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DUNMAN HIGH SCHOOL
Holiday Revision Set B
Year 5

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1 An army tank fires a bomb at an initial speed of 800 m s^{-1} at an angle of elevation of α as shown in Fig. 1.1. The bomb is released at a height 300 m above the ground of the valley. Assume air resistance is negligible.

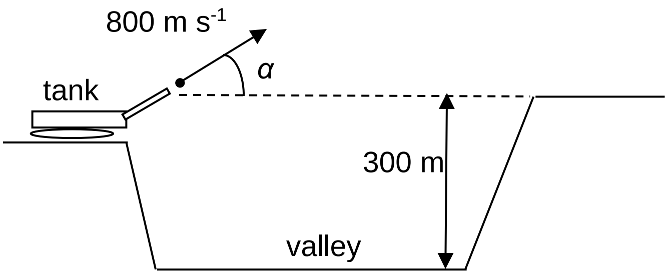


Fig. 1.1

(a) Determine the minimum height, in terms of α and g, which an airplane can fly above the ground of the valley without being hit by the bomb.

minimum height = ………………….. m [2]

(b) Show that the horizontal distance, x, travelled by the bomb is

$$x = \frac{640000 \sin 2\alpha}{g}$$

[2]

(c) The bomb exploded after travelling the distance in **(b)**. The spherical shockwave produced expands as shown in Fig. 1.2.

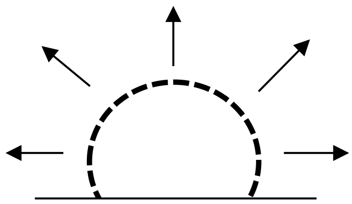


Fig. 1.2

The radius R of the shockwave, at time t after the explosion, is related to the energy E released and the density ρ of the surrounding medium according to the equation

$$R = E^{0.2}\rho^{-0.2}t^{z}$$

where z is a constant to be determined.

(i) Determine the value of z.

z = ………………….. [2]

(ii) If R = (80 ± 2) m at t = (0.006 ± 0.001) s, and the density ρ = (1.2 ± 0.1) kg m^{-3}, calculate the energy released E, with its appropriate uncertainty.

E = ……………±………….. J [3]

2 **(a)** Define *velocity*.

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

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

(b) A car travels along a long flat road. The velocity-time graph representing the motion of the car is shown in Fig. 2.1 below.

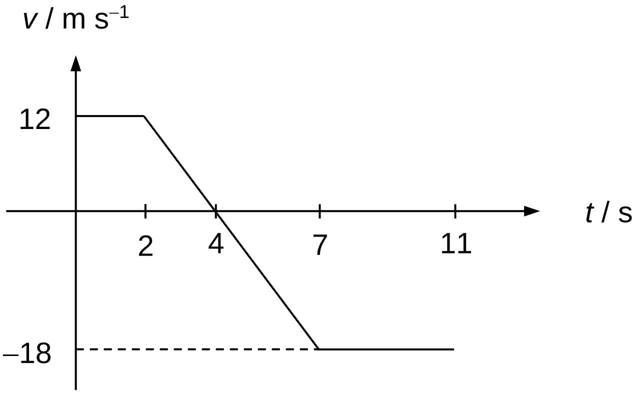


Fig. 2.1

(i) Assuming that the car has zero displacement at t = 0 s, find the displacement of the car at t = 11 s.

displacement =…………………………… m [2]

(ii) Draw a well-labelled displacement-time graph for the motion of the car in Fig. 2.2 below. [3]

