DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 1

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|---|---|
| CANDIDATE NAME | |
| CLASS | |
| INDEX NUMBER | |

# PHYSICS

**8866/02**

Paper 2 Structured Questions

**September 2016**

**2 hours**

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

**READ THESE INSTRUCTIONS FIRST**

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

The use of an approved scientific calculator is expected, where appropriate.

**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** | **7** |
| **2** | **5** |
| **3** | **6** |
| **4** | **11** |
| **5** | **11** |
| **Section B** | |
| **6** | **20** |
| **7** | **20** |
| **8** | **20** |
| **Total** | **80** |

This document consists of **24** printed pages and **0** blank page.

**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, | $m_\mathrm{e}$ | $= 9.11 \times 10^{-31}\ \mathrm{kg}$ |
| rest mass of proton, | $m_\mathrm{p}$ | $= 1.67 \times 10^{-27}\ \mathrm{kg}$ |
| 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, | $p = \rho g h$ |
| resistors in series, | $R = R_1 + R_2 + \ldots$ |
| resistors in parallel, | $1/R = 1/R_1 + 1/R_2 + \ldots$ |

For Examiner's Use

## Section A

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

**1** **(a)** A student throws a ball from point S to a friend at point F. The path of the ball is shown in Fig. 1.1.

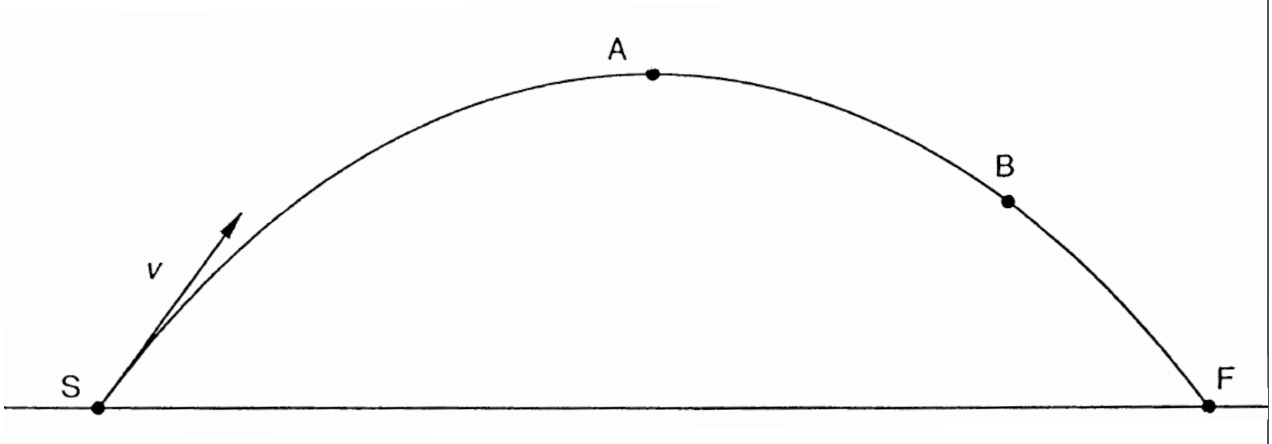


**Fig. 1.1**

The points S and F are on the same horizontal level. Air resistance is negligible.
The ball is thrown from point S with velocity *v*, represented by the vector arrow shown in Fig. 1.1.

On Fig. 1.1,

**(i)** draw arrows from point S to represent the initial horizontal and vertical components of the velocity *v* (label these components $v_H$ and $v_V$ respectively). [1]

**(ii)** draw arrows at A and at B to represent the horizontal and vertical components of the velocity of the ball at these two points. [3]

**(b)** The horizontal distance from S towards F is *x*.

**(i)** On Fig. 1.2, sketch the variation with *x* of the potential energy $E_p$ of the ball. [1]


**Fig. 1.2**

For Examiner's Use

**(ii)** On Fig. 1.3, sketch the variation with $x$ of the kinetic energy $E_k$ of the ball. [2]


**Fig. 1.3**

**2** Fig. 2.1 shows two toy trains T and R held in place on a level track against the force exerted by a compressed spring.

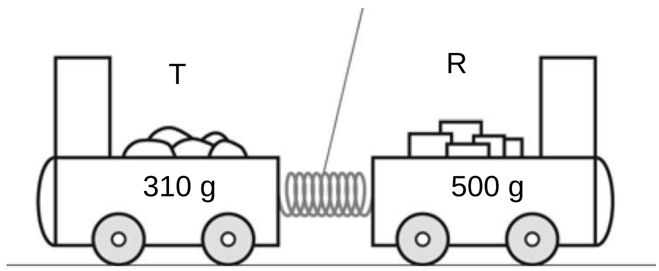


**Fig. 2.1**

When the trains are released, R moves to the right at a speed of 3.8 m $s^{-1}$. The spring takes 0.25 s to uncoil to its natural length.

