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QUESTION 1 [20]

- 1.1 B✓✓ Speed = v ; $acc = g$; formula in D omits initial velocity term
- 1.2 C✓✓ in A weight is vector, mass is scalar; In B both are scalars; in D, Δp is vector, speed is scalar
- 1.3 A✓✓ Use $v_f^2 = v_i^2 + 2a\Delta x$ to get $\Delta x = -v_i^2 / 2a \therefore$ if v_i is constant, $\Delta x \propto 1/a$
If a is double, Δx (or h) will be half
- 1.4 C✓✓ Since v is constant, $a = 0 \therefore F_{net} = 0 \therefore$ the horizontal component of $F = F_{friction}$
- 1.5 D✓✓ NIII
- 1.6 D✓✓ area = $xy = F \cdot t = \text{impulse} = \text{change in momentum}$
- 1.7 C✓✓ Since D is the same, $F \propto q_1 q_2$. Original $q_1 q_2 = 6Q^2$;
new charges after touching are $(6 - 1) / 2 = 2,5Q$
 $\therefore$ New $q_1 q_2 = (2,5Q)^2 = 6,25 Q^2$
 $\therefore$ New Force = $6,25 / 6$ times original force
- 1.8 C✓✓ In circuit 1, when bulbs have same voltage across them, the one with more power (X) will be brighter. Since $R = V^2 / P$, the 100W bulb has less resistance.
In circuit 2, when same current flows through both, since $P = I^2 R$, the bulb with more resistance (Y) will be brighter.
- 1.9 B ✓✓ Power loss = $I^2 R \therefore$ current must be low. Since $P = VI$, for constant P supplied, if I for transmission must be low then V must be high.
- 1.10 A✓✓ Increasing the frequency of incident light will increase the energy of incident light and therefore the E_k of emitted photoelectrons (for a given metal cathode work function). If intensity is same, number of photons/s is same $\therefore$ number of emitted photoelectrons/s is same $\therefore$ current is same.

QUESTION 2 [10]

- 2.1 the single vector ✓ which has the same effect as the original vectors acting together. ✓ (2)
- 2.2 $\sin 40^\circ = \frac{F_{vert}}{0,05}$
 $F_{vert} = 0,05 \sin 40^\circ \checkmark$
 $= 0,032 \text{ N} \checkmark$ (2)
- 2.3 $6 \times F_{vert} = F_g \checkmark$
 $6 \cdot (0,032) \checkmark = mg$
 $0,19 = m \cdot (9,8) \checkmark$
 $m = 0,02 \text{ kg} \checkmark$ (4)
- 2.4 $\cos 40^\circ = \frac{F_{Hor}}{0,05}$
 $F_{Hor} = 0,05 \cos 40^\circ \checkmark$
 $= 0,038 \text{ N} \checkmark$ (2)

QUESTION 3 [25]

3.1 0-15s: Rocket increases speed ✓ travelling upwards ✓
15-25s: Rocket slows down ✓ travelling upwards ✓, coming to rest at 25 s (4)

3.2 $t = 10 \text{ s}$ ✓ (1)

3.3 sections D-F ✓ (1)

3.4 change in position ✓✓ (2)

3.5 max height = area ✓ (from 0-25s)
= $\frac{1}{2}bh$
= $\frac{1}{2}(25)(30)$ ✓
= 375 m ✓ (4)

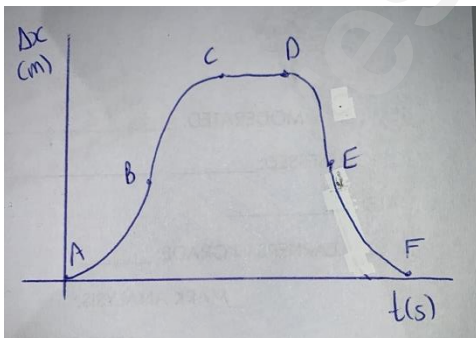
3.6 a = gradient ✓
$$= \frac{\Delta y}{\Delta x} = \frac{-35-0}{50-35}$$

a = - 2,33 m.s⁻²
a = 2,33 m.s⁻² ✓ (down) (3)

3.7 Rocket is not in free-fall ✓
or
The vector sum of upward F_{thrust} + Friction up + weight down results in a reduced acceleration down ✓✓ (2)

