A and block B are held at rest and the spring is at its original, unstretched position. The spring obeys Hooke's law.

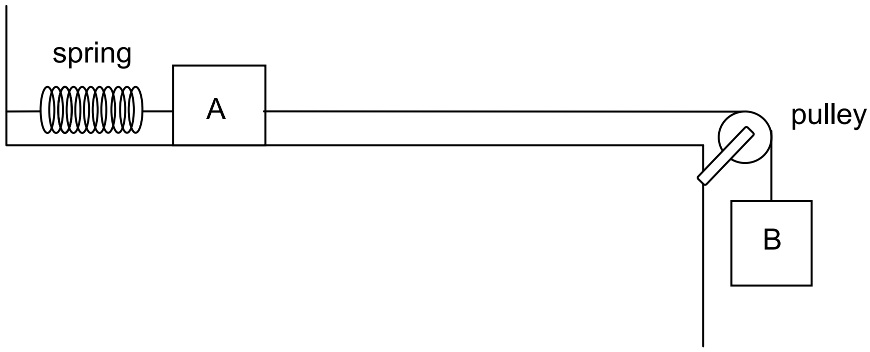


Fig. 2.1

Block B is released from rest and falls vertically to a maximum distance.

(a) Describe the energy changes that take place for the system.

....

....

....

....

....

....

....

....

.... [4]

(b) (i) Calculate the maximum distance fallen by block B.

maximum distance = ... m [2]

(ii) Calculate the speed of block A when block B has fallen to half of its maximum distance.

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

3 Fig. 3.1 shows the I-V characteristics of an electrical component X.

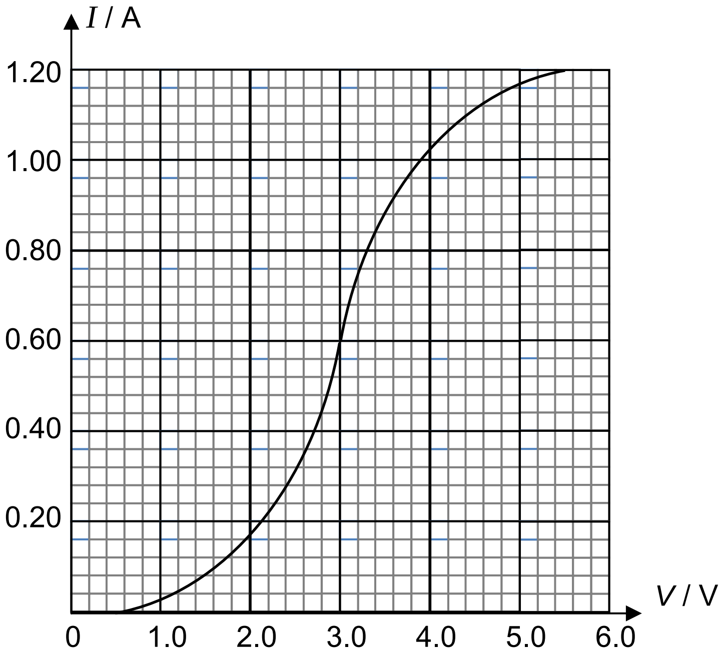


Fig. 3.1

(a) Determine the smallest possible resistance of X.

smallest resistance = ... Ω [2]

(b) Fig. 3.2 shows X connected in parallel to a resistor of resistance 5.0 Ω and a 5.0 V cell of negligible internal resistance.

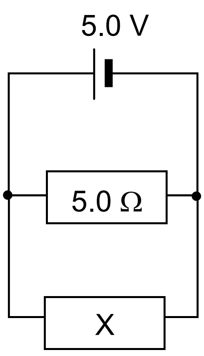


Fig. 3.2

(i) Explain what is meant by *resistance of 5.0 Ω* .

....

.... [1]

(ii) On Fig. 3.1, draw the I-V characteristics of the 5.0 Ω resistor. Label this line Y. [1]

(iii) Determine the current drawn from the cell.

current = ... A [2]

(c) A new circuit is assembled by connecting the 5.0 Ω resistor, component X and a 7.0 V battery in series.

(i) Using Fig. 3.1, determine the current drawn from the battery, assuming that it has negligible internal resistance.

current = ... A [1]

(ii) Explain your answer for **(c)(i)**.

