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HILTON COLLEGE
GRADE 12 TRIAL EXAMINATIONS
SEPTEMBER 2022

PHYSICAL SCIENCES: PAPER I

Examiner: Mr MJ van Wyk
Moderator: Mr MJ Green

Time: 3 hours
200 Marks

MARK SCHEME

QUESTION 1 MULTIPLE CHOICE

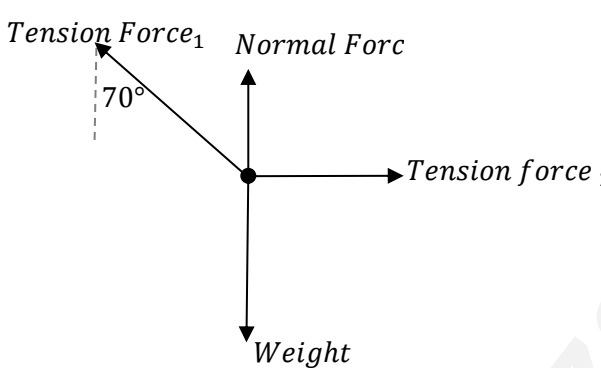
- 1.1 C ✓✓
1.2 A ✓✓
1.3 C ✓✓
1.4 D ✓✓
1.5 A ✓✓
1.6 B ✓✓
1.7 B ✓✓
1.8 C ✓✓
1.9 D ✓✓
1.10 A ✓✓

[10 x 2 = 20]

QUESTION 2

- 2.1 2.1.1 When a net force, F_{net} , 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. ✓ (2)

2.1.2



✓ per F.
(-1 per extra F)
(-1 angles)
(-1 not fully labelled)
(-1 $N > W$)

(4)

- 2.1.3 Convention: up as positive
 $F_{\text{net}} = 0$
 $\vec{T}_2 - m_2 g = 0$ ✓ (implied below)
 $\vec{T}_2 = m_2 g$
 $\vec{T}_2 = (5)(9,8)$ ✓
 $\vec{T}_2 = 49 \text{ N}$ ✓ (no units no mark) (3)

- 2.1.4 right as positive
 $\vec{F}_{\text{net}} = 0$ on box mass 2 kg
 $T_{1x} = 49 \text{ N to the left}$ ✓
- OR $T_1 \sin 70^\circ = T_{x1}$ ✓
 ✓ equating $T_1 = T_{x1} = 49 \text{ N (COE)}$
 $T_1 \sin 70^\circ = 49$
 $T_1 = 52,14 \text{ N}$ ✓

Using trigonometry to work out T_{1y} :

$$\frac{T_{1x}}{T_{1y}} = \tan \alpha \text{ ✓ (implied)}$$

$$T_{1y} = \frac{T_{1x}}{\tan \alpha}$$

$$T_{1y} = \frac{49}{\tan 70^\circ}$$

$$T_{1y} = 17,83 \text{ N} \checkmark$$

$$T_{1y} = (52,14)(\cos 70^\circ) \checkmark$$

$$= 17,83 \text{ N} \checkmark \text{ magnitude}$$

Working with vertical forces (up as positive):

$$\vec{F}_{\text{nety}} = 0$$

$$T_{1y} + N - F_g = 0 \checkmark$$

$$17,83 + N - (2)(9,8) = 0$$

$$N = 1,77 \text{ N} \checkmark \quad (\text{magnitude})$$

(5)

- 2.2 2.2.1 When object A exerts a force on object B, object B **simultaneously** exerts an oppositely directed force of equal magnitude on object A. ✓✓ (2)

- 2.2.2 Migael is correct. ✓



Meaningful, labelled diagram ✓✓

A : force of man on CAR

B : force of road surface on CAR (friction)

CAR'S motion to the left is due to A being greater than B ✓

Net force means car will accelerate. ✓

(5)

- 2.2.3 Downward force would increase N ✓

$F_{f \max} = \mu N$ so larger N results in larger $F_{f \max}$ ✓

so car more difficult to push. ✓

(3)