**(a)** Calculate the velocity of train T.

velocity = ………………………………. m $s^{-1}$ [2]

For Examiner's Use

**(b)** Calculate the average force exerted by the spring on each train.

force = ………………………………. N [3]

**3** **(a)** Distinguish between *mass* and *weight*.

mass: ......…………………………………………………………………………………………

……………………………………………………………………………………………………..

weight: ...…………………………………………………………………………………………

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

**(b)** A gardener pulls a 50 kg roller along level ground, as shown in Fig. 3.1. The roller moves at a steady speed along the level ground when the handle makes an angle of 30° to the horizontal ground and the gardener pulls with a force of 300 N along the handle.

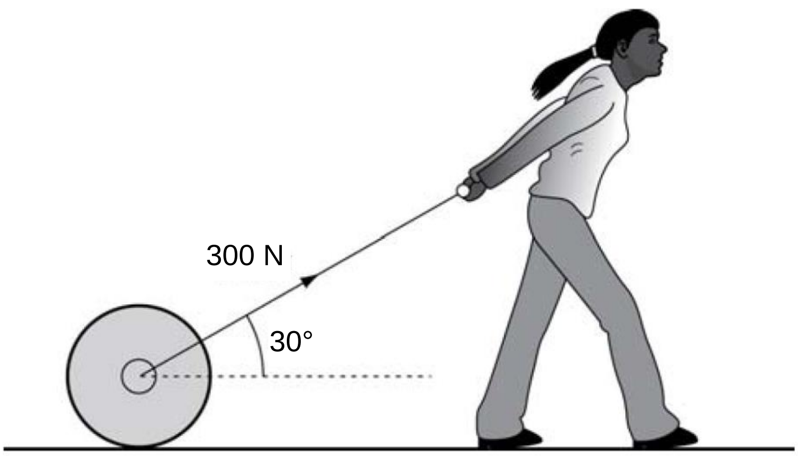


**Fig. 3.1**

For Examiner's Use

Determine,

**(i)** the magnitude of the resistive force acting on the roller, and

resistive force = ………………………………. N [2]

**(ii)** the vertical contact force acting on the roller due to the ground.

vertical contact force = ………………………………. N [2]

**4** **(a)** A double-slit interference experiment is set up using coherent red light as illustrated in Fig. 4.1.

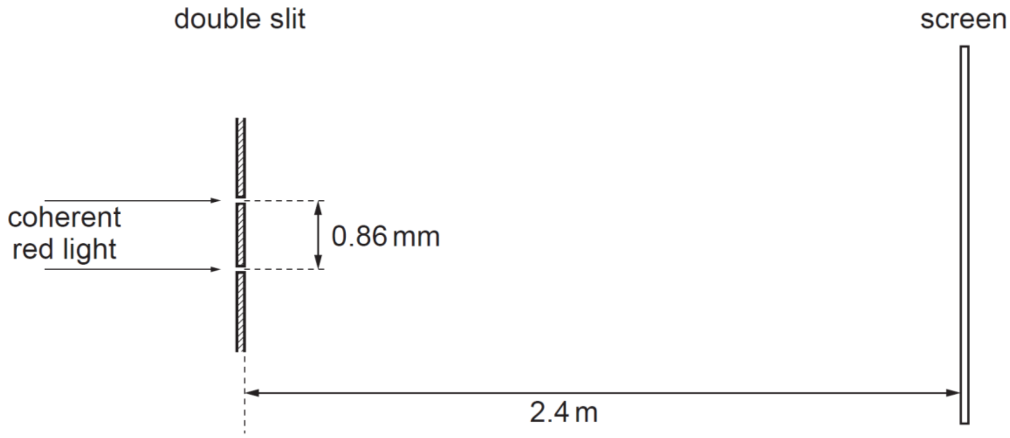


**Fig. 4.1** (not to scale)

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 [2]

**(iii)** Initially, the light passing through each slit has the same intensity.
The intensity of light passing through one slit is now reduced.
State and explain the effect, if any, on the intensity of the fringes observed on the screen.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

**(iv)** The light is replaced by coherent blue light. State and explain the change in the distance between the bright fringes observed on the screen.

……………………………………………………………………………………………

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

**(b)** A string of length 80 cm is fixed at both ends. The middle of the string is plucked. This creates a stationary wave pattern on the string with one complete ‘loop’. The string is vibrating in fundamental mode with a frequency of 20 Hz.

**(i)** State the wavelength of the wave.

wavelength = ………………………………. cm [1]

**(ii)** Calculate the speed of the wave in the string.

speed = ………………………………. m $s^{-1}$ [1]

*For Examiner's Use*

**(iii)** By reference to the formation of the stationary wave on the string, explain what is meant by the speed calculated in **(b)(ii)**.

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..........................................................................................................................

