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PHYSICAL SCIENCES PAPER 1

PHYSICS

MODEL ANSWERS

Question 1

1.1 B ✓✓ each

1.2 C

1.3 D

1.4 D

1.5 A

1.6 C

1.7 A

1.8 B

1.9 A

1.10 C

[20]

Question 2

2.1.1 $v^2 = u^2 + 2as$ ✓

$0^2 = 18^2 + 2(-9,8)(s)$ ✓✓

$s = 16,53\text{m}$ ✓

height from sea = $70 + 16,53 = 86,53\text{m}$ ✓ (5)

2.1.2 Choosing downward as positive

$s = ut + \frac{1}{2}at^2$ ✓

$70 = -18t + \frac{1}{2}(9,8)t^2$ ✓✓ [Check for correct sign convention]

$0 = 4,9t^2 - 18t - 70$ [Solve as quadratic equation]

$t = 6,04\text{ s}$ ✓

OR Calculate time to max height; then time from max height to sea level and add

Time from start to max height: $v = u + at$

$0 = 18 + (-9,8)t$

$t = 1,84\text{ s}$ ✓

Time from max height:

$s = ut + \frac{1}{2}at^2$ ✓

Carry of error from 2.1.1 → $86,53 = 0t + \frac{1}{2}(9,8)t^2$

$t = 4,20\text{ s}$ ✓

Total time = $1,84 + 4,20 = 6,04\text{ s}$ ✓ (4)

2.2 Velocity reached at 196cm: from 196cm to 227cm:

$v^2 = u^2 + 2as$ ✓

$s = ut + \frac{1}{2}at^2$ ✓

$v^2 = 0^2 + 2(9,8)(1,96)$ ✓

$0,31 = 6,2t + \frac{1}{2}(9,8)t^2$ ✓ [quadratic equation]

$v = 6,2\text{ m}\cdot\text{s}^{-1}$ ✓

$t = 0,05\text{ s}$ ✓

OR Calculate time to 196cm mark: $s = ut + \frac{1}{2}at^2$ ✓

$1,96 = 0 + \frac{1}{2}(9,8)t^2$ ✓

$t = 0,63\text{ s}$ ✓

Calculate time to 227cm mark: $s = ut + \frac{1}{2}at^2$

$2,27 = 0 + \frac{1}{2}(9,8)t^2$ ✓

$t = 0,68\text{ s}$ ✓

Difference: $t = 0,68 - 0,63 = 0,05\text{s}$ ✓

2.3.1 100 m.s^{-1} ✓ and 80 m.s^{-1} ✓ (2)

2.3.2 Acceleration is the rate of change of velocity. ✓✓ (2)

2.3.3 $a = \frac{\Delta v}{\Delta t} \checkmark = \frac{-100}{6} \checkmark = -16,67 \text{ m.s}^{-2} \checkmark$ (3)

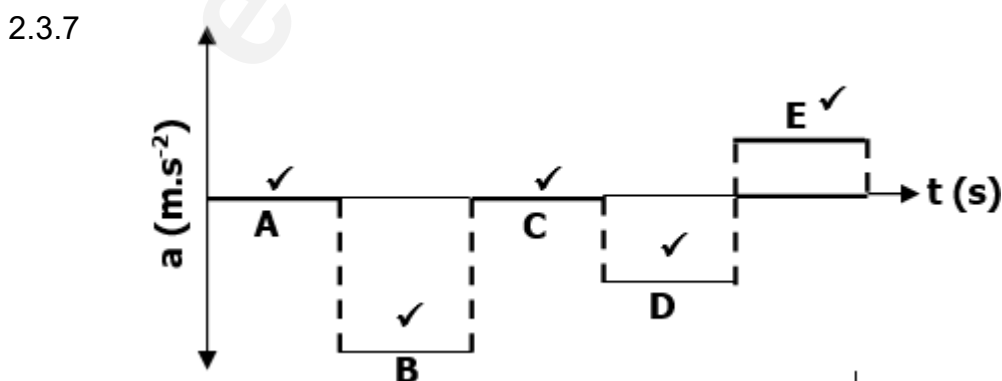
[Question asks for magnitude only – thus ignore negative sign]