- 2.2.4 An object with mass will have inertia. ✓

Inertia is an objects' property to resist a change in its state. ✓

The car will resist its change in motion, to remain stationary. ✓

(3)

[27]

QUESTION 3

3.1 3.1.1 Rate of change of velocity. ✓ ✓ (2)

3.1.2 F_{friction} $F_{\text{gravitation}}$ ✓ ✓ forces and labels



(2)

3.1.3 (i) $\Delta X_{\text{DART}}(h) = 20 t \checkmark + \frac{1}{2}(-9,8 \checkmark)t^2$
OR $\Delta X_{\text{DART}}(h) = 20(t-1) \checkmark + \frac{1}{2}(-9,8 \checkmark)(t-1)^2$
 (1 mark only as instructions regarding t not followed)

(2)

(ii) $\Delta X_{\text{BALL}}(h) = 20(t+1) \checkmark + \frac{1}{2}(-12 \checkmark)(t+1)^2$
OR $\Delta X_{\text{BALL}}(h) = 20 t \checkmark + \frac{1}{2}(-12 \checkmark)t^2$

(2)

3.1.4 (i) $\Delta X_{\text{DART}} = \Delta X_{\text{BALL}} \checkmark$ (mark for equating/method)
 $20 t - 4,9 t^2 = 20 t + 20 - 6 t^2 - 12 t - 6 \checkmark$
 $1,1 t^2 + 12 t - 14 = 0 \checkmark$
 $t = 1,06 \text{ s} \checkmark$

(3)

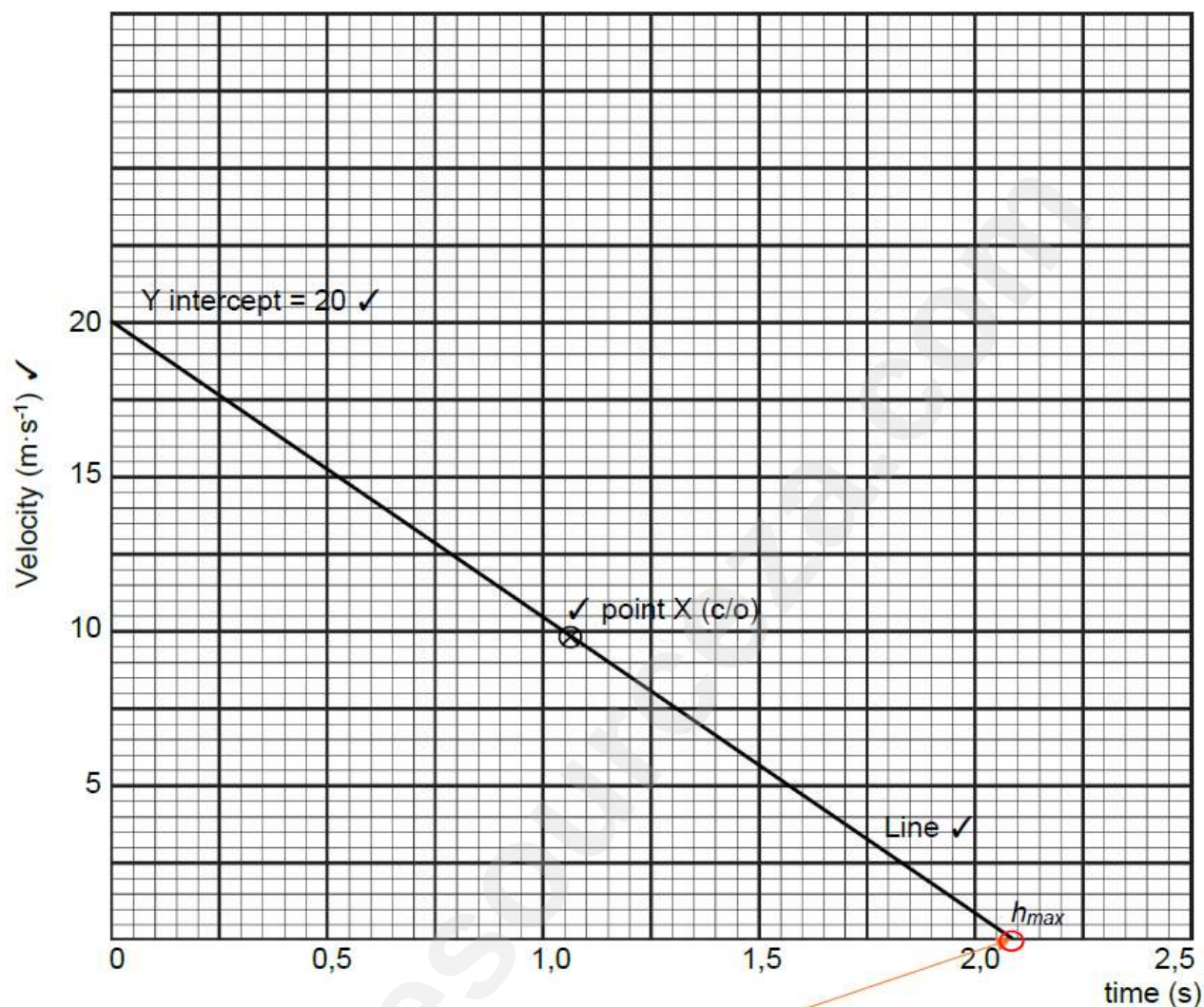
(ii) $h = 20(1,06) \checkmark - \frac{1}{2}(9,8)(1,06)^2 \checkmark = 15,69 \text{ m} \checkmark$
OR $20 t - 20 - 4,9 t^2 + 9,8 t - 4,9 = 20 t - 6 t^2 \checkmark$
 $1,1 t^2 + 9,8 t - 24,9 \checkmark$
 Hence $t = 2,06 \text{ s}$ (time for ball to reach X)
 And time for dart to reach X = $1,06 \text{ s} \checkmark$
 $h = 20(1,06) \checkmark - \frac{1}{2}(9,8)(1,06)^2 \checkmark = 15,69 \text{ m} \checkmark$

