JURONG JUNIOR COLLEGE
2016 JC2 Preliminary Examination

Name		Class	16S

PHYSICS **8866/02**
Higher 1

Structured Questions

26 Aug 2016

2 hours

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

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use 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	
2	
3	
4	
5	
Section B	
6	
7	
8	
Total	

(This question paper consists of 25 printed pages)

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-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
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	$= \rho gh$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$

Section A

Answer **all** questions in this section.

1 A small block of wood is held at a horizontal distance of 1.2 m from a metal ball as shown in **Fig. 1.1**. The metal ball is fired horizontally towards the block at a speed of 8.0 m s^{-1}. At the same instant the ball is fired, the block is released and it falls vertically under gravity.

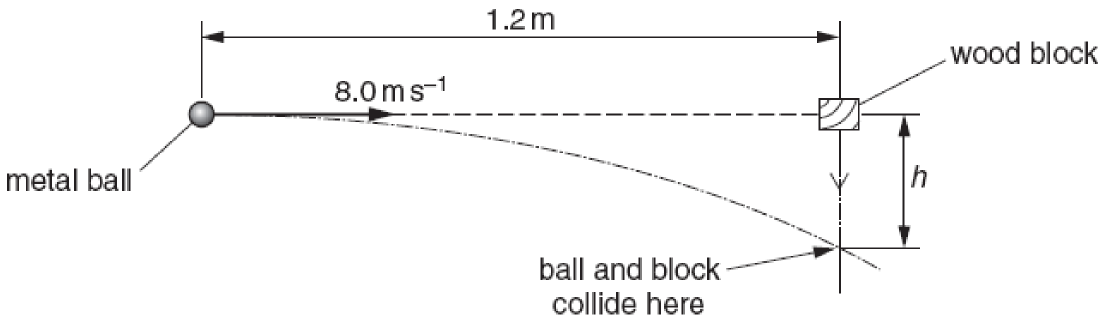


Fig. 1.1

Determine

(a) the time taken for the ball to collide with the block.

time = ... s [1]

(b) the vertical distance h, travelled by the block when it collides with the ball.

h = ... m [2]

(c) the speed of the ball just before it collides with the block.

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

(d) Explain why the ball will always collide with the block, even if the horizontal speed of the ball or its horizontal distance is changed.

____

____

____

____ [1]

2 **(a)** Starting with the definition of work, deduce the change in the gravitational potential energy of a mass *m* when moved a distance *h* upwards near the Earth's surface.

....

....

....

....

....

....

.... [3]

(b) **Fig. 2.1** below shows a frictionless toy runway. Upon release from point A, Car 1 of mass 0.100 kg runs down a slope, and moves round the loop of radius 0.25 m, passing through points B and C. At point C, the speed of Car 1 is 1.6 m s^{-1}.

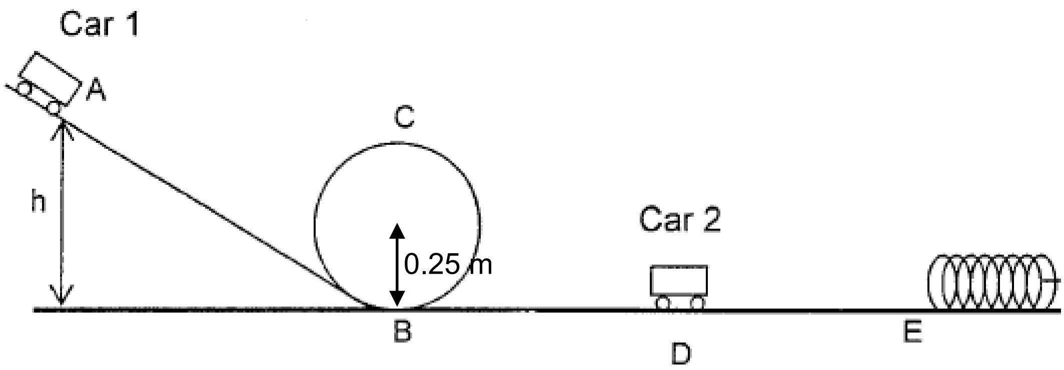


Fig. 2.1 (not drawn to scale)

(i) Determine the height *h* at point A.

h = ... m [2]

(ii) Car 1 moves down the loop and travels at constant speed at 3.5 m s^{-1} from point B towards a stationary Car 2 of mass 0.080 kg at point D. It collides head-on with Car 2 at point D.