....

.... [1]

4 **(a)** Define *magnetic flux density.*

....

....

.... [1]

(b) Fig. 4.1 shows a current balance which can be used to measure the strength of a magnetic field generated in a solenoid.

The balance consists of a weightless conducting wire, folded into a rectangular coil of 3.0 cm in width and attached to a non-conducting support block. The coil and block are then pivoted such that the supporting block is always at a distance of 2.0 cm away from the pivot, and the side of the rectangular coil is always at a distance of 5.0 cm away from the pivot.

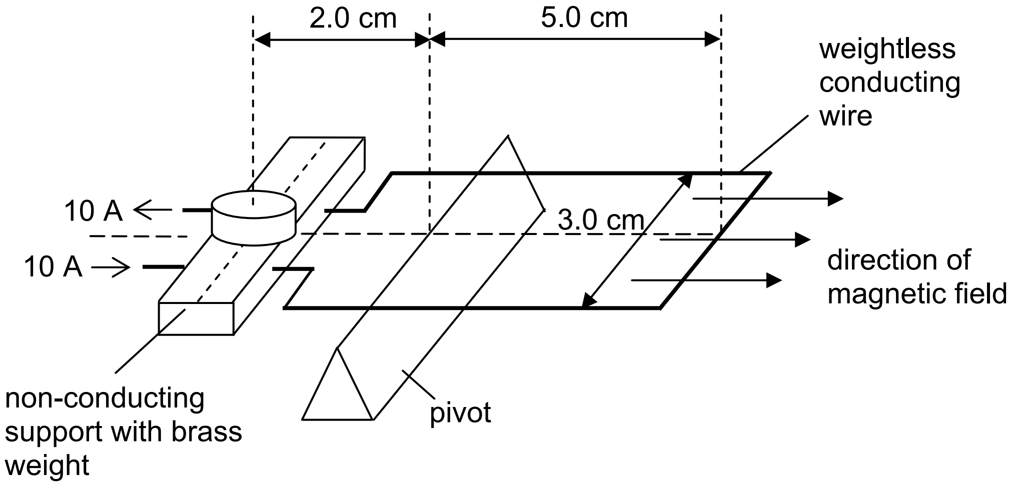


Fig. 4.1

A constant current of 10 A is passed through the coil. The current-carrying rectangular coil is then slotted inside a solenoid such that the uniform magnetic field generated by solenoid is directed parallel to the plane of the rectangular coil.

A downward magnetic force is generated. Brass weights are placed on the non-conducting support block until the coil is horizontally aligned. The support and brass weight have a combined mass of 50 g when the coil is horizontally aligned.

(i) Calculate the flux density of the uniform magnetic field generated by the solenoid.

magnetic flux density = ... T [3]

(ii) Predict and explain if the magnetic flux density calculated in **(b)(i)** would be larger or smaller than the actual value if the assumption that the wire was weightless is not valid.

....

....

....

.... [2]

5 Solar cells can be used as sources of electrical power. A solar cell provides electrical power for a load resistor when light is incident on it. Fig. 5.1 is a symbol for solar cell.

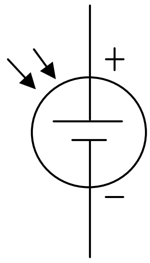


Fig. 5.1

Fig. 5.2 shows I-V characteristics of a single solar cell. The solar cell is operating at a light intensity of 1000 W m^{-2}, similar to that of sunlight on the Earth's surface.