.......................................................................................................................[3]

**5** When the structure of the Earth near the surface is surveyed in prospecting for oil or minerals, one frequently used method is that of seismic reflection surveying. The process can be very complex because the strata in the Earth's crust are by no means regular, and also the quantity of data that is usually received is very large. Some of the principles behind the practice of seismic reflection surveying are explained and used in this question. The data have, however been simplified.

In a place where there is horizontal change in rock type at a certain depth, an explosion is set off. Fig. 5.1 shows an arrangement of eight detectors ($D_1$ – $D_8$) to detect vibrations from the explosion at source S, a short time after the explosion.

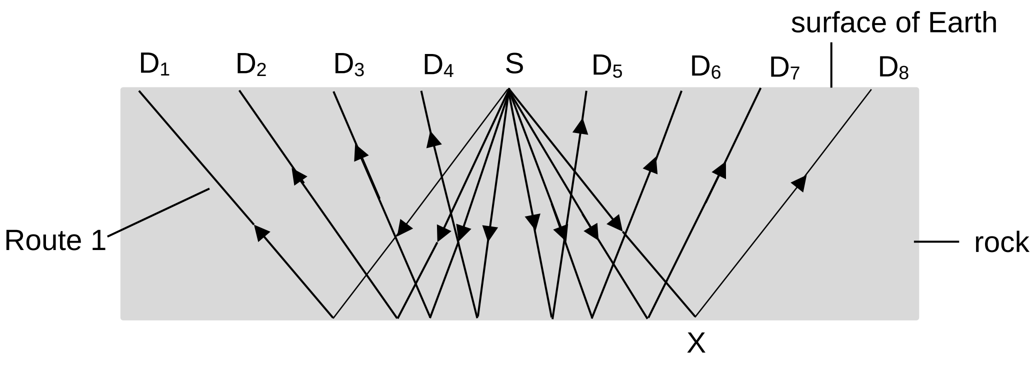


**Fig. 5.1**

Fig. 5.2 shows the traces received from the eight detectors printed alongside one another. Time $t$ = 0 is the time the explosion commences.

route _____

route _____

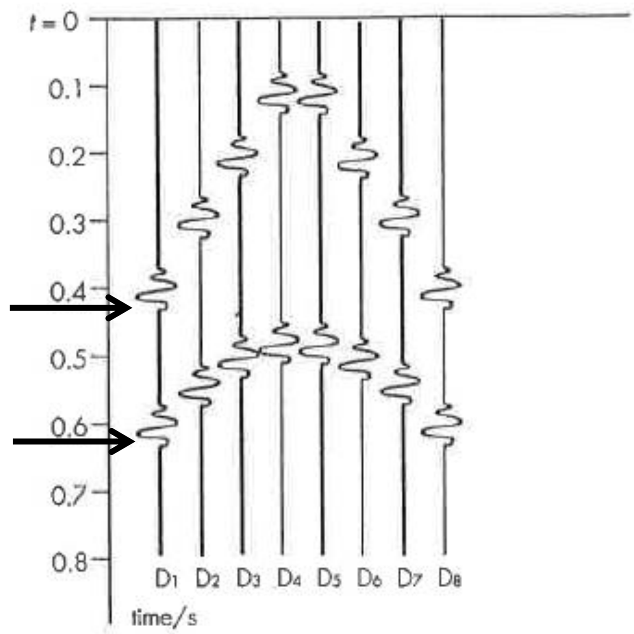


**Fig. 5.2**

The rock through which the waves are travelling is known to have a density of 2700 kg $m^{-3}$ and in rock of this density, the speed of P-waves is 3.1 km $s^{-1}$. P-waves are longitudinal waves and are responsible for the pulses shown in Fig. 5.2.

Answer the following questions, taking data from the diagrams where necessary.

**(a)** What is meant by a *longitudinal wave*?

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

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

**(b)** The speed $v$ of a P-wave is given by

$$v = \sqrt{\frac{A}{\rho}}$$

where $A$ is a constant and $\rho$ is the density of the rock.

*For Examiner's Use*

Determine the value and unit of $A$.

value of $A$ = ........................................ [1]
unit of $A$ = ........................................ [1]

**(c)** Apart from Route 1 shown in Fig. 5.1, draw, *on the same figure*, another shorter route P-waves can take to get from S to detector $D_1$. Label it Route 2. [1]

**(d)** For the detector $D_1$ shown in Fig. 5.2, indicate the route number corresponding to the two routes in which the P-waves arrive at the detector in **(c).** [1]

**(e)** The amplitude for each pulse of the same detector in Fig. 5.2 should *NOT* be the same. Suggest why this is so.

..........................................................................................................

..........................................................................................................

..........................................................................................................[2]

**(f)** Determine

1. the distances $SD_8$, and

distance = ........................................ km [1]

2. the distance $SXD_8$.

distance = ........................................ km [1]

**(g)** Use your answer in **(f)** to determine the depth of the rock in Fig. 5.1.

depth = ........................................ km [2]

For Examiner's Use

## Section B

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

**6** **(a)** By reference to energy transfers, distinguish between e.m.f. and p.d.

e.m.f. ..................................................................................................................