3.8 $\Delta x = \text{area } \triangle ABC = \text{area } \triangle DEF$
✓ $375 = \frac{1}{2}(35)(t - 35)$ ✓✓
 $375 = 17,5t - 612,5$
 $t = 56,43 \text{ s}$ ✓ (4)

3.9



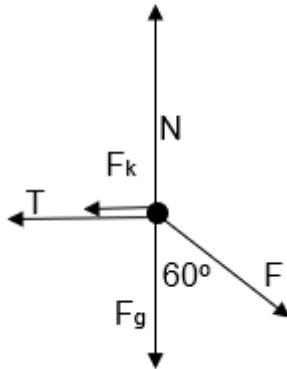
✓ labels correct
✓ shape A-C
✓ shape C-D
✓ shape D-F
-1 per error

(4)

QUESTION 4 [32]

- 4.1 When a net force acts on an object of mass m , the object will accelerate in the direction of the net force. The acceleration is directly proportional to the net force but inversely proportional to the mass of the object. ✓✓
OR The net force acting on an object is equal to the rate of change of momentum (2)

4.2



N = force of surface on box
 F_k = kinetic frictional force
 T = tension force in string
 F = pushing force of 25 N
 F_g = weight
Diagram correct + angle ✓✓
labels ✓✓✓

(5)

4.3 $F_k = \mu_k \cdot N$ ✓
 $= (0,15) \cdot (3) \cdot (9,8)$ ✓
 $= 4,41 \text{ N}$ ✓ (3)

4.4.1 $F_k = \mu_k \cdot N = \mu_k (mg + F_{\text{vert}})$
 $= 0,15 \cdot (1,5 \cdot 9,8 + 25 \cdot \sin 30^\circ)$ ✓
 $= 4,08 \text{ N}$ ✓ (3)

4.4.2 For 1,5 kg block: $25 \cos 30^\circ - T - 4,08 = 1,5 a$... (i) ✓✓
For 3 kg block: $T - 4,41 = 3a$... (ii) ✓✓ $\therefore T = 3a + 4,41$ sub into (i)
 $21,65 - (3a + 4,41) - 4,08 = 1,5 a$ ✓
 $A = 2,925 \text{ m/s}^2$ ✓
 $\therefore T = 3(2,925) + 4,41 = 13,18 \text{ N}$ ✓ (8)

4.5 The horizontal force component was insufficient to overcome the static friction force of the block system. ✓ (2)

4.6 So that the applied force is constant and the angle could be measured easily. ✓ (2)

4.7 By repeating the experiment they should have got results that were close together indicating that controlled variables were precise and that their measurements were of a high degree of precision. ✓

If reliable then they could make accurate predictions of the outcome and then could draw accurate conclusions and patterns from their results. ✓ (4)

4.8 The kinetic frictional force would decrease as the vertical component of the 25 N pushing force is decreased so the normal force decreases. ✓ (3)

QUESTION 5 [28]

$$\begin{aligned}
 5.1 \quad \Delta p_B &= mv_f - mv_i \checkmark \\
 &= (8).(3) - (8).(-2) \checkmark \\
 &= 40 \text{ kg.m.s}^{-1} \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 5.2 \quad F_{\text{net}} &= \frac{\Delta p}{\Delta t} \checkmark \\
 &= \frac{40}{1,5} \checkmark \\
 &= 26,67 \text{ N} \checkmark \text{ to the right} \checkmark
 \end{aligned}
 \tag{4}$$

5.3 The total linear momentum $\checkmark$ of an **ISOLATED SYSTEM** remains constant $\checkmark$ (is conserved) (2)

$$\begin{aligned}
 5.4 \quad \Sigma p_{\text{before}} &= \Sigma p_{\text{after}} & \text{OR } \Delta p_A &= -\Delta p_B = -40 \checkmark \\
 m_A.v_{iA} + m_B.v_{iB} &= m_A.v_{fA} + m_B.v_{fB} \checkmark & -40 &= m_A(v_{fA} - v_{iA}) \checkmark = m_A(-4 - 6) \checkmark \\
 m_A.(6) + (8).(-2) \checkmark &= m_A.(-4) + (8).(3) \checkmark & m_A &= 4 \text{ kg} \checkmark \\
 m_A &= 4 \text{ kg} \checkmark
 \end{aligned}
 \tag{4}$$