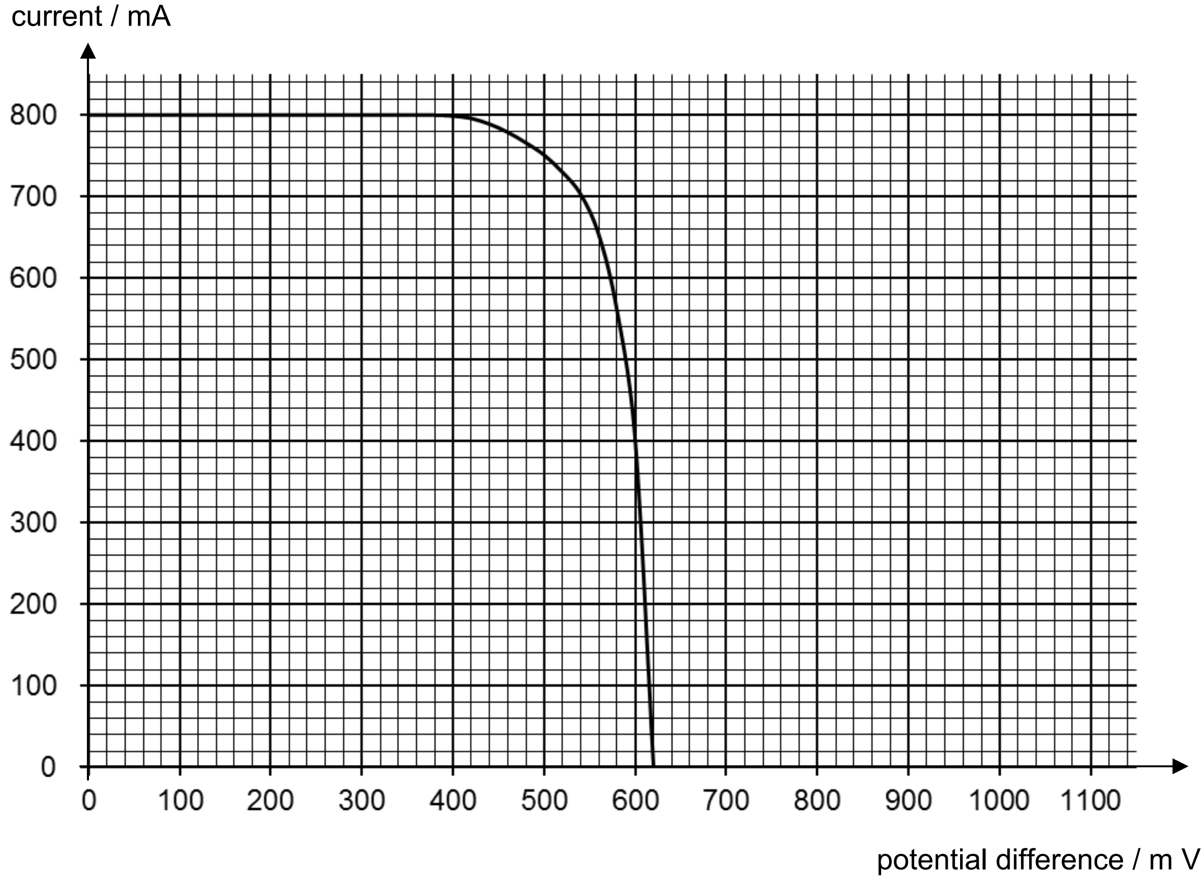


Fig. 5.2

(a) In the space below, draw a circuit diagram using a solar cell, a variable resistor, an ammeter, a voltmeter and connecting wires to determine the graph of Fig. 5.2.

[2]

(b) Fig. 5.3 shows some of the data for potential difference and current obtained from Fig. 5.2 and the corresponding calculated values for power.

V / mV	*I* / mA	*P* / mW
200	800	160
300	800	240
400	800	320
440	790	348
460		
480		
500	750	375
520	730	380
540	700	378
560	650	364

Fig. 5.3

Complete Fig. 5.3 for the potential difference of 460 V and 480 V. [2]

(c) Fig. 5.4. is a graph of some of the data of Fig. 5.3.