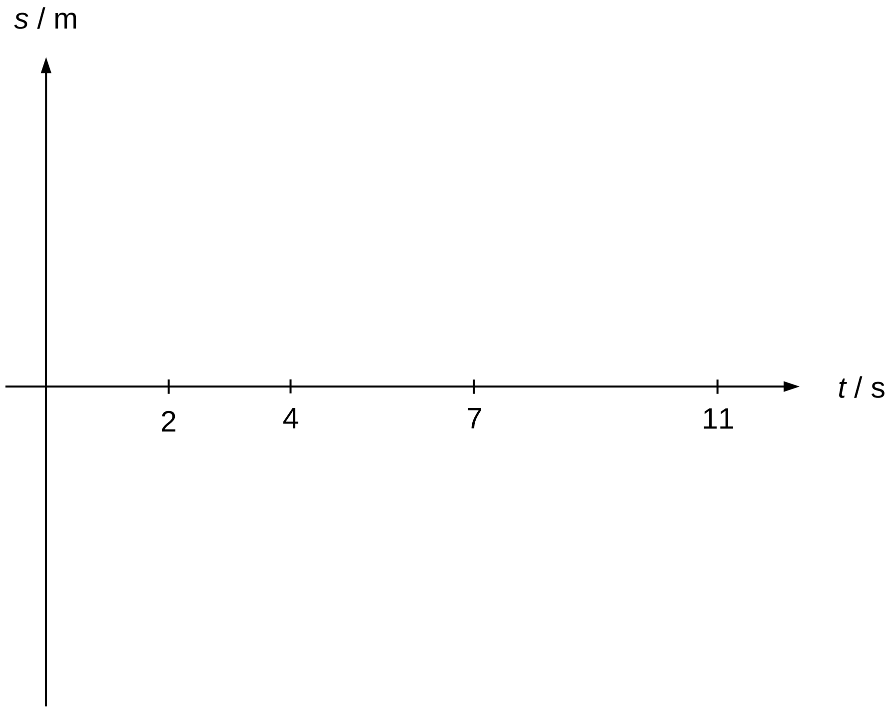


Fig. 2.2

(iii) Draw a well-labelled acceleration-time graph for the motion of the car in Fig. 2.3 below.

[2]

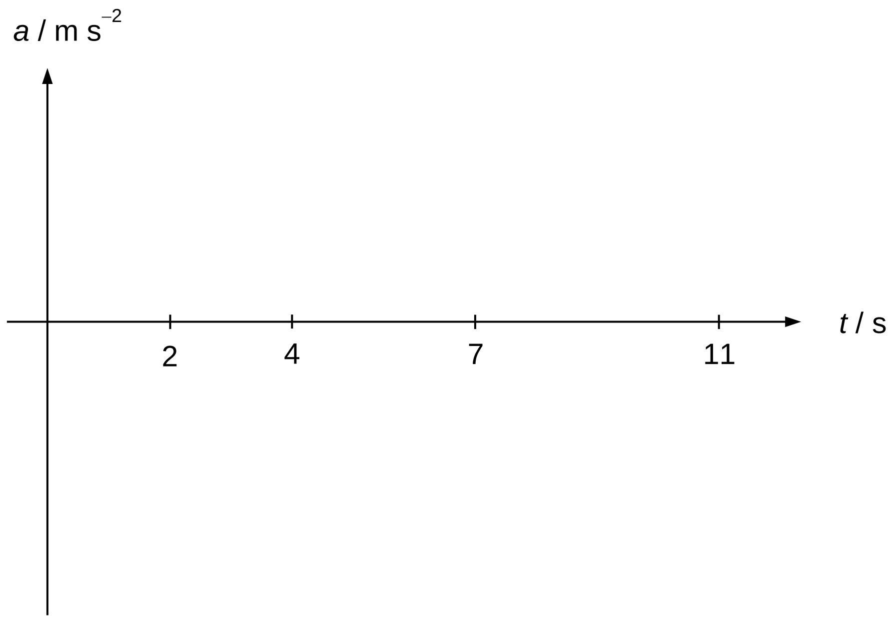


Fig. 2.3

3 A toy rocket consists of a plastic bottle which is partially filled with water. The space above the water contained compressed air, as shown in Fig. 3.1.

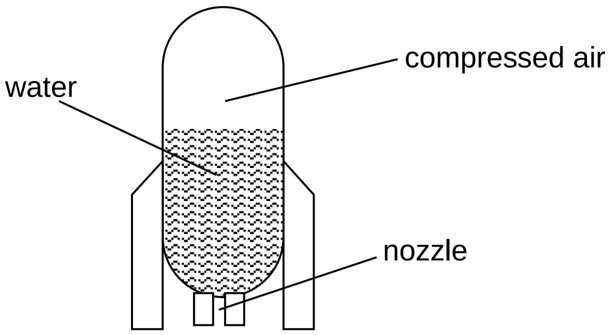


Fig 3.1

At one instant during the flight of the rocket, water of density ρ is forced through the nozzle of radius r at speed v relative to the nozzle.

(a) State Newton's 3rd Law.

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

.