..........................................................................................................................

p.d. ......................................................................................................................

.....................................................................................................................[2]

**(b)** A battery is connected to a variable resistor of resistance *R*, as shown in Fig. 6.1. The battery has an e.m.f. of 6.0 V and an internal resistance *r* of 2.0 Ω.

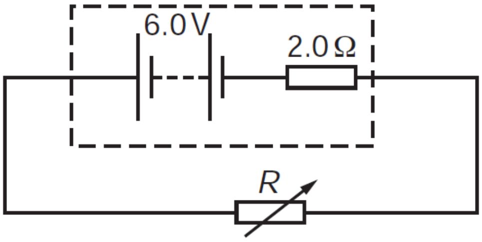


**Fig. 6.1**

Some values are given in Fig. 6.2 for total resistance (*R* + *r*), current *I* and power *P* dissipated in *R*.

| *R* / Ω | (*R* + *r*) / Ω | *I* / A | *P* / W |
|---|---|---|---|
| 0 | 2.0 | 3.0 | 0 |
| 0.5 | 2.5 | 2.4 | 2.9 |
| 1.0 | 3.0 | 2.0 | 4.0 |
| 2.0 | 4.0 | 1.5 | |
| 3.0 | 5.0 | | |
| 4.0 | 6.0 | | |
| 5.0 | 7.0 | 0.86 | 3.7 |
| 6.0 | 8.0 | 0.75 | 3.4 |
| 8.0 | 10.0 | 0.60 | 2.9 |
| 10.0 | 12.0 | 0.50 | 2.5 |

**Fig. 6.2**

*For Examiner's Use*

**(i)** Complete the table of Fig. 6.2. [2]

The graph of Fig. 6.3 shows how the power *P* dissipated in *R* varies as *R* changes.

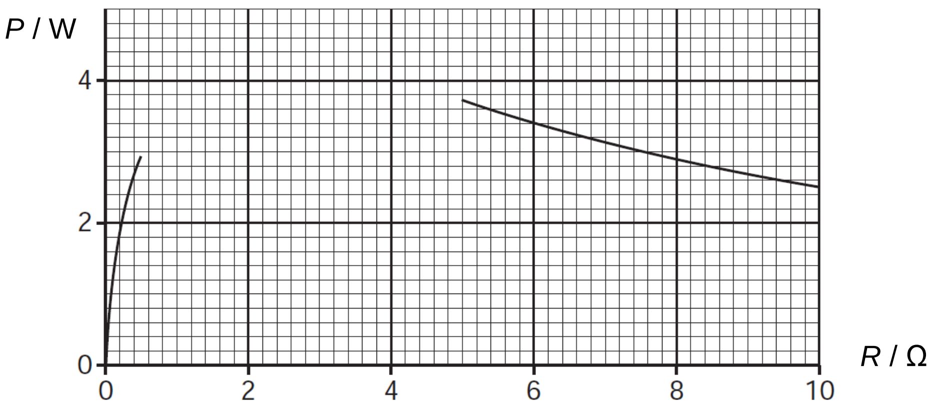


**Fig. 6.3**

**(ii)** Complete the graph in Fig. 6.3. [1]

**(iii)** State the value of *R* at which the power has its maximum value.

value of *R* = ……………………………… Ω [1]

**(iv)** Explain what happens to the power supplied by the 6.0 V battery when the current is 3.0 A.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

**(v)** The efficiency of the circuit is defined by the equation

$$\text{efficiency} = \frac{\text{power dissipated in } R}{\text{power supplied by battery}}$$

**1.** Determine the efficiency of the circuit when $R$ = 2.0 Ω.

efficiency = ……………………………… [2]

2. State the value of $R$ in the table that gives the greatest efficiency.

value of $R$ = ………………………………. Ω [1]

**(c)** The $I$-$V$ characteristics of a lamp are investigated using the circuit shown in Fig. 6.4.

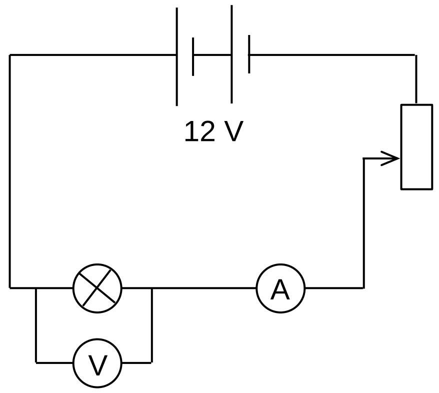


**Fig. 6.4**

The variable resistor can be adjusted to have resistance values between 0 and 10 Ω. Readings of potential difference (p.d.) $V$ across the lamp and current $I$ in the circuit are taken. The results obtained are shown in Fig. 6.5.