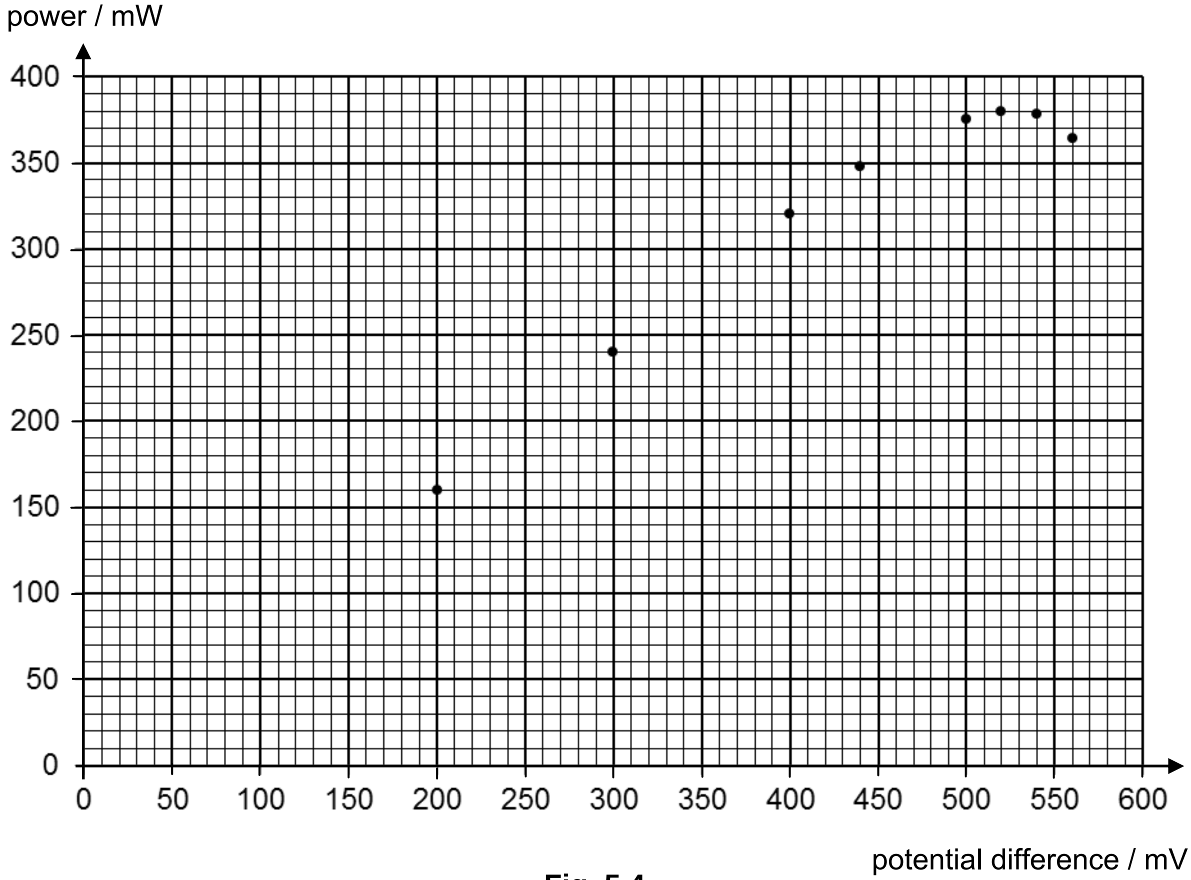


Fig. 5.4

Complete Fig. 5.4 using your data for the potential difference of 460 mV and 480 mV, and draw a best fit curve through your points. [2]

(d) Use Fig. 5.4 to estimate the value of the maximum power delivered by the solar cell.

maximum power = ... W [1]

(e) Fig. 5.5 shows an arrangement of eight solar cells, each of the type described above. They are connected to supply current to a load and to recharge a battery which acts as a reserve energy source.

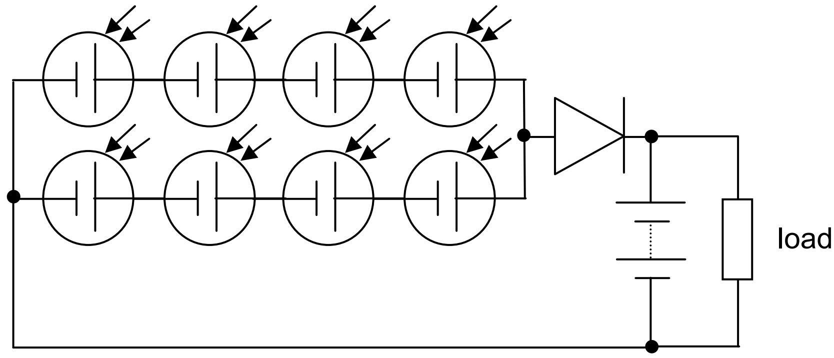


Fig. 5.5

(i) Assuming that the light intensity due to sunlight on the Earth's surface is 1000 W m^{-2}, determine the maximum power that the solar cells can supply.

maximum power = ... W [1]

(ii) If the sun shines for an average of four hours per day, calculate the average power the system of solar cells can supply to the load resistance in a day. Ignore the power from the battery.

average power = ... W [2]

Section B

Answer **two** of the questions in this section.