5.5 A collision in which both momentum $\checkmark$ and kinetic energy are conserved $\checkmark$. (2)

$$\begin{aligned}
 5.6 \quad E_{ki} &= \frac{1}{2} m_A.v_{iA}^2 + \frac{1}{2} m_B.v_{iB}^2 \checkmark \\
 &= \frac{1}{2} (4).(6)^2 + \frac{1}{2} (8).(-2)^2 \checkmark \\
 &= 88 \text{ J} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 E_{kf} &= \frac{1}{2} m_A.v_{fA}^2 + \frac{1}{2} m_B.v_{fB}^2 \\
 &= \frac{1}{2} (4).(-4)^2 + \frac{1}{2} (8).(3)^2 \checkmark \\
 &= 68 \text{ J} \checkmark
 \end{aligned}$$

Do NOT start by equating the initial and final kinetic energy. You are trying to find out whether they are equal or not.

$$E_{ki} \neq E_{kf} \therefore \text{inelastic collision} \checkmark \tag{6}$$

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

$$\begin{aligned}
 5.8 \quad W_{\text{net}} &= \Delta E_k = W_f \checkmark & \text{Get } \Delta x &\text{ from graph (area)} \\
 \frac{1}{2} m.v_f^2 - \frac{1}{2} m.v_i^2 &= F_f \Delta x & \frac{1}{2} bh &= \frac{1}{2} (0,5)(3) = 0,75 \text{ m} \\
 0 - \frac{1}{2} (8).(3)^2 \checkmark &= F_f.(0,75) \checkmark \\
 F_f &= -48 \text{ N} \\
 F_f &= 48 \text{ N} \checkmark \text{ left} \checkmark
 \end{aligned}
 \tag{5}$$

QUESTION 6 [17]

6.1 The emf induced is directly proportional to the rate of change of magnetic flux (flux linkage). ✓✓ (2)

6.2

- As the armature is rotated, the angle between the magnetic field and the normal to the area of the armature ✓ changes ✓
- the change in angle causes a change in magnetic flux ✓
- the change in flux induces an emf in the armature ✓

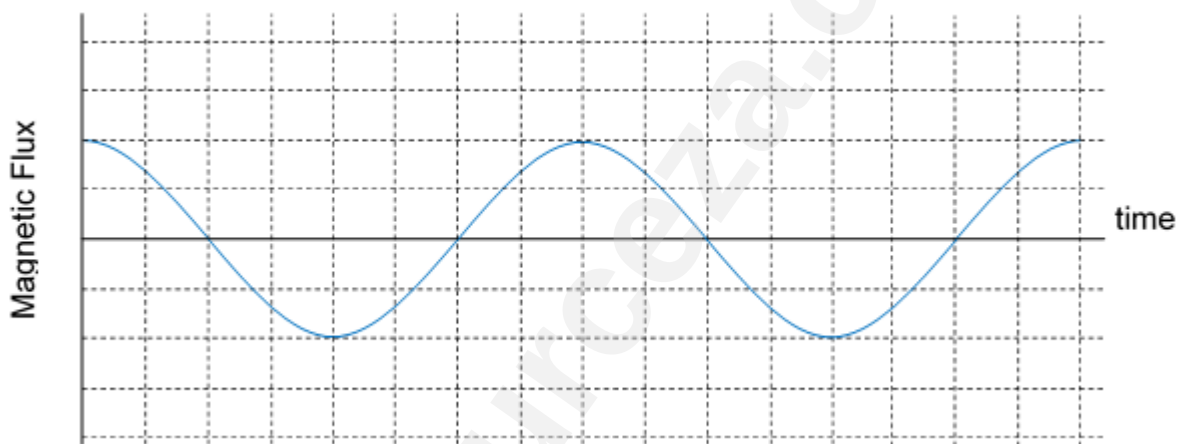
(4)