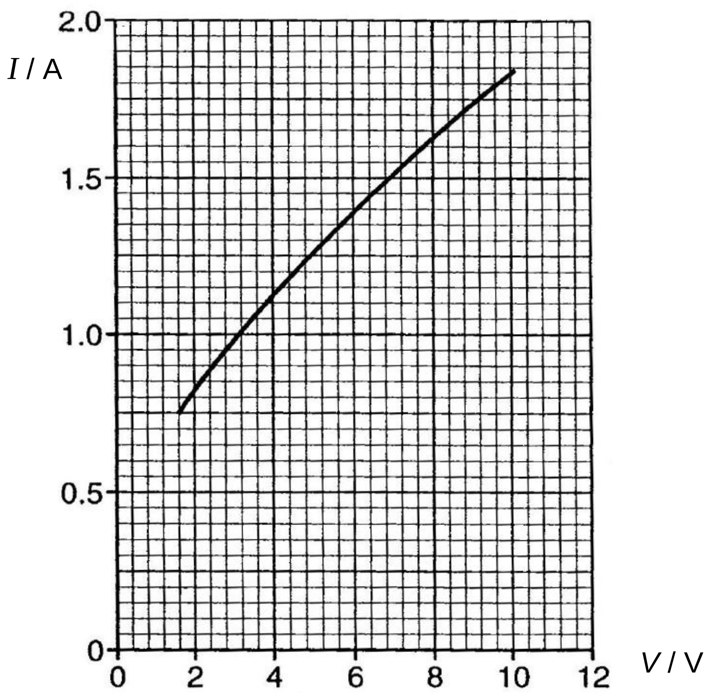


**Fig. 6.5**

For Examiner's Use

**(i)** Explain how the resistance of the lamp can be obtained from Fig. 6.5.

..........................................................................................................................

..........................................................................................................................[1]

**(ii)** On Fig. 6.6, sketch the variation in resistance of the lamp when the p.d. across it is varied over the range of 2 V to 10 V. (Numerical values for the resistance are not expected.) [2]

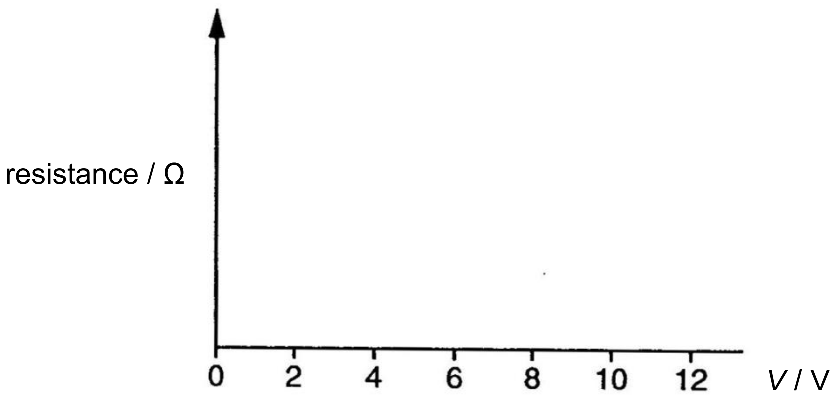


**Fig. 6.6**

**(iii)** Explain why, in the circuit of Fig. 6.4, the p.d. across the lamp cannot be varied from 0 to 12 V.

..........................................................................................................................

..........................................................................................................................

..........................................................................................................................[2]

For Examiner's Use

**(d)** All the electrical sockets in a house are connected to a circuit called a ring main. The circuit is connected between P and Q to the 240 V supply as shown in Fig. 6.7.

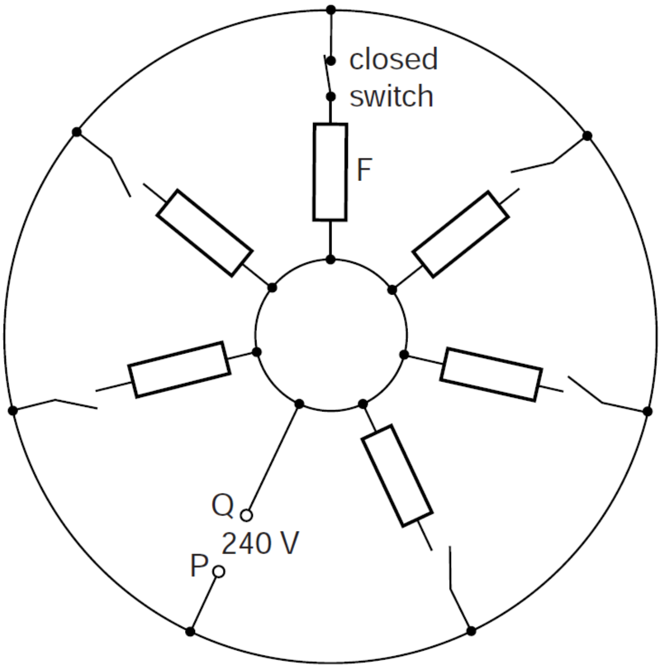


**Fig. 6.7**

**(i)** All the switches are open except the one to a computer at F, which is closed as shown. Draw arrows on Fig. 6.7 to show the paths of the current when the computer is in use at an instant in time when P is positive. [2]

**(ii)** Suggest two advantages of using a ring main.

**1.** ..................................................................................................................