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

(b) Given that the mass of water ejected per unit time from the nozzle is

$$\pi r^2 \rho v$$

show that the accelerating force F acting on the rocket is given by the expression

$$F = \pi r^2 \rho v^2 - mg$$

where m is the mass of the rocket and its contents at the instant considered

[3]

(c) The toy manufacturer recommends that the rocket should contain about 550 cm^3 of water before take-off. If the initial air pressure is 1.6×10^5 Pa, all of this water will be expelled and the pressure is just reduced to atmospheric pressure as the last of the water is expelled. However, on one flight, the initial volume of water was 750 cm^3 but the initial air pressure in the rocket was still 1.6×10^5 Pa. State, without calculation but with a reason, the effect of this increased volume of water on

(i) the initial thrust

....

.... [1]

(ii) the initial acceleration

....

.... [1]

(iii) the maximum height reached

....

.... [1]

4 A horizontal flat plate is free to rotate about a vertical axis through its centre as shown in Fig. 4.1.

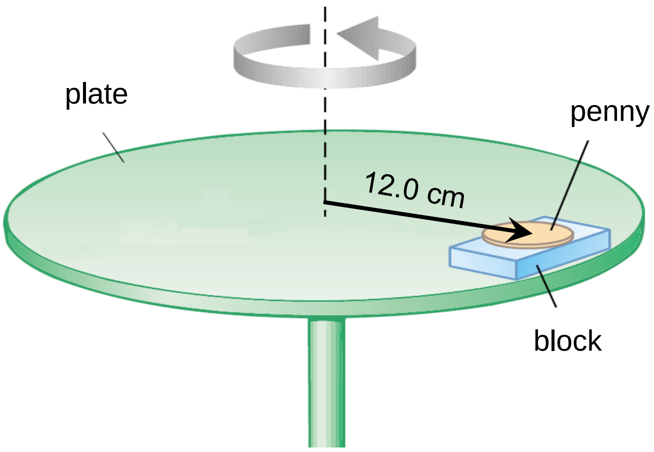


Fig. 4.1

(a) A penny of mass 3.10 g rests on a small block of mass 20.0 g. The penny and block are then placed on the plate with each centre of mass 12.0 cm from the axis of rotation. The speed of rotation of the plate can be gradually increased from zero.

The maximum frictional forces F_1 between the plate and the block and F_2 between the penny and the block are given by the expressions

$$F_1 = 0.40\,(W_1+W_2)$$
$$F_2 = 0.52\,W_2$$

where W_1 and W_2 are the weights of the block and penny respectively.

(i) Calculate the angular velocity when the block, with the penny, starts to slide.

angular velocity = ………………………………. rad s^{-1} [2]

(ii) Calculate the angular velocity when the penny starts to slide.

angular velocity = ………………………………. rad s^{-1} [2]

(iii) Hence, determine the maximum number of revolutions of the plate per minute for both the block and the penny to remain on the plate.

maximum number of revolutions per minute = **…………………….** min^{-1} [2]

(b) The plate in **(a)** is covered, when stationary, with mud.

Suggest and explain whether mud near the edge of the plate or near the centre will first leave the plate as the speed of rotation of the plate is slowly increased.

………………………………………………………………………………………….

………………………………………………………………………………………….

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

5 (a) Define *gravitational potential* at a point in a gravitational field.

……………………………………………………………………………………..…..

……………………………………………………………………………………[1]

(b) Four identical masses, each of mass m, are arranged symmetrically about a light circular ring of radius R as shown in Fig. 6.1. Point P is at a distance h from the centre O of the ring along the central axis of the ring.

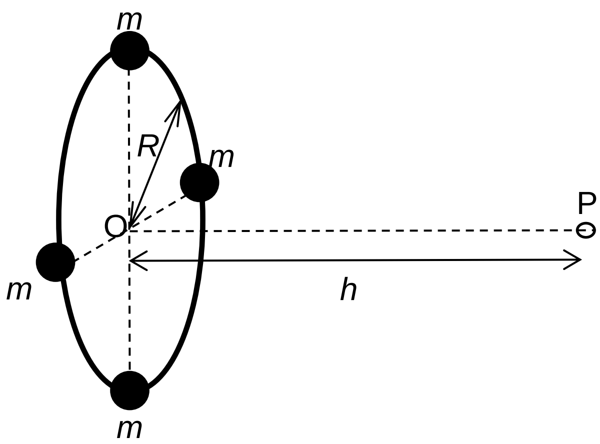


Fig. 6.1

Derive an expression in terms of m, h, R and the gravitational constant G, for

(i) the gravitational potential at point P,

[2]