Upon collision, the two cars stick together and continue to travel towards point E until it is stopped by a spring buffer of force constant 120 N m^{-1}.

Determine the maximum compression of the spring buffer when the cars collide into it.

maximum compression = ………………… m [3]

3 Railgun is researched as a weapon that would rely on electromagnetic forces to launch a projectile to very high kinetic energy.

The railgun is basically a large electric circuit, made up of three parts: a power source, a pair of parallel conducting rails and a movable conducting projectile as shown in **Fig. 3.1**.

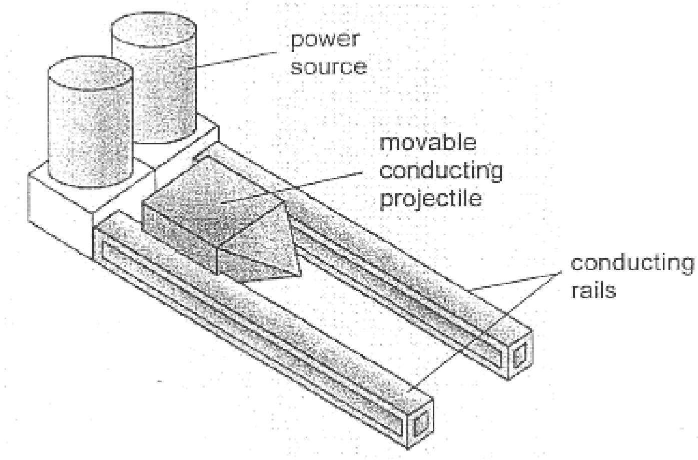


Fig. 3.1

When a potential difference of 1.0 kV is applied, a current I of 56 kA passes through the rail.

I will flow from the power supply to the positive rail, across the projectile of negligible resistance and back to the power supply through the negative rail as shown in **Fig. 3.2**.

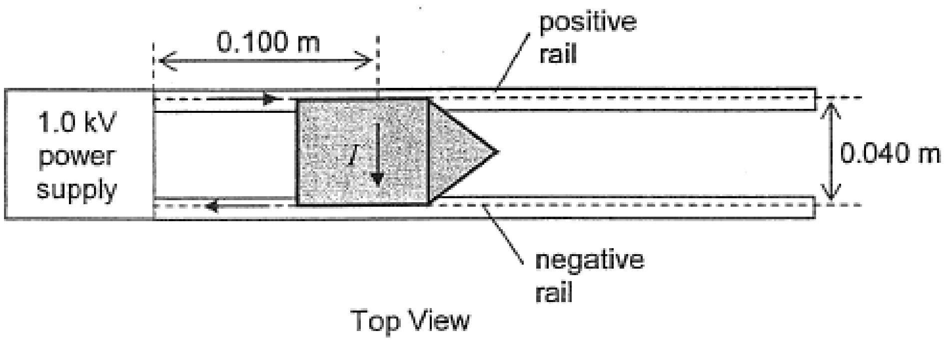


Fig. 3.2

(a) With reference to **Fig. 3.2**,

(i) show that the resistance of the rails is 0.018 Ω.

[1]

(ii) state the direction of the resultant magnetic field (due to the current) through the projectile.

[1]

(b) The resultant magnetic field at the centre of the projectile is 1.12 T and is assumed to be uniform throughout the projectile. As a result, a magnetic force *F* is exerted on the projectile.

(i) Determine *F*.

F = ______________ N [2]

(ii) State and explain whether *F* would be higher or lower in practice as the projectile travels along the rail.

[2]

(iii) State the direction of *F* if the direction of the current is reversed.

[1]

(iv) Explain one way in which *F* can be increased.

[1]

4 **(a)** In order to investigate the photoelectric effect, a student set up the apparatus as illustrated in **Fig. 4.1**. When the potential difference *V* is varied it is found that the photoelectric current varies as shown in the curve A in **Fig. 4.2**.