..................................................................................................................

**2.** ..................................................................................................................

..................................................................................................................[2]

*For Examiner's Use*

**7** **(a)** **(i)** Describe what is meant by a *magnetic field*.

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..........................................................................................................

..........................................................................................................[3]

**(ii)** State the conditions for a charged particle to experience a force in a magnetic field.

..........................................................................................................

..........................................................................................................

..........................................................................................................[2]

**(b)** A metal rod AB is pushed to the right so that it cuts across the magnetic field, as shown in Fig. 7.1.

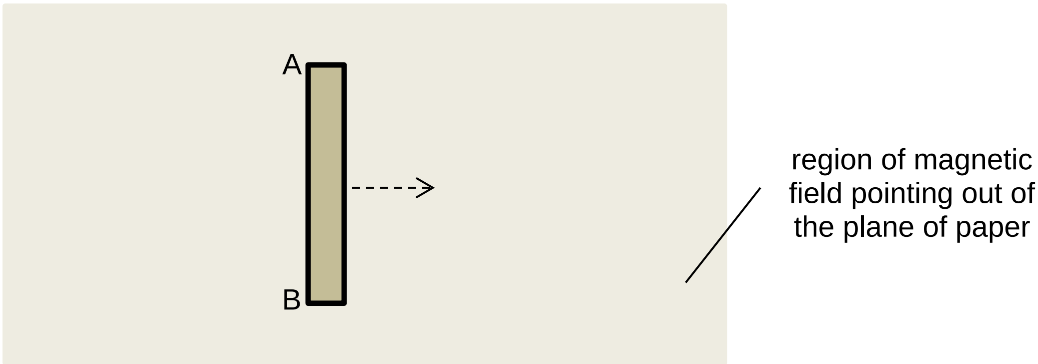


**Fig. 7.1**

**(i)** State and explain whether A or B is at a higher potential as the rod moves to the right.

..........................................................................................................

..........................................................................................................

..........................................................................................................[2]

For Examiner's Use

The rod is then connected by two wires to a lamp as shown in Fig. 7.2.

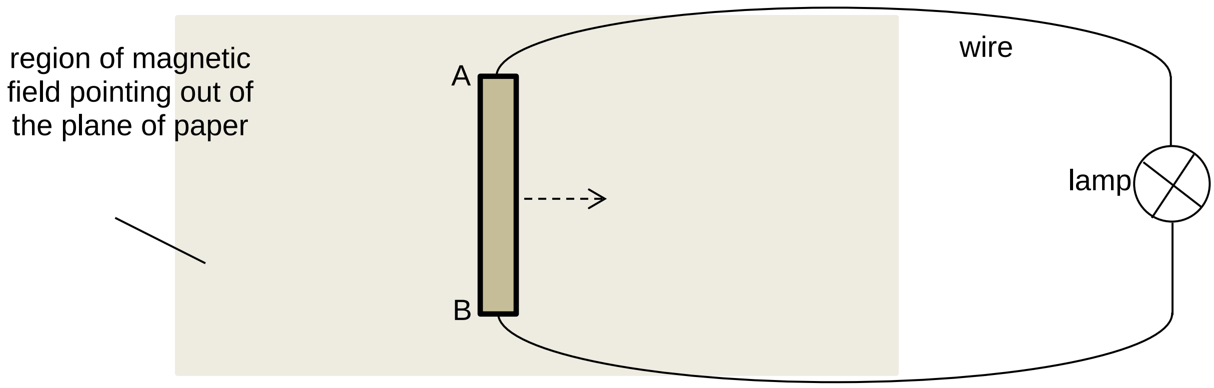


**Fig. 7.2**

**(ii)** State and explain whether the lamp will light up as the rod moves to the right at a constant speed.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

**(c)** A horseshoe permanent magnet of mass 85.00 g rests on an electronic balance as shown in Fig 7.3. The magnetic flux density in the space between the poles of the magnet is uniform and is zero outside this region.

The metal rod AB connected in a circuit is now situated between the poles of the magnet. The rod is horizontal and normal to the magnetic field.