2.3.4 Constant ✓ acceleration ✓ east ✓
Or constantly ✓ increasing velocity ✓ east ✓
Or constant ✓ deceleration ✓ west ✓ (3)

2.3.5 Distance = Area A + B ✓
 $= (100 \times 9) \checkmark + (\frac{1}{2} \times 6 \times 100) \checkmark$
 $= 1200 \text{ m} \checkmark$ (4)

OR A: $s = ut = (100 \times 9) \checkmark = 900 \text{ m}$
B: (can use $v^2 = u^2 + 2as$ or $s = ut + \frac{1}{2} at^2$)
 $s = \frac{(u + v) \cdot t}{2} \checkmark = \frac{(100 + 0) \cdot 6}{2} \checkmark = 300 \text{ m}$
 $s_{\text{total}} = 900 + 300 = 1200 \text{ m} \checkmark$

2.3.6 $S_{AB} = S_{DE}$
 $1200 \checkmark = (\frac{1}{2} \times b \times 80) \checkmark$
 $b = 30 \text{ s} \checkmark$
 $t_x = (20 + 30) = 50 \text{ s} \checkmark$ (4)



(5)

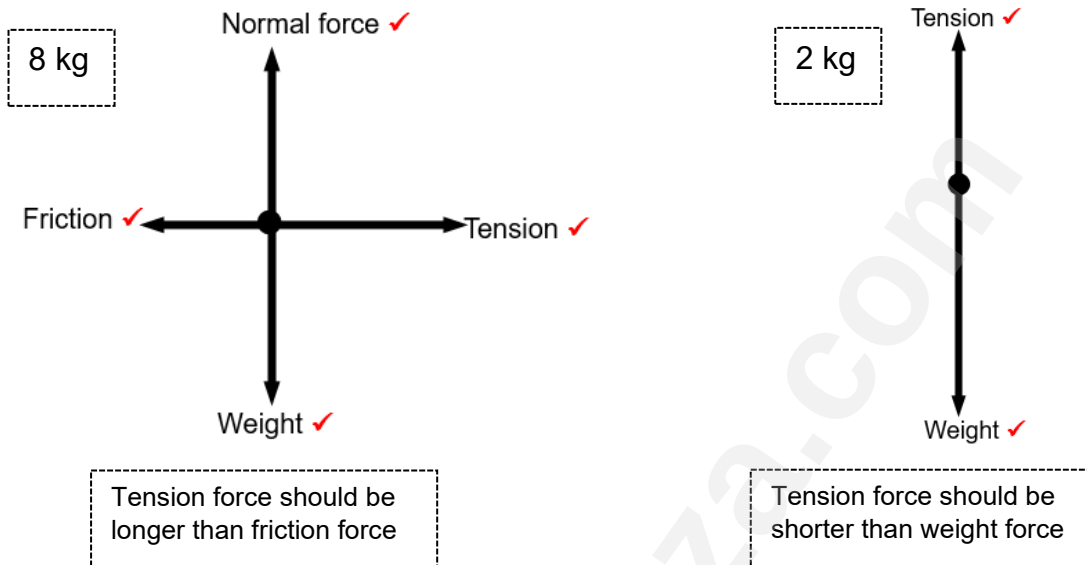
[38]

QUESTION 3

3.1 The gravitational force the Earth exerts on any object on or near its surface. ✓✓ (2)

3.2 $F_g = mg = 2 \times 9,8 = 19,6 \text{ N}$ ✓ downward ✓ (2)

3.3



(6)

3.4 When a net force is applied to an object of mass, m , it accelerates in the direction of the net force. The acceleration, a , is directly proportional to the net force and inversely proportional to the mass. ✓✓

OR

The net force acting on an object is equal to the rate of change of momentum. ✓✓ (2)