(ii) the minimum velocity that a mass placed at P needs to be projected with, such that it is able to escape the gravitational field of the four masses.

velocity = ………………………………m s^{-1} [2]

6 The variation of displacement x of the acceleration a of a system is shown in Fig 8.1.

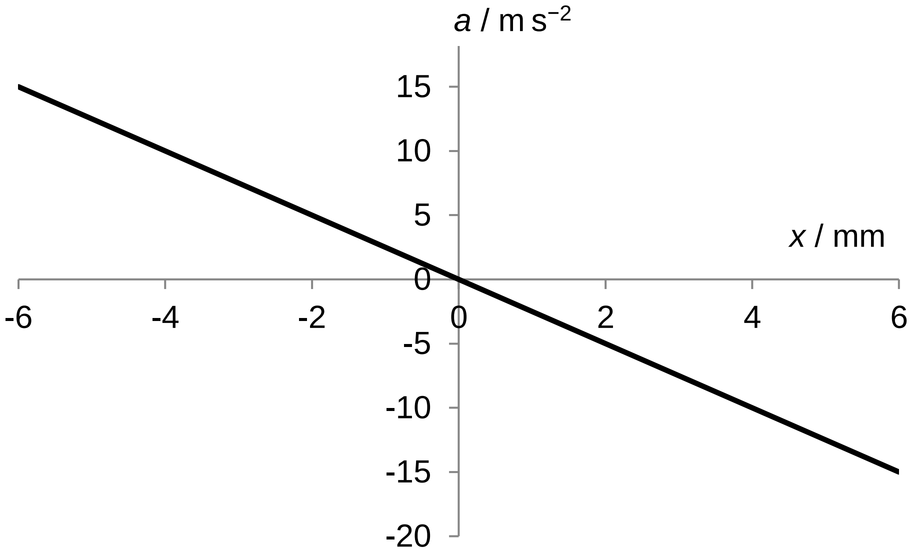


Fig. 8.1

(a) Explain how it may be deduced that the oscillations of the system are simple harmonic.

....

....

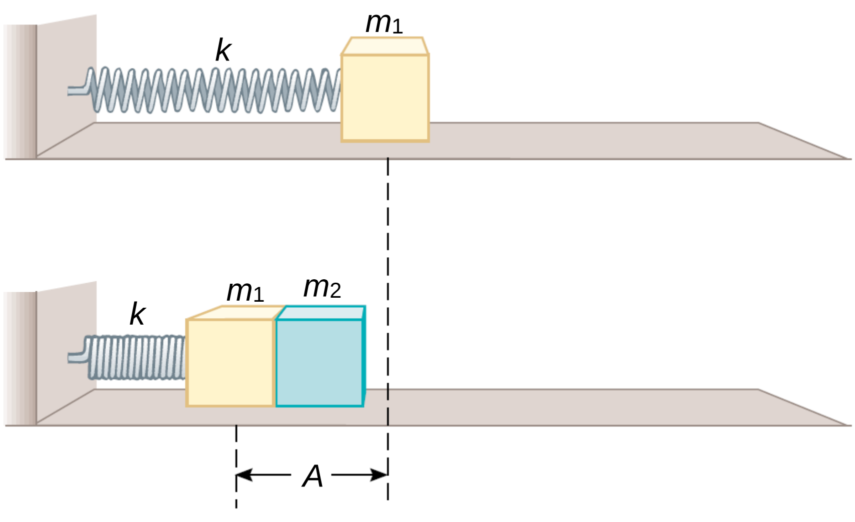
....

....[3]

(b) An object of mass m_1 = 9.00 kg is in equilibrium while connected to a light spring of spring constant k = 100 N m^{-1} that is fastened to a wall as shown in Fig. 8.2.1. A second object m_2 = 7.00 kg is slowly pushed up against m_1, compressing the spring by the amount A = 0.200 m (see Fig. 8.2.2).