*For Examiner's Use*

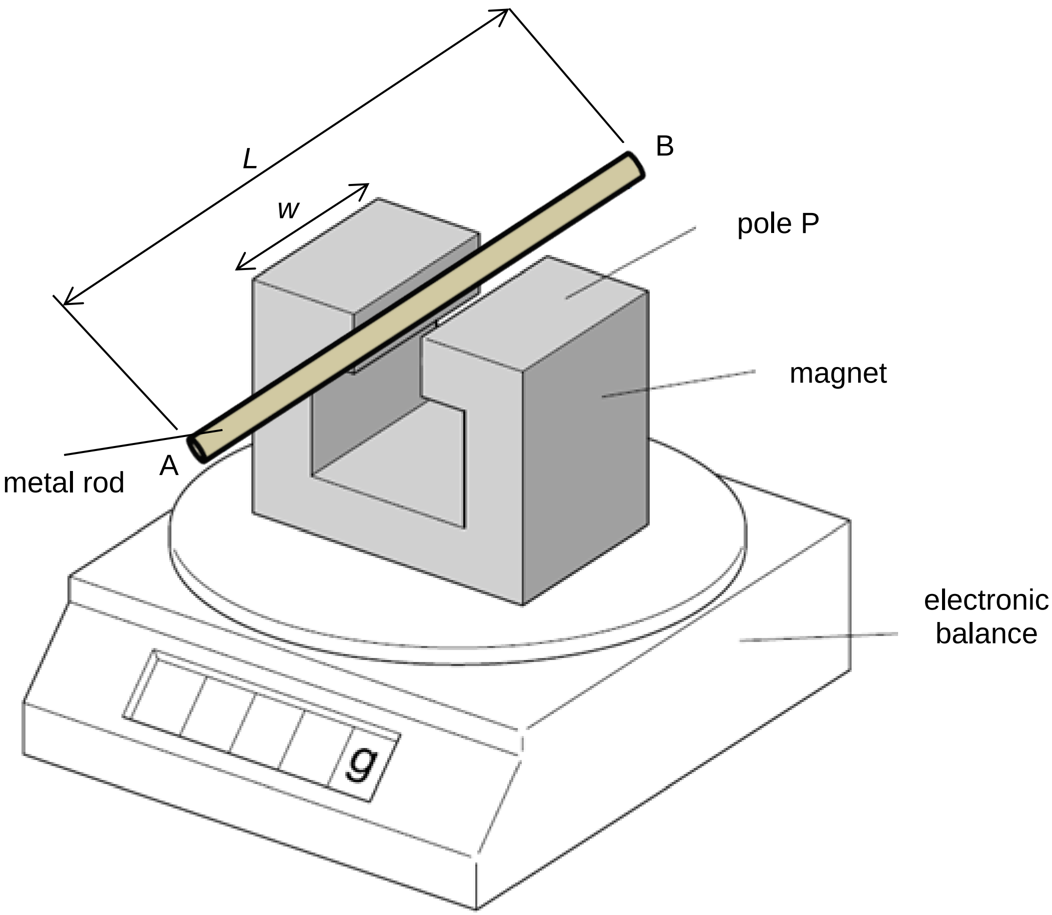


**Fig. 7.3**

**(i)** A direct current is passed through the metal rod in the direction from A to B and the reading on the balance decreases to 84.60 g.

Calculate the reduction in the force on the magnet.

reduction in force = ………………………………… N [1]

**(ii)** State and explain the polarity of the pole P of the magnet.

.................................................................................................................

.................................................................................................................

.................................................................................................................

...............................................................................................................[3]

**(iii)** The length of metal rod is $L$ = 40.0 cm and the width of magnet is $w$ = 10.0 cm. The magnetic flux density of the magnet is 30.0 mT.

Calculate the direct current in the rod.

current = ...................................... A [2]

**(d)** Fig. 7.4 shows the top view of a current balance where the rectangular wire loop PQRS pivoted at XY is in equilibrium. It is connected in series with a battery of mass 300 g and an e.m.f. of 2.0 V. Part of the wire loop is placed inside a solenoid. The mass of the loop can be taken to be negligible.

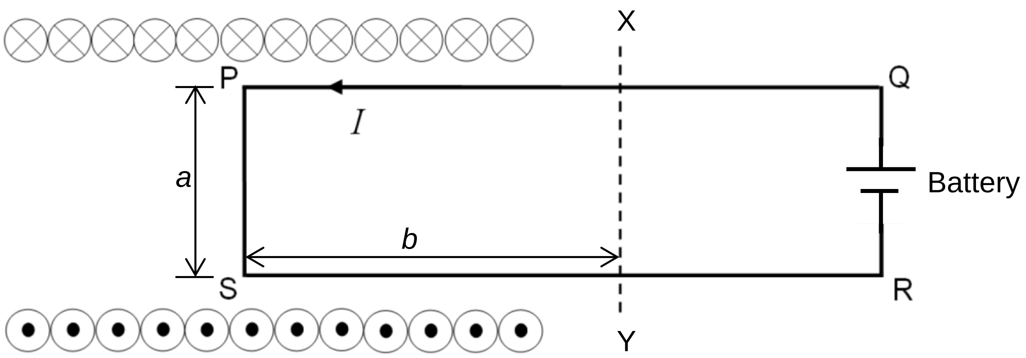


**Fig. 7.4**

**(i)** On Fig. 7.4, draw the magnetic flux pattern at the central region in the solenoid. [2]

For Examiner's Use

**(ii)** The length of *a* is 6.0 cm and *b* is six-tenths the length of SR. Given that the magnetic flux density in the solenoid is 0.40 T and the wire has no resistance, calculate the internal resistance of the battery.

resistance = …………………………………. Ω [3]

For Examiner's Use

**8** **(a)** A photon of wavelength $6.50 \times 10^{-12}$ m is incident on an isolated stationary electron, as illustrated in Fig. 8.1.