3.5 Applying NII on the system: Applying NII to either weight. Choosing down as positive:

$$F_{\text{net}} = ma \quad \checkmark$$

$$19,6 - 6 \checkmark = 10a \quad \checkmark$$

$$a = 1,36 \text{ m.s}^{-2} \quad \checkmark$$

$$2\text{kg: } F_{\text{net}} = ma$$

$$19,6 - T \checkmark = 2 \times 1,36 \quad \checkmark$$

$$T = 16,88 \text{ N} \quad \checkmark$$

$$8\text{kg: } F_{\text{net}} = ma$$

$$T - 6 = 8 \times 1,36$$

$$T = 16,88 \text{ N}$$

OR Applying NII to each block separately:

$$8\text{kg: } F_{\text{net}} = ma \quad \checkmark$$

$$T - 6 = 8a \quad \checkmark \dots (A)$$

$$2 \text{ kg: } F_{\text{net}} = ma$$

$$19,6 - T = 2a \quad \checkmark \dots (B)$$

Adding (A) + (B): $19,6 - 6 = 10a$

$$a = 1,38 \text{ m.s}^{-2} \quad \checkmark$$

Applying NII to either weight. Choosing down as positive:

$$2\text{kg: } F_{\text{net}} = ma$$

$$19,6 - T \checkmark = 2 \times 1,38 \quad \checkmark$$

$$T = 16,84 \text{ N} \quad \checkmark$$

$$8\text{kg: } F_{\text{net}} = ma$$

$$T - 6 = 8 \times 1,36$$

$$T = 16,88 \text{ N}$$

(7)

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QUESTION 4

4.1 E_{Mech} at P = E_{Mech} at Q

$(mgh + \frac{1}{2}mv^2)_P = (mgh + \frac{1}{2}mv^2)_Q$ ✓

$5 \times 9,8 \times 4 + 0 = 0 + \frac{1}{2} \times 5 \times v^2$ ✓

$v = 8,85 \text{ m.s}^{-1}$ ✓

(4)

4.2 The work done by a net force on an object is equal to the change in the kinetic energy of the object. ✓✓

(2)

4.3 $F_{\text{net}} = ma$

$v^2 = u^2 + 2as$ ✓ (one tick for both formulae)

$-32,5 = 5.a$ ✓

$v^2 = 8,85^2 + 2(-6,5)(3)$ ✓

$a = -6,5 \text{ m.s}^{-2}$ ✓

$v = 6,27 \text{ m.s}^{-1}$ ✓

OR $W = \Delta E_K$ ✓

$-32,5 \times 3 = \frac{1}{2} \times 5 \times (v^2 - 8,85^2)$ ✓

$v = 6,27 \text{ m.s}^{-1}$ ✓

(5)

4.4 $E_P = mgd \sin 28^\circ$ ✓✓

OR $E_P = 49d \sin 28^\circ$

OR $E_P = 23d$

(2)

4.5 $W_{\text{Net}} = \Delta E_K$ ✓

$F_f.d + F_{g//}.d = \frac{1}{2}m(v^2 - u^2)$

$-19d - (5)(9,8)(\sin 28^\circ)d = \frac{1}{2} \times 5 \times (0^2 - 6,27^2)$ ✓

$-42.d = -98,28$

$d = 2,34 \text{ m}$ ✓

OR $E_{K \text{ at R}} = E_{P \text{ at S}} + W_{\text{friction}}$ ✓

$\frac{1}{2} \times 5 \times 6,27^2 = (5)(9,8)(\sin 28^\circ)d + 19d$ ✓

$d = 2,34 \text{ m}$ ✓

OR $F_{\text{net}} = ma$

$v^2 = u^2 + 2as$ ✓ (one tick for both formulae)

$-19 - (5)(9,8)(\sin 28^\circ) = 5a$ ✓

$0^2 = 6,27^2 + 2(-8,4)d$ ✓

$a = -8,4 \text{ m.s}^{-2}$ ✓

$d = 2,34 \text{ m}$ ✓

(5)