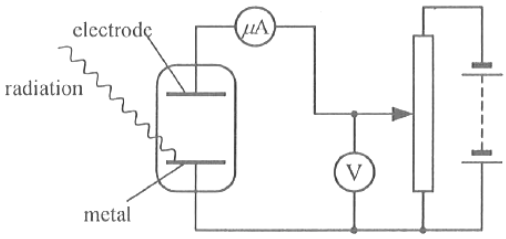


Fig. 4.1

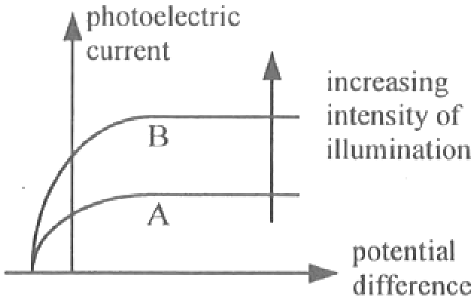


Fig. 4.2

(i) Explain why, for curve A, the photoelectric current reaches a maximum value no matter how large *V* is made.

[2]

(ii) The intensity of illumination is then increased and the experiment repeated to obtain curve B.

Explain why the maximum photoelectric current is increased.

[2]

(b) In a photoelectric emission experiment, light of wavelength 410 nm was shone on a metal surface of work function energy of 2.0 eV so that an area of 2.4×10^{-5} m^2 was illuminated. A photocurrent of 4.8×10^{-10} A was observed.

Determine

(i) the rate of emission of photoelectrons,

rate of emission = ______________________ s^{-1} [1]

(ii) the intensity of the light source, assuming that 1 in 2500 photons succeeds in ejecting an electron from the surface.

intensity = ______________________ W m^{-2} [3]

5 For thousands of years, Man has studied the night sky and some ancient buildings provide evidence of careful and patient astronomical observations by people of many different cultures. As instrumentation has improved, so has the precision with which astronomical observations could be made. Between 1576 and 1597, Brahe made comprehensive observations of planetary positions and, on his death, these records became available to Kepler.

Kepler was able to interpret the observations and deduced three laws, one of which had a great impact on latter discoveries. He deduced that, for a circular orbit of a planet around the Sun of mass *M*, if *T* is the period of orbit and *r* is the radius of the orbit, then

$$T^2 \propto r^3$$

As a result of Kepler's work, Newton formulated the law of gravitation.

The actual relationship between the period *T* of the moon moving in a circular orbit of radius *r*, around the planet of mass *M* is given as

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

where *G* is the gravitational constant.

(a) The planet Jupiter has a number of moons. Data for some of these are given in **Fig. 5.1.**

Moon	**Period** *T***/days**	**mean distance from centre of Jupiter** *r* **/ 10^9 m**	**$\log_{10}$ (*T*/days)**	**$\log_{10}$ (*r*/m)**
Sinope	758	23.7	2.88	10.37
Leda	239	11.1	2.38	10.05
Callisto	16.7	1.88		
Lo	1.77	0.422		
Metis	0.295	0.128	– 0.53	8.11

Fig. 5.1

(i) Complete **Fig. 5.1** by calculating values for $\log_{10}$ (*T*/days) and $\log_{10}$ (*r*/m).

[2]