6 **(a)** **(i)** State *Newton's third law of motion*.

....

....

.... [1]

(ii) Fig. 6.1 shows a box resting in equilibrium on a concrete block on the floor.

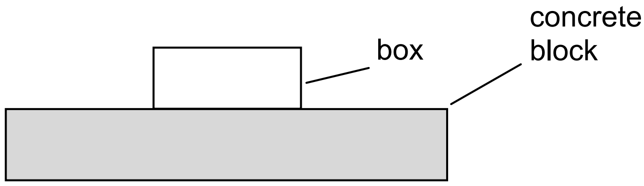
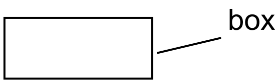


Fig. 6.1

1. On Fig. 6.2(a), draw and label all the forces acting on the box. [1]

2. On Fig. 6.2(b), draw and label all the forces acting on the concrete block. [1]



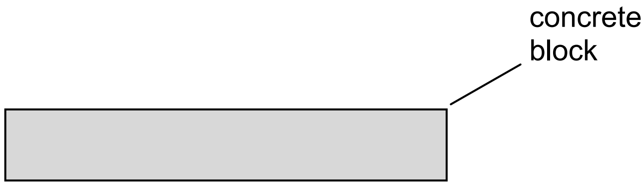


Fig. 6.2(a) **Fig. 6.2(b)**

3. State clearly which forces are action – reaction pair.

....

.... [1]

(iii) Suppose now the box has fallen onto the concrete block and has just landed on it.

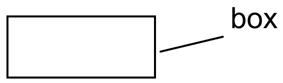


Fig. 6.3(a)

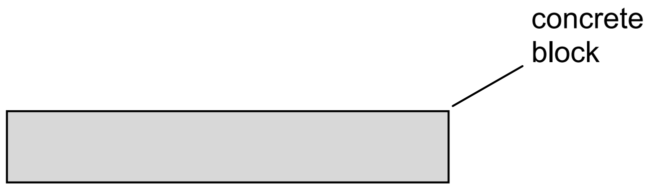


Fig. 6.3(b)

1. On Fig. 6.3(a), draw and label all the forces acting on the box at the instant of collision. Make it clear which forces are different in magnitude from those in **(ii)1**. [1]

2. On Fig. 6.3(b), draw and label all the forces acting on the concrete block at the instant of collision. Make it clear which forces are different in magnitude from those in **(ii)2**. [1]

3. State clearly which forces are action – reaction pair.

....

.... [1]

(b) The box of mass 2.0 kg is tied to an elastic rope and dropped vertically downwards towards the concrete block. The elastic rope has negligible mass and an unstretched length of 2.5 m. The rope obeys Hooke's law and a force of 10.0 N extends the rope by 0.20 m. The maximum length of the stretched rope is 4.0 m. You may assume that air resistance is negligible.

(i) On Fig. 6.4, sketch a labelled graph of the variation of tension T in the rope with extension e.

Fig. 6.4

[2]

(ii) When the rope is fully stretched, determine

1. the maximum tension in the rope,

tension = ... N [2]

2. the magnitude and direction of the acceleration of the box.

acceleration =....................................... m s^{-2} [2]

direction =....................................... [1]

(iii) The rope snaps and the box hits the concrete block with a speed of 4.0 m s^{-1} vertically downwards and rebounds with a speed 1.5 m s^{-1} vertically upwards.

1. Calculate the magnitude of the change in momentum of the box and state its direction.

change in momentum = ... kg m s^{-1}

direction = ... [2]

2. The time taken for the box to rebound is 0.20 s. Determine the magnitude of the force acting on the box.

force = ... N [2]

(iv) The momentum of the box increases during free fall. Explain whether or not this is a violation of the principle of conservation of momentum.

....

....

....

.... [2]

7 **(a)** Explain how stationary waves are formed.

....

....

.... [2]

(b) State two differences between stationary wave and progressive wave.

....

....

....