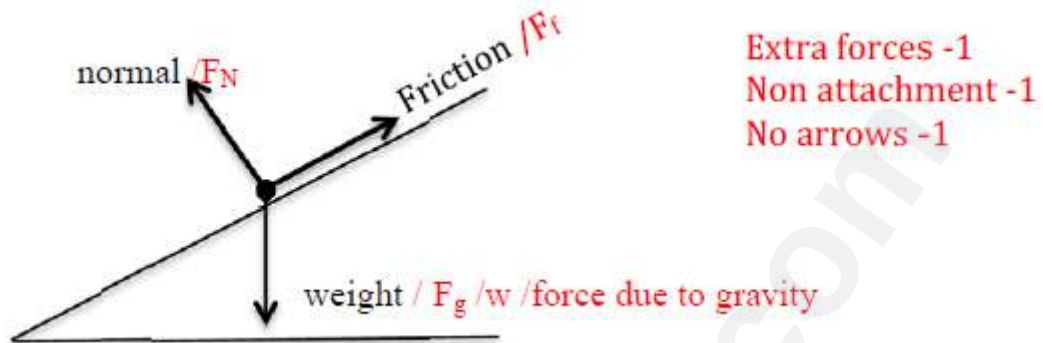
4.6 As the box moves up the incline, the Normal force decreases. ✓

Since $F_f = \mu N$, ✓ so the frictional force will decrease ✓

(3)

[$N = mg \cos \theta$; $\cos \theta$ decreases as θ increases Or $\cos 28 < 1$]

4.7



(3)

4.8 $F_f = mg \sin 28 = (5)(9,8)(\sin 28) = 23 \text{ N}$

(3)

4.9 $F_f = \mu N$ ✓

$23 = \mu(5)(9,8)(\cos 28)$ ✓

$\mu = 0,53$ ✓

(3)

4.10 Static friction is greater than kinetic friction ✓✓

OR Coefficient of static friction is greater than the coefficient of kinetic friction

(2)

[32]

QUESTION 5

5.1 The product of the mass and velocity of the object. ✓✓ (2)

5.2.1 Total p before = $m_A u_A + m_B u_B$ ✓ = $(500 \times 6) + 0$ ✓ = 3000 kg.m.s^{-1} east ✓ (3)

5.2.2 Total p after = $m_A v_A + m_B v_B$ = $(500 \times -1) + (700 \times 5)$ ✓ = 3000 kg.m.s^{-1} east ✓ (2)

5.2.3 Yes ✓ total momentum is conserved. (1)

5.3 Total E_K before collision = $\frac{1}{2} m u_A^2 + \frac{1}{2} m u_B^2 = \frac{1}{2} \times 500 \times 6^2 + 0$ ✓ = 9000 J ✓

Total E_K after collision = $\frac{1}{2} m v_A^2 + \frac{1}{2} m v_B^2 = \frac{1}{2} \times 500 \times (-1)^2 + \frac{1}{2} \times 700 \times 5^2$ ✓ = 9000 J ✓

Yes, ✓ it is an elastic collision (since E_K is conserved) (5)

NOTE:

You may NOT do the following...this is an example of poor mathematics...

Total E_K before collision = total E_K after collision

$$\frac{1}{2} m u_A^2 + \frac{1}{2} m u_B^2 = \frac{1}{2} m v_A^2 + \frac{1}{2} m v_B^2$$

$$\frac{1}{2} \times 500 \times 6^2 + 0 = \frac{1}{2} \times 500 \times (-1)^2 + \frac{1}{2} \times 700 \times 5^2$$

$$9000 \text{ J} = 9000 \text{ J}$$

$$5.4 \quad F_{\text{Net}} = \frac{\Delta p}{\Delta t} = \frac{mv - mu}{\Delta t} \quad \checkmark = \frac{[500 \times (-1)] \checkmark - [500 \times 6] \checkmark}{2 \checkmark} = \frac{-3500}{2} = -1750 \text{ N}$$

$$\therefore \text{magnitude } F = 1750 \text{ N} \checkmark \quad (5)$$

OR $v = u + at$ ✓

$$-1 = 6 + a.2 \quad \checkmark$$

$$a = -3,5 \text{ m.s}^{-2} \quad \checkmark$$

$$F_{\text{Net}} = ma$$

$$F_{\text{Net}} = 500 \times (-3,5) \quad \checkmark = -1750 \text{ N}$$

$$\text{Magnitude } F_{\text{Net}} = 1750 \text{ N} \checkmark$$

Note: Pupils may also calculate F_{Net} exerted on B.