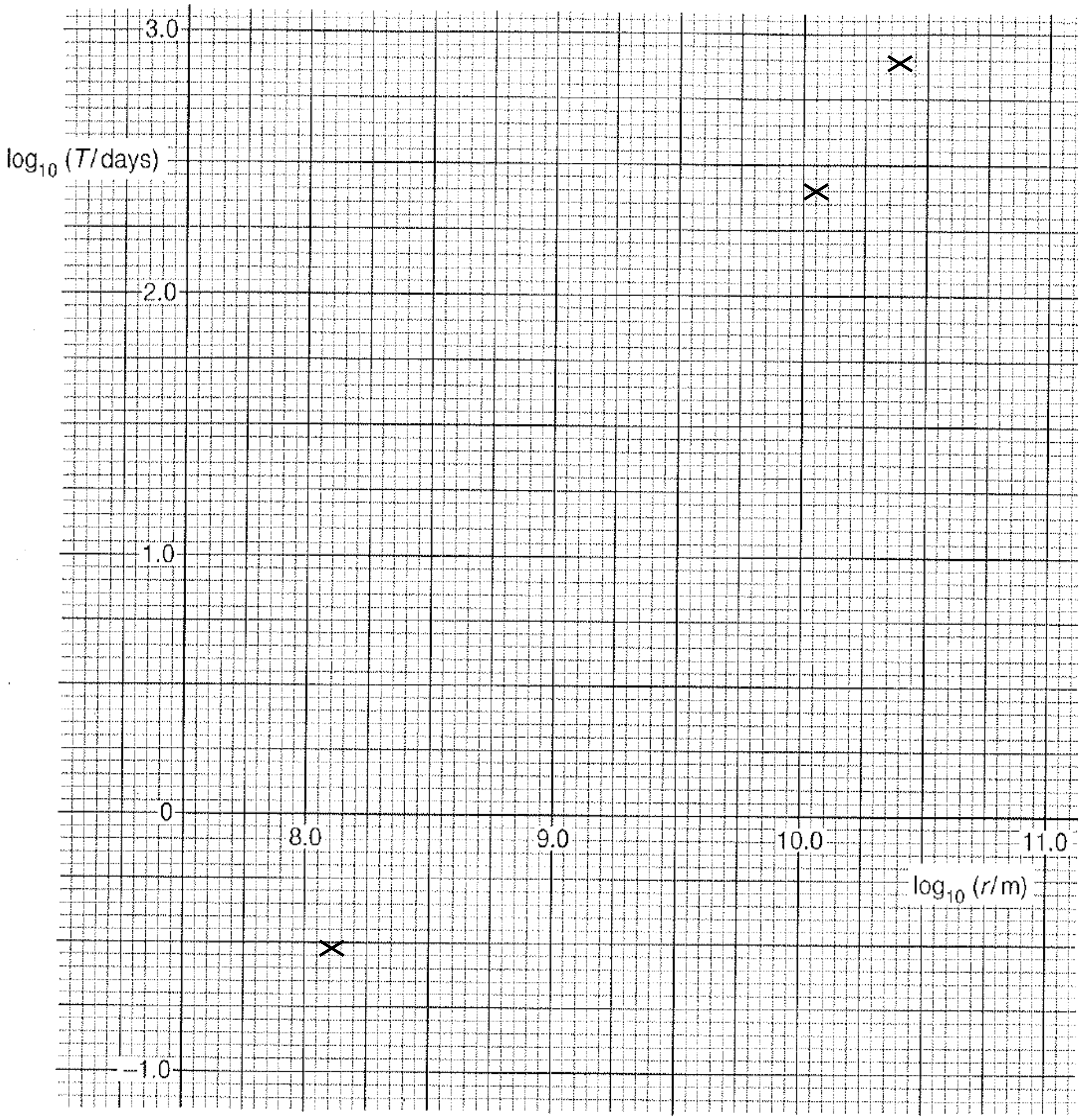


Fig. 5.2

(ii) On the axes of **Fig. 5.2**, plot a graph of $\log_{10}$ (T/days) against $\log_{10}$ (r/m).

[2]

(b) **(i)** Determine the gradient of the graph in **Fig. 5.2**.

gradient = ... [2]

(ii) Hence discuss whether the data in **Fig. 5.1** support the relation

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

....

....

.... [2]

(c) Observations show that the moon Ganymede orbits Jupiter with a period of 7.16 days. Use the graph of **Fig. 5.2** to estimate the orbital radius of Ganymede.

orbital radius = ... m [2]

Section B

Answer **two** questions from this section.

6 **(a)** Define force.

[1]

(b) Explain how it is possible for a body experiencing a resultant force to be at zero momentum.

[1]

(c) A karate expert can fracture a stack of bricks with the blow of her bare hand by bringing it swiftly against the bricks with considerable speed.

(i) Explain why she has to execute the blow very quickly.

[1]

(ii) Explain how the impact might be different if her hand bounces back upon striking the bricks.

[2]

(d) Sand falls at a rate of 0.50 kg s^{-1} onto a conveyor belt which is moving at a constant velocity of 2.0 m s^{-1} as shown in **Fig. 6.1**.