(3)

3.1.5 $v_f^2 = v_i^2 + 2a\Delta X_{\text{DART}} \checkmark$ **OR** $v_f = v_i + a\Delta t \checkmark$
 $v_f^2 = 20^2 \checkmark + 2(-9,8)(15,69) \checkmark$
 $v_f = 9,62 \text{ m}\cdot\text{s}^{-1} \checkmark$

(4)

3.1.6 Graph showing the relationship between velocity and time for A



(4)

3.1.7 Time at max height = 2,07 s ✓ (c/o from graph) ✓ accuracy

(2)

$$\begin{aligned}
 3.1.8 \quad \Delta X &= \frac{1}{2} \text{ base} \times \text{height} \\
 &= \frac{1}{2} (2,05)(20) \quad \checkmark \\
 &= 20,5 \text{ m} \quad \checkmark
 \end{aligned}$$

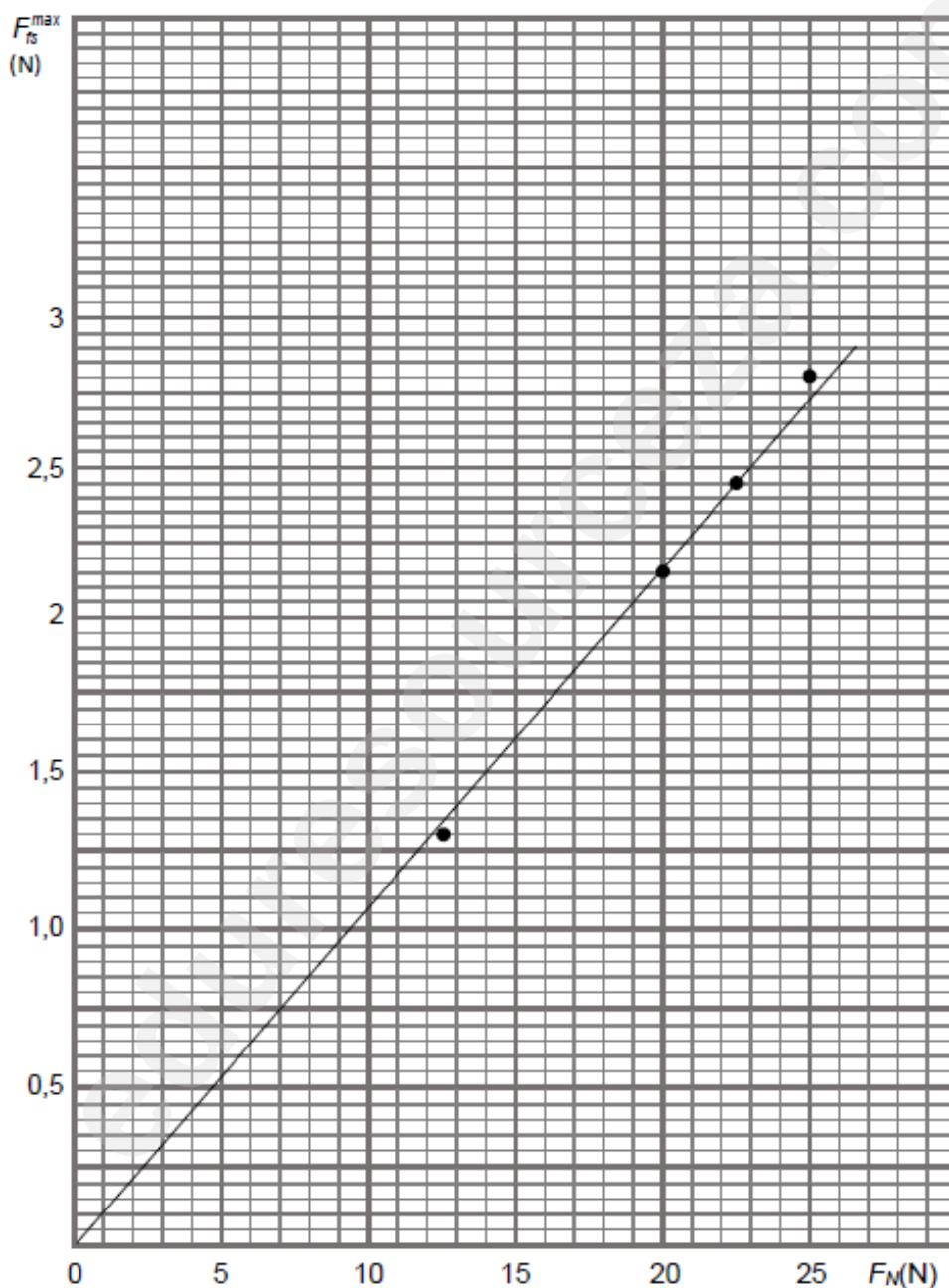
(2)

[26]

QUESTION 4

4.1 4.1.1 The perpendicular force ✓ exerted on an object by a surface in contact with it. ✓ (2)

4.1.2 Graph showing the relationship between the maximum force of kinetic friction and the normal reaction force for a brick on a surface



✓ heading

✓ y-axis label and unit

✓ plotting

✓ x-axis label and unit

✓ scale

✓ best fit ✓ through origin

(7)

4.3 Gradient of graph = μ_s ✓ method

$$\text{Gradient} = \frac{\Delta y}{\Delta x} = \frac{2,75 - 1,1}{25 - 10} \checkmark = 0,11 \checkmark \quad (4)$$

$$4.4 \quad F_N = mg \cos \theta \checkmark \checkmark \quad (2)$$

$$4.5 \quad F_{fs}^{\max} = mg \sin \theta \checkmark \checkmark \quad (2)$$

$$4.6 \quad \mu_s = \frac{F_{fs}^{\max}}{F_N} \checkmark = \frac{1,3 \times 9,8 \times \sin \theta}{1,3 \times 9,8 \times \cos \theta} \quad (4)$$

$$\tan \theta \checkmark = 0,48 \checkmark$$

$$\theta = 25,64^\circ \checkmark$$

[21]