QUESTION 6

- 6.1.1 Every particle in the universe attracts every other particle with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres ✓✓ (2)

$$6.1.2 \quad F_{m/e} = \frac{Gm_1m_2}{r^2} \checkmark = \frac{(6,7 \times 10^{-11})(5,97 \times 10^{24})(7,35 \times 10^{22})}{(3,84 \times 10^8)^2} \checkmark \checkmark$$

$$F = 1,99 \times 10^{20} \text{ N} \checkmark \quad (4)$$

- 6.1.3 If the F_{res} on the moon = 0 then $F_{\text{earth on moon}} = F_{\text{sun on moon}}$

$$\boxed{\text{Carry of error from 6.1.2}} \quad 1,99 \times 10^{20} \checkmark = \frac{(6,7 \times 10^{-11})(1,99 \times 10^{30})(7,35 \times 10^{22})}{r^2} \checkmark \checkmark$$

$$r = 2,22 \times 10^{11} \text{ m} \checkmark \quad (4)$$

- 6.2.1 The force per unit positive charge ✓✓ (2)

$$6.2.2 \quad E = \frac{kQ}{r^2} \checkmark$$

$$500 = \frac{(9 \times 10^9)(2,7 \times 10^{-9})}{r^2} \checkmark$$

$$r = 0,22 \text{ m} \checkmark \quad (3)$$

[15]

QUESTION 7

7.1.1 Emf is the **total energy** supplied per **coulomb (unit)** of charge by the **cell**. ✓✓
(Maximum power per unit current supplied by the cell) (2)

7.1.2 Option 1

$$V_{8\Omega} = IR = 0,2 \times 8 = 1,6 \text{ V} \checkmark$$

$$I_{4\Omega} = \frac{V}{R} = \frac{1,6}{4} = 0,4 \text{ A} \checkmark$$

$$A_1 = 0,2 + 0,4 = 0,6 \text{ A} \checkmark$$

Option 2

$$\text{Ratio of resistances} = 8\Omega : 4\Omega = 2:1$$

$$\text{Ratio of currents} = 1:2$$

$$\text{Current through } 4\Omega \text{ resistor} = 2 \times 0,2 = 0,4 \text{ A}$$

$$A_1 = 0,2 + 0,4 = 0,6 \text{ A}$$

Option 3

$$V_{8\Omega} = IR = 0,2 \times 8 = 1,6 \text{ V}$$

$$R_{//} = \frac{8 \times 4}{8 + 4} = 2,67 \Omega$$

$$\text{Total current } I = \frac{V}{R} = \frac{1,6}{2,67} = 0,6 \text{ A} \quad (4)$$

$$7.1.3 \quad R = \frac{V}{I} = \frac{15,4}{0,6} = 25,67 \Omega \checkmark \quad [\text{COE from 7.1.2}] \quad (3)$$

$$7.1.4 \quad R_{//} = \frac{8 \times 4}{8 + 4} = 2,67 \Omega \checkmark \checkmark \quad R_T = 2,67 + 25,67 = 28,34 \Omega \checkmark \quad (3)$$

$$7.1.5 \quad \text{Emf} = I(R + r) \checkmark$$

$$18 = 0,6(28,34 + r) \checkmark \checkmark \quad \leftarrow \begin{array}{|l|} \hline \text{COE from 7.1.2} \\ \text{and 7.1.4} \\ \hline \end{array}$$

$$18 = 17 + 0,6r$$

$$r = 1/0,6 = 1,67 \Omega \checkmark \quad \leftarrow \begin{array}{|l|} \hline \text{COE from 7.1.3} \\ \hline \end{array}$$

$$\text{OR} \quad V_{\text{Ext}} = (1,6 + 15,4) = 17 \text{ V}$$

$$V_{\text{lost}} = \text{Emf} - V_{\text{Ext}} = 18 - 17 = 1 \text{ V}$$

$$r = \frac{V_{\text{lost}}}{I} = \frac{1}{0,6} = 1,67 \Omega \quad (4)$$

7.1.6 (a) Decrease ✓ (1)