Fig. 8.2.1

Fig. 8.2.2



(i) Calculate the maximum energy stored in the spring when it is fully compressed by the amount A.

maximum energy = ... J [1]

The system is then released, and both objects start moving to the right on the frictionless surface. When m_1 reaches equilibrium point (Fig. 8.2.3), m_2 loses contact with m_1 and moves to the right with speed v (Fig. 8.2.4).

Fig. 8.2.3

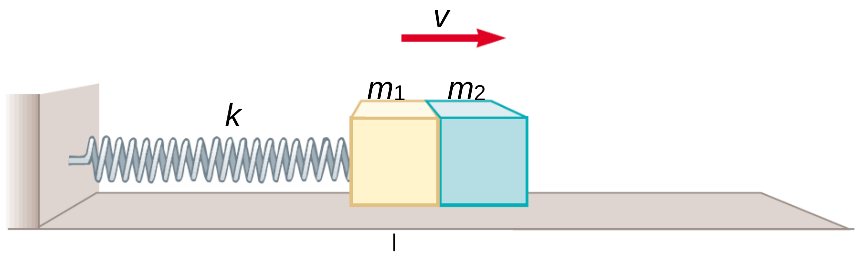
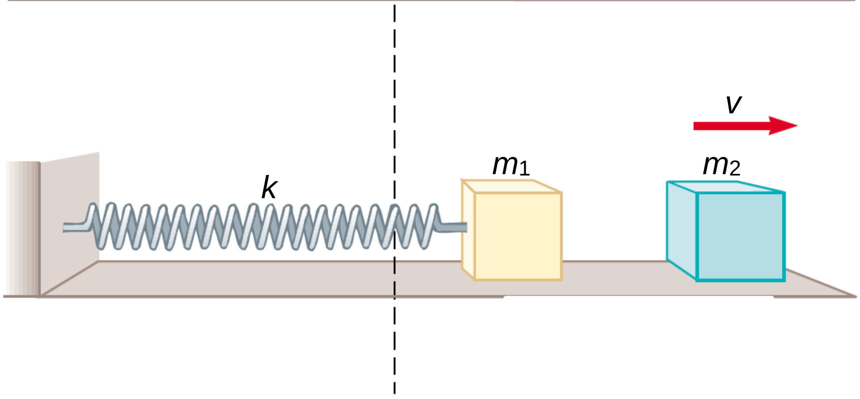


Fig. 8.2.4



(ii) Hence, or otherwise, determine the speed v.

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

(iii) Determine the amplitude of oscillations for m_1 after m_2 loses contact with m_1.

amplitude = ... m [2]

7 A 200 g mass hangs vertically from an attached spring and is initially stationary. The spring is light and has a spring constant of 20 N m^{-1}. The mass is then pulled down by 8.0 cm and released. The spring-mass system starts oscillating with a period of (π/5) s. Let the positive direction be in the upward direction. Take value of *g* as 10 m s^{-2}.

(a) Determine the maximum speed of the mass as it oscillates.

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

(b) Draw a well-labeled velocity-time graph for the motion of the spring-mass system in Fig. 9 below. Take t = 0 s to be the time when the mass is released and starts oscillating.

[2]

Fig. 9

(c) At a certain displacement below the equilibrium point, the mass has a speed of $0.42\ \text{m s}^{-1}$. Find the displacement of the mass from the equilibrium point.

displacement =.. cm [2]

(d) Calculate the minimum elastic potential energy stored in the spring as the spring mass system oscillates.

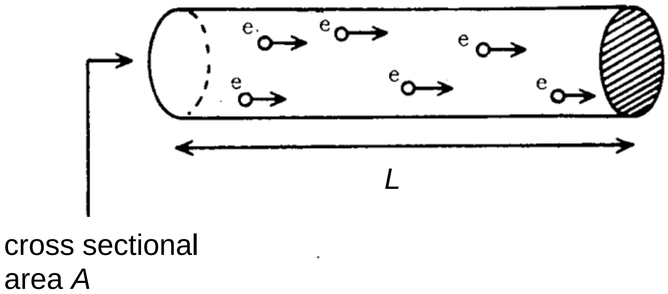
minimum elastic potential energy =.. mJ [2]

(e) Hence complete the following table.

	Lowest Point	Equilibrium Point	Highest Point
Gravitational Potential Energy / mJ	0		
Elastic Potential Energy / mJ			
Kinetic Energy / mJ			

[5]

8



(a) The diagram shows a length L of conductor of cross-sectional area A. The conductor contains charged particles free to move from left to right as shown.