QUESTION 5

- 5.1 The total linear momentum of an isolated system remains constant (is conserved). ✓✓ (2)

5.2

$$\sum \vec{p}_i = \sum \vec{p}_f \quad \checkmark$$

$$m_1 \vec{v}_{1,i} + m_2 \vec{v}_{2,i} = m_1 \vec{v}_{1,f} + m_2 \vec{v}_{2,f}$$

$$(0,9)(4,5) + (0,65)(0) = (0,9)(0,5) + (0,65)\vec{v}_{2,f} \quad \checkmark \checkmark \text{subs}$$

$$v_{2,f} = 5,5384 \dots \text{m} \cdot \text{s}^{-1}$$

$$\approx 5,54 \text{ m} \cdot \text{s}^{-1} \quad \checkmark \quad (4)$$

5.3

$$\sum E_{k,i} = \frac{1}{2} m_1 v_{1,i}^2 + \frac{1}{2} m_2 v_{2,i}^2 \quad \checkmark$$

$$\sum E_{k,i} = \frac{1}{2} (0,9)(4,5)^2 + \frac{1}{2} (0,65)(0)^2 \quad \checkmark$$

$$\sum E_{k,i} = 9,11 \text{ J} \quad \checkmark$$

$$\sum E_{k,f} = \frac{1}{2} m_1 v_{1,f}^2 + \frac{1}{2} m_2 v_{2,f}^2$$

$$\sum E_{k,f} = \frac{1}{2} (0,90)(0,5)^2 + \frac{1}{2} (0,65)(5,54)^2 \quad \checkmark$$

$$\sum E_{k,f} = 10,08727 \dots \text{J}$$

$$\sum E_{k,f} \approx 10,1 \text{ J} \quad \checkmark$$

$$\sum E_{k,i} < \sum E_{k,f} \quad \checkmark$$

COE

The collision is inelastic because the system gained kinetic energy. (6)

- 5.4 In the absence of air resistance or any external forces, the mechanical energy of an object is constant. ✓✓ (2)

5.5 Conservation of mechanical energy:

$$mgh_i + \frac{1}{2}mv_i^2 = mgh_f + \frac{1}{2}mv_f^2 \checkmark$$

Dividing by m and solving for h_f :

$$\begin{aligned} h_f &= h_i + \frac{v_i^2 - v_f^2}{2g} \checkmark \\ &= 0 + \frac{(5.54)^2 - 0^2}{(2)(9.8)} \checkmark \quad \text{COE Q.5.2} \\ &= 1,5658 \dots \text{m} \\ &\approx 1,57 \text{ m} \checkmark \end{aligned}$$

OR

Substitute first then solve for h_f :

$$(0,65)(9,8)(0) + \frac{1}{2}(0,65)(5,54)^2 \checkmark = (0,65)(9,8)h_f + \frac{1}{2}(0,65)(0)^2 \checkmark$$

$$\begin{aligned} h &= 1,5658 \dots \text{m} \\ &\approx 1,57 \text{ m} \checkmark \end{aligned}$$

(4)

[18]

QUESTION 6

6.1 $F_{\parallel} = W \sin 30^{\circ} \checkmark$
 $= (70)(9,8) \checkmark \sin 30^{\circ}$
 $= 343 \text{ N} \checkmark$ (3)

6.2 $W_{\text{net}} = F_{\text{net}} \Delta x \checkmark$
 $= (F_{\parallel} - F_f) \Delta x$
 $= (343 \checkmark - 150 \checkmark)(50 \checkmark)$
 $= 9\,650 \text{ J} \checkmark$ (5)

6.3 *Work done by a net force on an object $\checkmark$ is equal to the change in the kinetic energy of the object. $\checkmark$* (2)

6.4 $W_{\text{net}} = \Delta E_k \checkmark$ (implied below)
 $= \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2$
 $9\,650 \checkmark = \frac{1}{2} (70) v_f^2 - \frac{1}{2} (70)(3)^2 \checkmark$ (needs to show that E_k initial 0)
 $v_f^2 = 284,714 \dots$ (4)
 $v_f = 16,87 \text{ m.s}^{-1} \checkmark$