7.1.6 (b) The **total resistance of the circuit decreases** ✓ therefore **current increases**. ✓
More volts will be lost ✓ OR
Ir increases therefore the reading on the voltmeter will decrease,
since $V_1 = \text{emf} - Ir$ ✓ OR $\text{emf} = V_{\text{ext}} + V_{\text{lost}}$ ($Ir = \text{'lost' volts}$) (4)

7.2.1 When the kettle is connected to a **voltage (potential difference) of 220 V** ✓,
its **power (consumption) is 1 500 W** ✓ (or J.s^{-1}).
[NB connection between the power consumption ONLY being 1500 W WHEN the kettle is connected to 220 V.] (2)

$$7.2.2 \quad P = V.I \checkmark$$

$$1500 = 220.I \checkmark$$

$$I = 6,82 \text{ A} \checkmark \quad (3)$$

$$7.2.3 \quad \text{Cost} = 1,5 \text{ kW} \times (20/60) \times 2,50 \checkmark \checkmark = \text{R}1,25 \checkmark$$

$$\text{OR} \quad W = Pt = 1500 \times 20 \times 60 = 1\,800\,000 \text{ J}$$

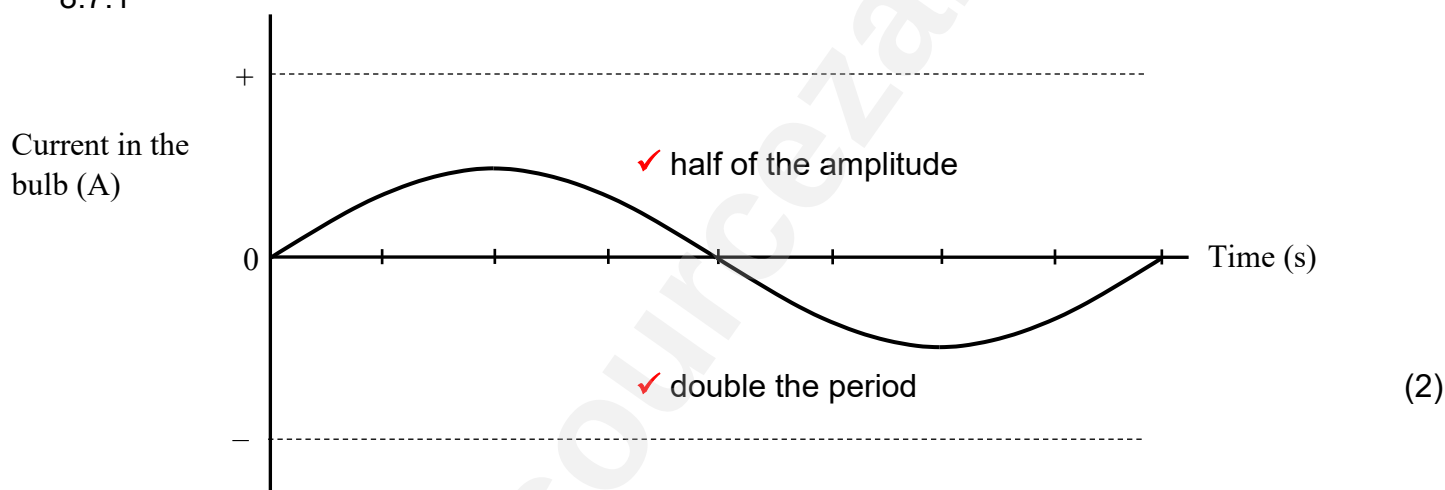
$$\text{Cost} = 1\,800\,000 / 3\,600\,000 \times 2,50 = \text{R}1,25 \quad (3)$$