.... [2]

(c) Musical instruments such as guitars have stretched strings which oscillate when plucked or struck. The strings in such musical instruments are fixed at two ends. Stationary waves are formed in the string when a note is played.

Fig. 7.1 shows a stretched guitar string fixed at both ends X and Y, which are 0.40 m apart. A stationary wave with 4 antinodes is formed between X and Y.

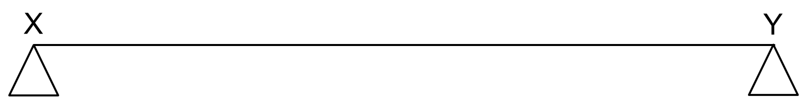


Fig. 7.1

(i) On Fig. 7.1, sketch the stationary wave pattern formed between X and Y. [1]

(ii) On your diagram in **(c)(i)**, label two points P and Q, which are more than half a wavelength apart and are in phase with each other. The amplitude of the particle at P is larger than that at Q. [2]

(iii) On the same diagram, label a point R which is in antiphase with point Q, and has the same amplitude as that at Q. [1]

(iv) Given that the speed of the wave is 80 m s^{-1}, calculate the frequency of the wave.

frequency = ... Hz [2]

(v) State two physical properties of a fixed length of string which will affect the frequency of the wave produced in the string.

....

.... [2]

(d) Fig. 7.2 shows a transmitter T on a building, which emits radio waves of wavelength 2.0×10^3 m. The radio waves from transmitter T travels to a receiver R by two paths as shown in Fig. 7.2 (not to scale).

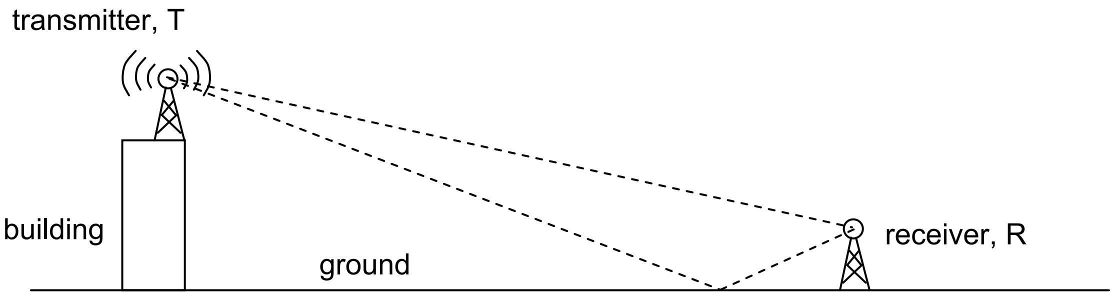


Fig. 7.2

For the first path, the wave travels 2.4×10^4 m directly from T to R. For the second path, the wave travels to the ground and is reflected to R. Maximum intensity is received at R. It is assumed that there is no change in phase of the radio wave upon reflection at the ground.

(i) Explain why maximum intensity is received at R.

....

....

.... [2]

(ii) Calculate the minimum distance travelled by the radio wave in the second path (reflected path), which will produce maximum intensity at R.

minimum distance = ... m [3]

(iii) In order to receive radio waves, an antenna must be used at R. Calculate the frequency of the radio waves received at the antenna.

frequency = ... Hz [2]

(iv) The antenna is configured to resonate at a particular frequency. Suggest a reason why the phenomenon of resonance is used in receiving radio wave.

....

.... [1]

8 (a) Explain what is meant by *photoelectric effect*.

....

....

.... [2]

(b) Fig. 8.1 shows a typical set-up of the photoelectric experiment where a metal surface (emitter) is illuminated with monochromatic radiation of wavelength 300 nm and intensity 200 W m^{-2} over an area of 0.4 cm^2. The setup is connected to a variable d.c. supply, a voltmeter and an ammeter.