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

6.4 Out of the page ✓✓ (use Fleming's Right Hand generator rule) (2)

6.5 A ✓✓ At A, $\theta = 90^\circ \therefore \cos\theta = 0$ and flux = 0 $\therefore$ emf is max (2)

6.6

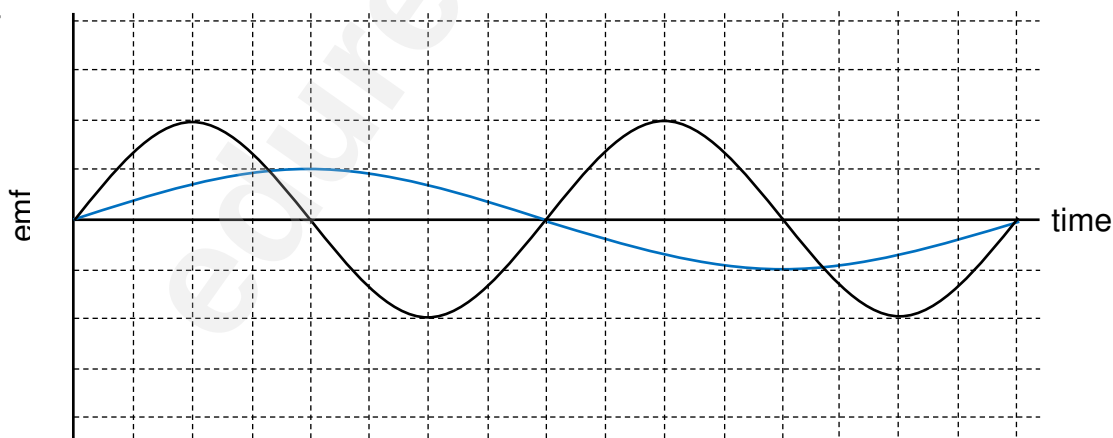


- Start at positive maximum flux ✓
- Alternating flux ✓
- Two full rotations in the same time period ✓

Remember, the emf is proportional to the negative of the gradient of the graph of flux vs time.

(3)

6.7



- Half maximum emf ✓ (acc. To Faraday's Law)
- Only one full rotation in same time period ✓ ($T = 1 / f$)

(2)

QUESTION 7 [19]

7.1 The direction that a positive test charge would move if placed at that point ✓✓ (2)

$$7.2 \quad E_M = \frac{k \cdot Q_M}{r^2} \checkmark$$

$$= \frac{(9 \times 10^9) \cdot (4 \times 10^{-9})}{(0,015)^2} \checkmark$$

$$= 1,6 \times 10^5 \text{ N.C}^{-1}, \text{ towards M / right / east} \quad (4)$$

Do not use the sign of the charge in the calculation. The direction of the field is deduced from the sign of the charge.

7.3 **Note:** If the electric field at point **P** due to presence of sphere **M** is directed towards M / right / east and it is given that the net electric field at point **P** due to presence of **M** and **N** is directed eastwards then in the equation that follows, the direction of E_{net} and E_M must either both be negative or both be positive.

If right/east is positive:

$$E_{\text{net}} = E_M + E_N$$

$$2 \times 10^5 \checkmark = 1,6 \times 10^5 + E_N \checkmark$$

$$E_N = 4 \times 10^4 \text{ N.C}^{-1} \checkmark \text{ right}$$

or

If right/east is negative

$$E_{\text{net}} = E_M + E_N$$

$$-2 \times 10^5 = -1,6 \times 10^5 + E_N$$

$$E_N = -4 \times 10^4 \text{ N.C}^{-1}$$

$$= 4 \times 10^4 \text{ N.C}^{-1} \text{ to the right}$$

$$E_N = \frac{k \cdot Q_N}{r^2}$$

$$4 \times 10^4 \checkmark = \frac{(9 \times 10^9) \cdot Q_N}{(0,045)^2} \checkmark$$

$$Q_N = 9 \times 10^{-9} \text{ C} \checkmark$$

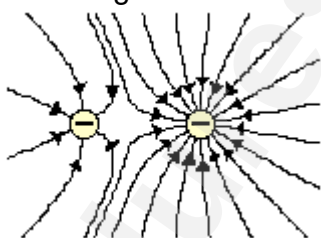
(6)

7.4 If the field at P due to N is to the right (towards N), then N must be negative (1)

Continued accuracy for (7.4) and (7.5)

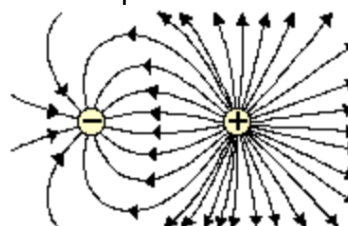
If both negative

7.5



or

If N positive



shape and direction ✓

ratio of lines ✓

field lines not touching or crossing each other or entering spheres ✓

(3)

$$7.6 \quad E_{\text{net}} = \frac{F}{q} \checkmark$$

$$2 \times 10^5 = \frac{F}{1,6 \times 10^{-19}} \checkmark$$

Don't use signs here. The direction of the force, if required, is deduced from the direction of the field and the sign of the charge. Positive charges experience a force in the direction of the field and vice versa.