QUESTION 8

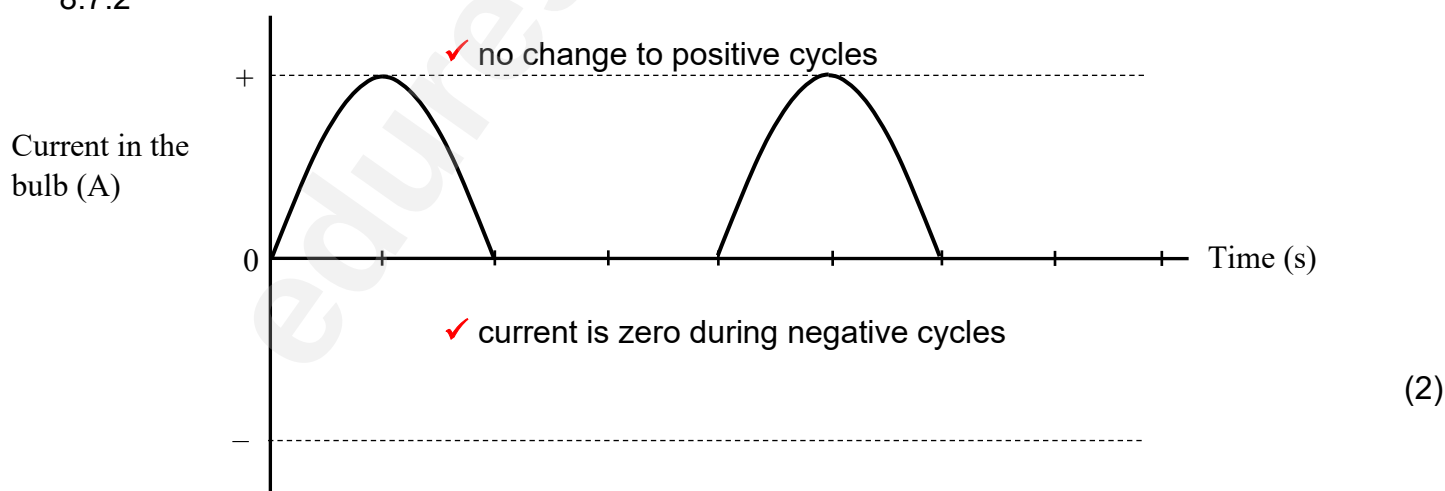
- 8.1 **A** Slip rings✓
B Carbon brushes✓ (2)
- 8.2 x to y✓ (1)
- 8.3 Mechanical Energy to electrical energy ✓✓ (2)
- 8.4 The product of the number of turns on the coil and the flux through the coil. ✓✓ (2)

- 8.5 Rotate the coil faster✓ **Two only**
 Use stronger magnets ✓
 Increase the number of turns in the coil. (2)
- 8.6 Replace bulb with a DC source (battery) ✓
 Replace the slip rings with a split ring commutator✓. (2)

8.7.1



8.7.2



- 8.8 AC voltages can be stepped up using a transformer. ✓ **One only**
 Stepping up the voltage allows the current to be stepped down, reducing heat energy lost in long distance power lines. ✓ (1)
- 8.9 The emf induced is directly proportional to the rate of change of magnetic flux. ✓✓ (2)

QUESTION 9

9.1 The induced current flows in a direction so as to set up a magnetic field to oppose the change in magnetic flux. ✓✓ (2)

9.2 A step-up transformer ✓

A step-up transformer has more✓ turns in the secondary coil✓. (2)

9.3.1 No✓

DC will **not** produce the required change in magnetic flux ✓ in order to induce an emf in the secondary coil. (2)

9.3.2 $\frac{N_s}{N_p} = \frac{V_s}{V_p}$ ✓

$$\frac{2250}{900} = \frac{V_s}{96} \quad \checkmark$$

$$V_s = 240 \text{ V} \quad \checkmark$$

$$I = \frac{V}{R} = \frac{240}{800} \quad \checkmark = 0,3 \text{ A} \quad \checkmark \quad (5)$$

[11]