[14]

QUESTION 7

7.1 7.1.1 $F = G \frac{m_1 m_2}{r^2} \checkmark$

$$\frac{6,7 \times 10^{-11} \times 7,16 \times 10^{22} \times 5,97 \times 10^{24}}{(3,84 \times 10^8)^2} \checkmark \text{ (conversion to m)} \checkmark$$

$$F = 1,94 \times 10^{20} \text{ N} \checkmark \quad (4)$$

7.1.2 $g = \frac{GM}{r^2}$

$$4,9 \checkmark = \frac{6,7 \times 10^{-11} \times 5,97 \times 10^{24}}{r^2} \checkmark$$

$$r = 9,03 \times 10^6 \text{ m} \checkmark$$

Height above surface = $9,03 \times 10^6 - 6,38 \times 10^6$ ($\checkmark$ method)

$$= 2,65 \times 10^6 \text{ m} \checkmark \quad (5)$$

7.2.1 $F_g = m g \checkmark$

$$= 3 \times 10^{-3} (9,8) \checkmark$$

$$= 0,029 \text{ N} \checkmark \quad (3)$$

7.2.2 $F_e = 0,029 \text{ N} \quad (2,94 \times 10^{-2}) \checkmark \quad (1)$

7.2.3 *Two point charges in free space or air exert forces on each other. The force is directly proportional to the product of the charges $\checkmark$ and inversely proportional to the square of the distance between the charges. $\checkmark$* (2)

7.2.4 $\frac{F = k Q Q}{r^2} \checkmark$

$$Q^2 = 4,18 \times 10^{-13} \checkmark \checkmark \text{ (for substitution)}$$

$$Q = 6,47 \times 10^{-7} \text{ C} \checkmark \text{ (647 nC)} \quad (4)$$

7.3 7.3.1 The force per unit positive charge. ✓✓

(2)

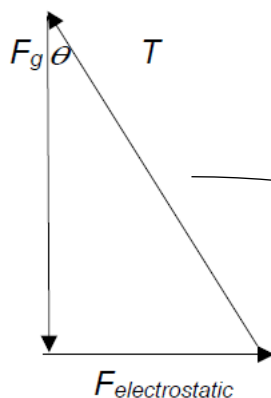
$$7.3.2 \quad q = \frac{F}{E} = \frac{0,07}{3 \times 10^5} = 6 \times 10^{-6} \text{ C } \checkmark \text{ positive } \checkmark$$

(4)

7.3.3 zero N ✓✓ (0)

(2)

7.3.4



- Lenient on Labelling.
- Head to Tail.

(2)

$$(i) \quad T^2 = ((0,004)(9,8))^2 + 0,07^2 \checkmark$$

$$T = 0,08 \text{ N } \checkmark$$

Mark for vector sketch

$$(ii) \quad \tan \theta = \frac{0,07}{0,004 \times 9,8} \checkmark \text{ hence } \theta = 60,75^\circ \checkmark$$

(3)

[32]

QUESTION 8

8.1 8.1.1 *The total energy supplied per coulomb of charge by the cell.* ✓ ✓ (2)

8.1.2 **Series resistance calculation**

$$R = R_{3\Omega} + R_{2\Omega}$$

$$R = 3 + 2 \quad \checkmark$$

$$R = 5 \Omega \quad \checkmark$$

Working with emf and internal resistance

$$\varepsilon = I(R + r)$$

$$6 = (1,091)(5 + r) \quad \checkmark$$

$$r = 0,4995 \dots \Omega$$

$$r \approx 0,5 \Omega \quad \checkmark$$

(4)