$$F = 3,2 \times 10^{-14} \text{ N} \checkmark \text{ (to the left; negative charges move in the opposite direction to the field)}$$

(3)

QUESTION 8 [28]

8.1 A material's opposition to the flow of electric current. ✓✓ (2)

$$\begin{aligned} 8.2 \quad R_s &= R_1 + R_2 \\ &= 8\checkmark + 3,8\checkmark \\ &= 11,8\ \Omega\checkmark \end{aligned} \quad (3)$$

$$\begin{aligned} 8.3 \quad E &= I(R + r)\checkmark \\ 15 &= (1,2)(11,8\checkmark^{CA} + r)\checkmark \\ r &= 0,7\ \Omega\checkmark^{CA} \end{aligned} \quad (4)$$

$$\begin{aligned} 8.4 \quad W &= I^2 \cdot R \cdot t\checkmark \quad (t = 2,5 \times 60 = 150\text{ s}) \\ &= (1,2)^2 \cdot (8) \cdot (150)\checkmark \\ &= 1728\text{ J}\checkmark \end{aligned} \quad (3)$$

8.5.1 decreases ✓ (1)

8.5.2 increases ✓ (1)

8.6 The parallel component is now part of the circuit ✓
As r_i remains constant, the change in the total resistance is determined by R_{ex}

$$R_{\text{parallel}} = \frac{\text{product}}{\text{sum}} = \frac{80}{18}\checkmark = 4,44\ \Omega\checkmark$$

Hence $R_{ex} = 4,4 + 3,8 = 8,24\ \Omega\checkmark$
and this is less than $11,8\ \Omega$ when the switch was open ✓ (5)

8.7 Since the resistance decreased, and emf and r remain constant ✓

$$\begin{aligned} E &= I(R + r) \\ 15 &= I(8,24\checkmark^{CA} + 0,7)\checkmark \\ I &= 1,68\text{ A}\checkmark \end{aligned} \quad (4)$$

8.8 INCREASE ✓
 R_{ext} decreases ✓ and I through battery increases ✓
 $W = I^2 r t\checkmark$
If r and t remain constant, work done / electrical energy converted to heat energy by the battery increases ✓ (5)

QUESTION 9 [21]

$$9.1.1 \quad \Delta \text{Energy} = -1,51 - (-13,6) \\ = 12,09 \text{ eV} \checkmark$$

$$= 12,09 \times 1,6 \times 10^{-19} \checkmark$$

$$= 1,93 \times 10^{-18} \text{ J} \checkmark$$

(3)

$$9.1.2 \quad E = h.f \checkmark$$

$$1,93 \times 10^{-18} = (6,6 \times 10^{-34}).f \checkmark$$

$$f = 2,92 \times 10^{15} \text{ Hz} \checkmark$$

(3)

9.2.1 The minimum amount of energy needed to emit an electron from the surface of a metal $\checkmark\checkmark$

(2)

$$9.2.2 \quad E = \frac{h.c}{\lambda} \checkmark$$

$$= \frac{(6,6 \times 10^{-34}).(3 \times 10^8)}{250 \times 10^{-9}} \checkmark$$

$$= 7,92 \times 10^{-19} \text{ J} \checkmark$$

(4)

$$9.2.3 \quad E = W_f + \frac{1}{2} mv^2 \checkmark$$

$$7,92 \times 10^{-19} \checkmark_{CA} = 6,9 \times 10^{-19} \checkmark + \frac{1}{2}(9,1 \times 10^{-31} \checkmark).v^2$$

$$v = 473\,472,09 \text{ m.s}^{-1} \checkmark (4,73 \times 10^5 \text{ m.s}^{-1})$$

(5)

9.2.4 **Increase.** $\checkmark$

More photons per second $\checkmark$ hit the metal surface

or

Each photon collides with one electron which is released. ($\checkmark$)

$\therefore$ more electrons released per second $\checkmark$

$\therefore$ greater current as $I = Q/t$ $\checkmark$ or more charge (Q) per second ($\checkmark$)

(4)

EXAMINATION TOTAL: 200 marks