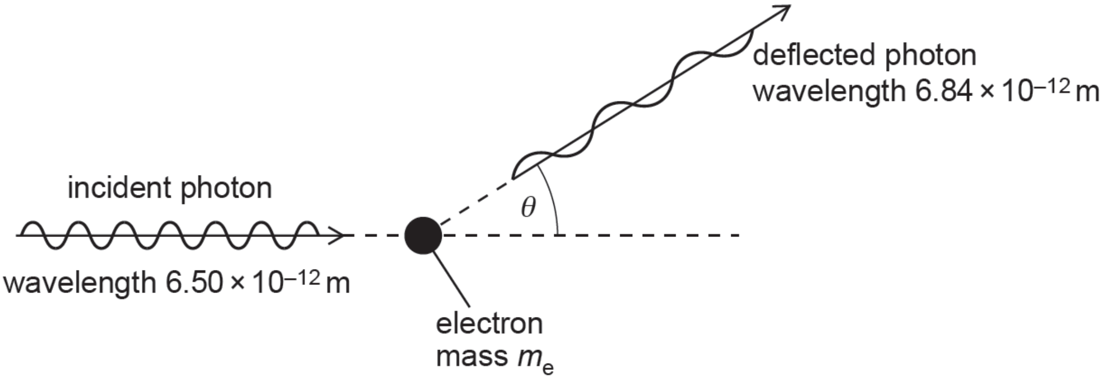


**Fig. 8.1**

The photon is deflected elastically by the electron of mass $m_e$. The wavelength of the deflected photon is $6.84 \times 10^{-12}$ m.

**(i)** On Fig. 8.1, draw an arrow to indicate a possible initial direction of motion of the electron after the photon has been deflected. [1]

**(ii)** Calculate, for the incident photon,

**1.** its momentum,

momentum = ………………………………… N s [2]

**2.** its energy.

energy = ………………………………… J [2]

*For Examiner's Use*

**(iii)** The angle $\theta$ through which the photon is deflected is given by the expression

$$\Delta\lambda = \frac{h}{m_e c}\left(1 - \cos\theta\right)$$

where $\Delta\lambda$ is the change in wavelength of the photon, $h$ is the Planck constant and $c$ is the speed of light in free space.

**1.** Calculate the angle $\theta$.

$\theta$ = ………………………………. ° [2]

**2.** Use energy consideration to suggest why $\Delta\lambda$ must always be positive.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[3]

**(iv)** Calculate the speed of the electron after the photon has been deflected.

speed = ………………………………. m $s^{-1}$ [2]

*For Examiner's Use*

**(v)** Explain why the magnitude of the final momentum of the electron is not equal to the change in magnitude of the momentum of the photon.

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..........................................................................................................................[2]

**(b)** **(i)** Describe how line spectra can be explained using the idea of discrete electron energy levels in isolated atoms.

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..........................................................................................................................

..........................................................................................................................[2]

**(ii)** Under what conditions and in what state are atoms sufficiently isolated so that line spectra can be observed?

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..........................................................................................................................

..........................................................................................................................[2]

**(c)** A beam of light has a continuous spectrum of wavelengths from 400 nm to 700 nm. The light is incident on some cool hydrogen gas, as illustrated in Fig. 8.2.

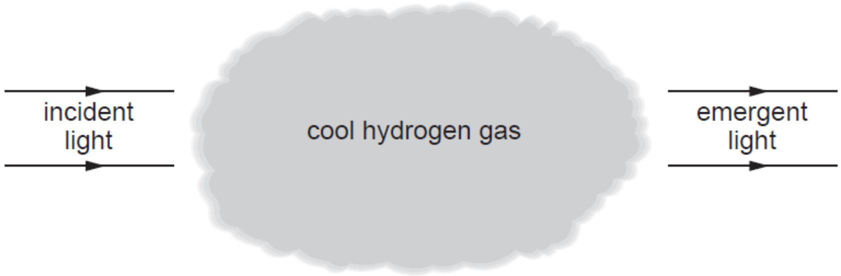


**Fig. 8.2**

State and explain the appearance of the spectrum of the emergent light.

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..........................................................................................................................

.......................................................................................................................... [2]