(i) If there are n such particles per unit volume each with charge e, derive an expression for the total charge of these particles in the length of conductor.

[1]

(ii) If the particles are each moving with a drift velocity v in the direction shown, write down an expression for the time taken for all the particles to through the shaded area.

[1]

(iii) Show that the current I flowing in the conductor is given by the equation:

$$I = nAve$$

[2]

A circuit contains three similar filament lamps A, B and C. The circuit also contains three switches S_1, S_2, and S_3, as shown in Fig. 10.1.

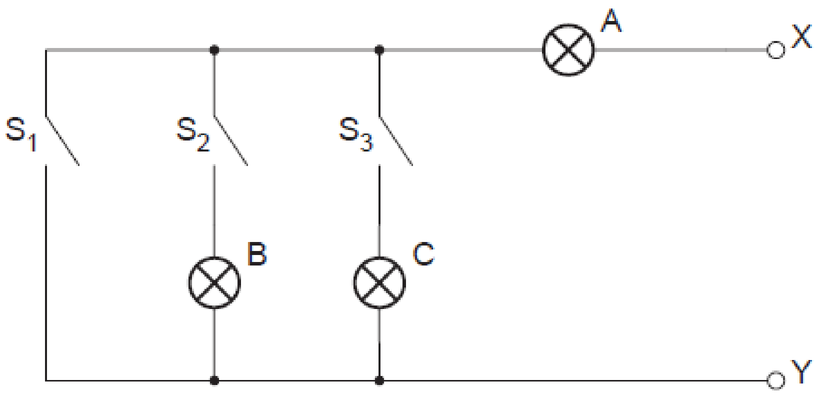


Fig. 10.1

One of the lamps is faulty. In order to detect the faulty lamp, an ohm-meter (a device which measures resistance) is connected between terminals X and Y. When measuring resistance, the ohm-meter causes negligible current in the circuit.

Fig. 10.2 shows the readings of the ohm-meter for different switch positions.

switch			meter reading
S_1	S_2	S_3	/ Ω
open	open	open	∞
closed	open	open	15
open	closed	open	30
open	closed	closed	15

Fig. 10.2

(b) Identify the faulty lamp and the nature of the fault.

faulty lamp: ……………………………………………………..…………………..…………[1]

nature of fault: ……………………………………………………………….…………….............[1]

(c) State the resistance of one of the non-faulty lamps.

resistance = **……………………..** Ω [1]

(d) Each lamp is rated for operation at 6.0 V and 0.20 A. Determine the resistance for one of the lamps operating at nominal brightness.

resistance = **……………………..** Ω [1]

(e) Explain why the resistance stated in **(c)** is not the same as the resistance calculated in **(d)**.

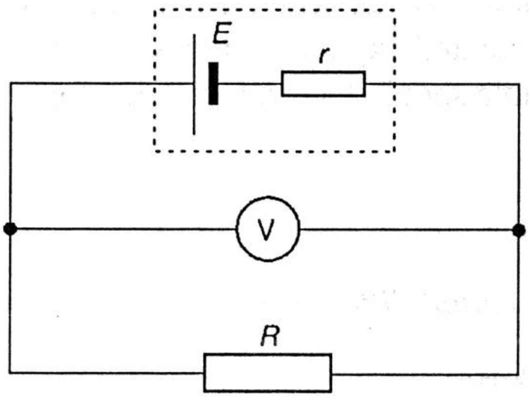
……………………………………………………………………………………………………....

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

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

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

(f) A cell of e.m.f. E and internal resistance r is connected to an external resistor of resistance R as shown below.



A voltmeter of infinite resistance is connected in parallel with the resistor.

(i) Include in the circuit a switch so that the voltmeter may be used to measure either the e.m.f. E of the cell or the terminal p.d. V. [1]

(ii) State whether the switch should be open or closed when measuring

1. the e.m.f. E,

…………………………………………..

2. the terminal p.d. V.

………………………………………….. [2]

(iii) The cell has an e.m.f. of 15.0 V. The terminal voltage of the cell is 11.6 V when it is delivering 20.0 W of power to the external resistor.

Calculate

1. the value of R,

R = …………………………………… Ω [2]

2. the value of r.

r = …………………………………… Ω [3]

End of Holiday Revision Set B