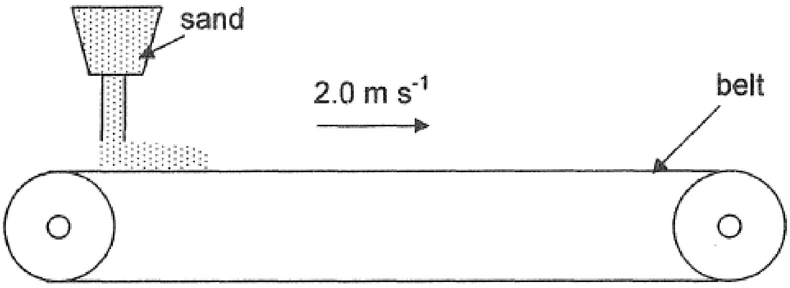


Fig. 6.1

(i) Determine the additional power expended in driving the belt,

power = ... W [2]

(ii) Determine the rate at which the sand acquires kinetic energy.

rate = ... W [2]

(iii) Account for the difference between the two answers.

....

....

.... [1]

(e) A steel ball is suspended by two rigid light rods that are hinged to the ceiling as shown in **Fig. 6.2**.

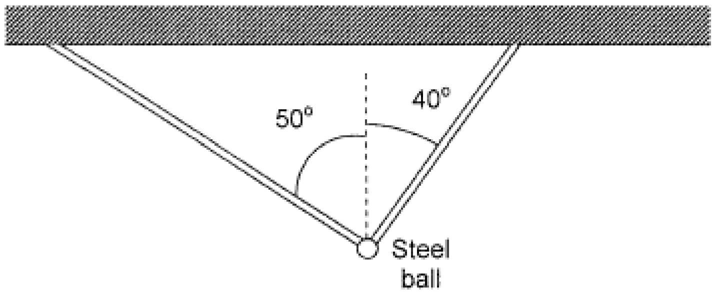


Fig. 6.2

(i) Draw the free body diagram of the steel ball. Label all forces. [2]

(ii) Calculate the weight of the steel ball if the tension in the longer rod is 80.6 N.

weight = ... N [3]

(iii) A wind blowing from right to left exerts a force on the steel ball. Without further calculation, suggest and explain the effect of the wind on the magnitude of the tension in the shorter rod.

....

....

....

.... [2]

(iv) Due to prolong periods of neglect, the shorter rod gave way at the point of its connection with the steel ball. That caused the steel ball to swing downwards.

Calculate the maximum speed attained by the steel ball if the length of the longer rod is 2.0 m.

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

(v) Suggest with a reason, whether in practice you will expect the maximum speed attained by the steel ball to be higher or lower than the value calculated in **(e)(iv)**.

....

....

.... [1]

7 **(a)** Define the resistance of a resistor.

[1]

(b) A copper wire with a resistance of 6.0 Ω is stretched so that its new length is three times its original length. Assuming that the resistivity and density of copper are not changed during the stretching process, calculate the resistance of the longer wire.

resistance = Ω [3]

(c) The circuit shown in **Fig. 7.1** is constructed with resistors, each of which has a maximum safe power rating of 0.40 W.

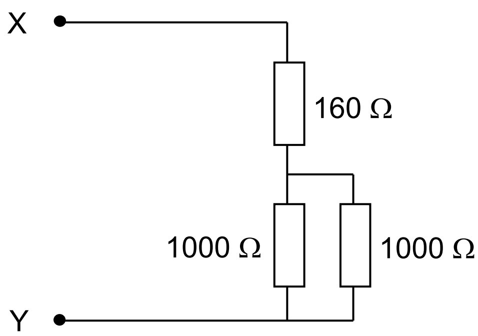


Fig. 7.1

(i) Determine the maximum potential difference that can be applied between X and Y without damage to any of the resistors.

maximum potential difference = V [3]

(ii) If the maximum potential difference is exceeded, state and explain which resistor would most likely fail first.