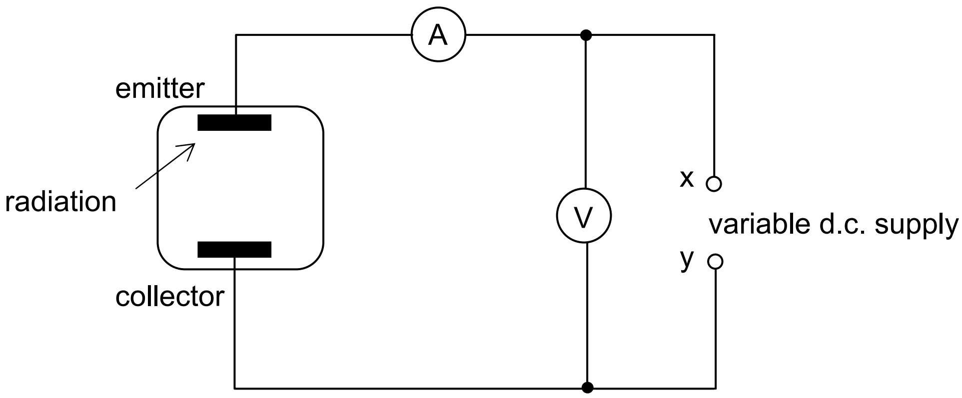


Fig. 8.1

The current I in the circuit is measured for various values of the applied potential difference V between the collector and emitter. The results are shown in Fig. 8.2.

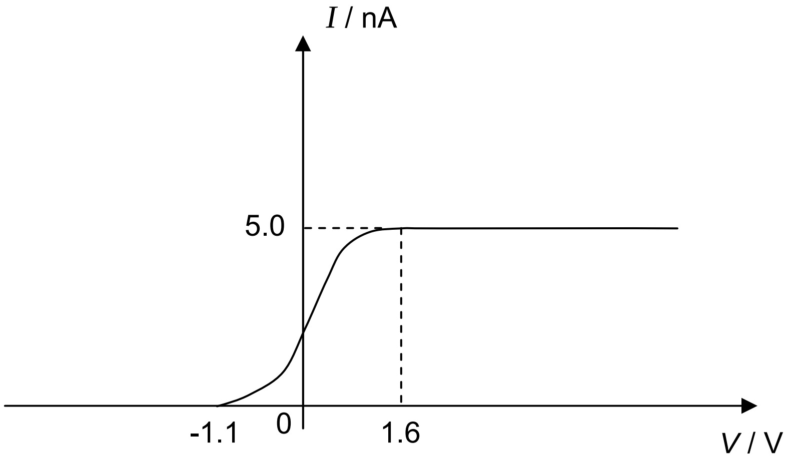


Fig. 8.2

(i) Calculate the rate of incidence of photons on the emitter**.**

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

(ii) Calculate the rate of emission of electrons.

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

(iii) The photoelectric quantum yield is defined as the ratio

$$\frac{\text{rate of emission of photoelectrons}}{\text{rate of incidence of photons}}.$$

Calculate the quantum yield of the experiment.

quantum yield = ... [1]

(iv) According to experiments conducted, a student claimed that it is impossible to achieve a quantum yield of 1. Provide two reasons to support the student's claim.

....

....

....

.... [2]

(v) Calculate the work function energy of the emitter.

work function energy = ...eV [3]

(c) State and explain two observations from the photoelectric effect experiment which provides evidence of a particulate nature of electromagnetic radiation.

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.... [4]

(d) Fig. 8.3 below represents the energy levels of the four lowest states in a hydrogen atom. The energies are in units of electron volts, eV.

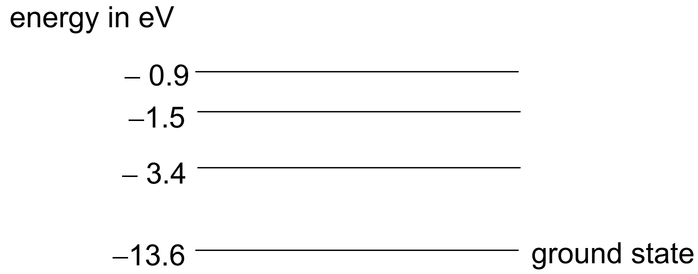

Fig. 8.3

(i) Calculate the energy required to excite the atom to the first excited state.

energy = ... J [1]

(ii) Determine the ionisation energy of the atom.

ionisation energy = ... J [1]

(iii) A photon with energy higher than the ionisation energy calculated in **(d)(ii)** is incident on the hydrogen atom. Explain whether this photon will be absorbed.

....

....

.... [2]

End of paper