8.1.3 **Using modified emf formula**

$$V_{\text{load}} = \varepsilon - Ir \quad \checkmark$$

$$V_{\text{load}} = 6 - (1,846)(0,4995 \dots) \quad \checkmark \checkmark$$

$$V_{\text{load}} = 5,07792 \dots \text{ V}$$

$$V_{\text{load}} \approx 5,08 \text{ V} \quad \checkmark$$

OR Long version! Starting with parallel resistance

$$\frac{1}{R_p} = \frac{1}{R_{1\Omega}} + \frac{1}{R_{3\Omega}}$$

$$\frac{1}{R_p} = \frac{1}{1} + \frac{1}{3}$$

$$\frac{1}{R_p} = \frac{4}{3}$$

$$\therefore R_p = \frac{3}{4} = 0,75 \Omega \quad \checkmark$$

Equivalent resistance

$$R_{\text{eq}} = R_p + R_{2\Omega}$$

$$R_{\text{eq}} = 0,75 + 2$$

$$R_{\text{eq}} = 2,75 \Omega \quad \checkmark$$

Using Ohm's Law in the external circuit

$$V_{\text{load}} = IR_{\text{ext}} \quad \checkmark$$

$$V_{\text{load}} = (1,846)(2,75)$$

$$V_{\text{load}} = 5,0765 \text{ V}$$

$$V_{\text{load}} \approx 5,08 \text{ V} \quad \checkmark$$

(4)

8.1.4 (i) INCREASES ✓✓ (2)

(ii) Another resistor is added in parallel so external resistance (R) and hence total resistance ($R + r$) decreases. ✓

From $\varepsilon = I(R + r)$, total current will increase. ✓

From $V_{\text{internal resistance}} = Ir$, more energy is used up to overcome internal resistance. ✓

This energy is released as heat ✓ which will increase the temperature of the battery. (4)

8.2 8.2.1 It means that 1 500 J of energy ✓ is transferred per second. ✓ (2)

8.2.2 $I = \frac{P}{V}$ ✓ hence $I_{\text{total}} = \frac{1\,500}{220}$ ✓ + $\frac{1\,800}{220}$ ✓ = 15,0 A ✓ (3)

[21]

QUESTION 9

9.1 9.1.1 $\frac{V_p}{N_p} = \frac{V_s}{N_s}$ ✓ $\therefore N_s = \frac{(1000)(36)}{240}$ ✓✓ = 150 turns ✓ (4)

9.2 9.2.1 Kinetic/mechanical to electrical ✓✓ (2)

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

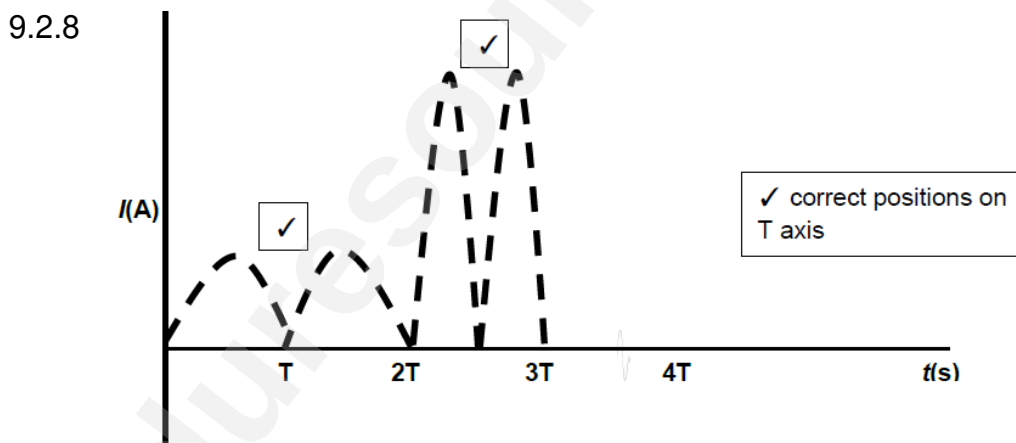
9.2.3 Lenz's Law ✓✓ (2)

9.2.4 A to B ✓✓ (2)

9.2.5 Moved coil faster ✓✓ (2)

9.2.6 Provides current that changes direction ✓ (polarity) at regular intervals. ✓ (2)

9.2.7 (Full wave) rectifier ✓✓ or Converts AC to DC. (2)



(3)

[21]

Total: 200 marks