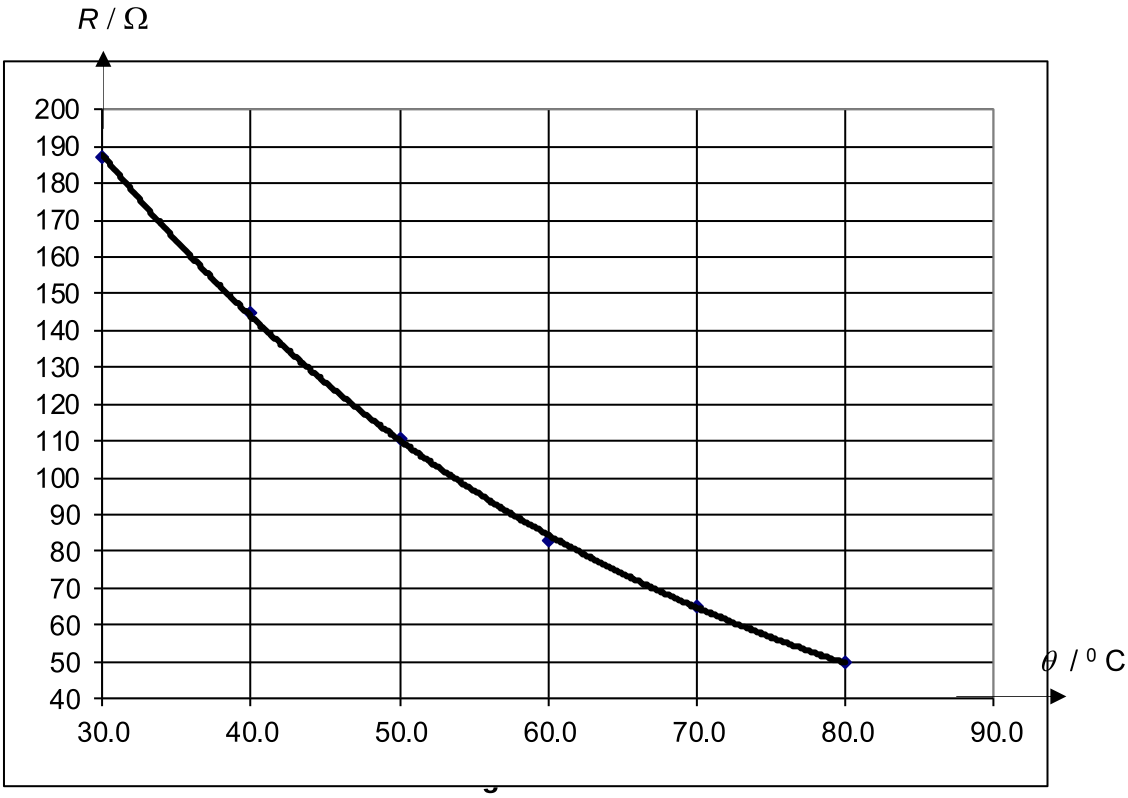
....

....

....

.... [2]

(d) A student investigated how the resistance R of a small semiconductor device X varies with Celsius temperature θ. **Fig. 7.2** shows the variation with temperature θ of resistance R.



(i) Assuming that the device X conforms to a relationship of the form

$$R = Ae^{\frac{B}{T}}$$

where A and B are constants, calculate a value for A and for B by using values of R corresponding to temperatures 50.0 °C and 80.0 °C.

Note that T represents the thermodynamic temperature.

$$T\,/\text{K} = T\,/\,^{\circ}\text{C} + 273.15$$

A = ... Ω [2]

B = ... K [2]

(ii) Discuss whether there is a better method of determining more reliable values of A and B.

....

....

.... [1]

(e) Sketch a graph of the current I through device X against the potential difference V across it in **Fig. 7.3** .

Fig. 7.3

[1]

(f) Device X is now connected to a fixed resistor of resistance 40.0 Ω as shown in **Fig. 7.4**.

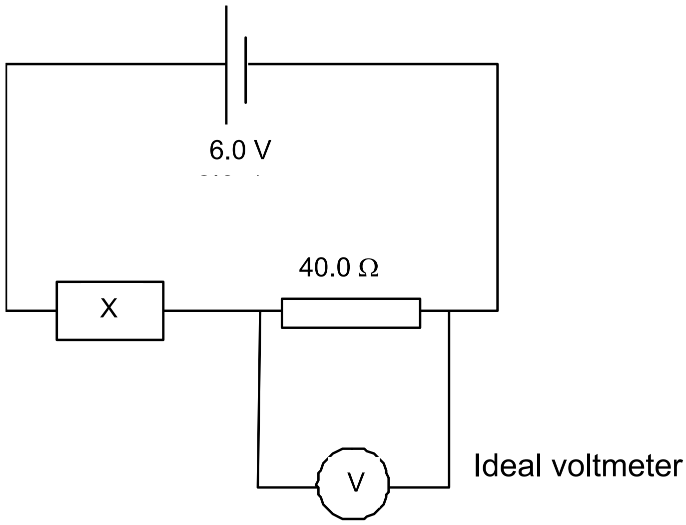


Fig. 7.4

(i) Calculate an estimated value of the voltmeter reading when device X is immersed in water at temperature 30.0^{0}C.

voltmeter reading V = ... V [2]

(ii) The device X is then allowed to heat up. State and explain whether the voltmeter reading would increase or decrease.

....

....

....

.... [2]

(iii) Suggest and explain briefly how a buzzer can be connected to the circuit so that it will sound when the temperature is too high.

....

....

.... [1]

8 **(a)** Distinguish between

(i) *longitudinal* and *transverse* waves.

[2]

(ii) *progressive* and *stationary* waves.

[2]

(b) A water wave has wavelength 1.50 m. What is the distance between two points along this wave with a phase difference of $\frac{\pi}{6}$ rad?

distance = ... m [2]

(c) **Fig. 8.1** shows two coherent loudspeakers S_1 and S_2 placed 4.0 m apart in an open field on a calm day. D is a detector placed in the same horizontal plane as the loudspeakers. D is placed 12.0 m away from S_2.

When the loudspeakers are switched on, sound of frequency 1780 Hz is emitted from the two loudspeakers in phase. The lines S_1S_2 and S_2D are perpendicular to each other.

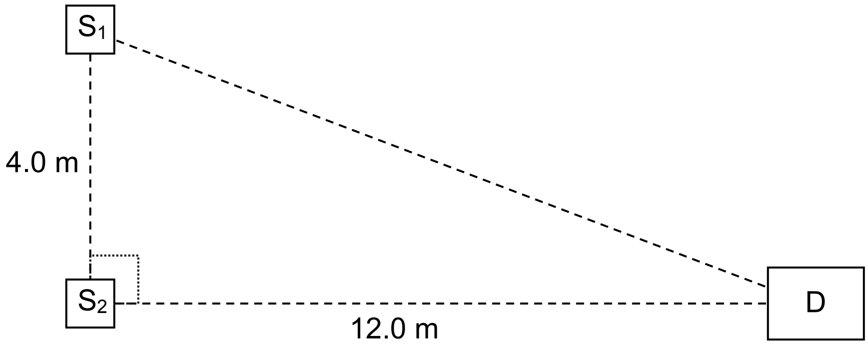


Fig. 8.1

(i) Given that the speed of sound in air is 330 m s^{-1}, calculate the wavelength λ of the sound emitted from S_1 and S_2.

λ = ... m [1]

(ii) Calculate the path difference, in terms of λ, between the sound waves reaching D from S_1 and S_2. You may assume that the two loudspeakers and the detector are point objects.

path difference = ... λ [2]

(iii) Using your answer in part **(ii)**, state the phase difference between the sound waves reaching D from S_1 and S_2. Hence, explain whether D would detect a minimum or maximum intensity.

[3]

(d) Microwave ovens cook food by generating electromagnetic radiation that gets absorbed and converted into the internal energy of the food molecules. A device called a magnetron emits electromagnetic radiation of 2.45 GHz from one side of the microwave oven. Stationary waves are produced in the oven's interior. A typical microwave oven of length 36.6 cm is shown in **Fig. 8.2**.

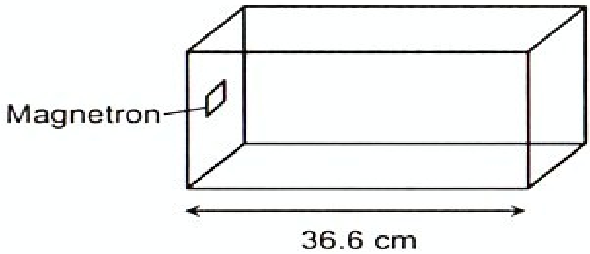


Fig. 8.2

(i) Explain how a stationary wave may be formed in the interior of the oven between the magnetron and the opposite wall.

[2]

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

wavelength = ... m [2]

(iii) Hence, or otherwise, sketch, on **Fig. 8.2**, the stationary wave pattern produced in the interior of the microwave oven of length 36.6 cm. Label one node (other than at the magnetron) and one antinode in your sketch.

[2]

(iv) Explain why food has to be placed on a turntable within the microwave oven and constantly rotated when cooking.

[2]

End of Paper