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Question 1

1.

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

(2x10 = 20)

Question 2**[31]**

2.

2.1.1. Speed = distance / time ✓
 $= 87 \times 10^3 \checkmark / (5 \times 60 \times 60) + (58 \times 60) + 33 \checkmark$ (2 marks conversion)
 $= 4,04 \text{ m.s}^{-1} \checkmark$ (4)

2.1.2. Distance is the length of the path taken ✓
 Displacement is the change in position ✓
 Distance is a scalar and displacement is a vector ✓ (3)

2.1.3. $35 \text{ m.s}^{-1} \checkmark$ (1)

2.1.4. $s = ut + \frac{1}{2} at^2$ $a = 0$
 $s = (35)(1920) \checkmark$ (2)
 $= 67\,200 \text{ m} \checkmark$

2.2.

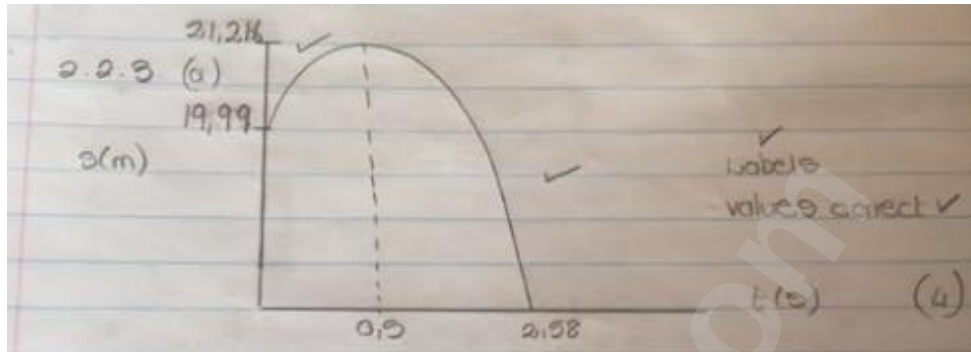
- 2.2.1. a) Between 0,5 s and 2,58 s ✓
 b) Between 0 s and 0,5 s ✓ (2)

2.2.2. S up = $\frac{1}{2} b \times h \checkmark$ S down = $\frac{1}{2} b \times h$
 $= \frac{1}{2} (0,5)(4,9)$ $= \frac{1}{2} (2,08)(20,40)$
 $= 1,225 \text{ m} \checkmark$ $= 21,216 \text{ m} \checkmark$

Balcony height = $21,216 - 1,225 = 19,99 \text{ m} \checkmark$ (4)

2.2.3.

- a) Labels ✓ values correct ✓ Curve up ✓ curve down ✓ (4)



- b) (3)



2.3.

2.3.1. $s = ut + \frac{1}{2}at^2$ ✓
 $= \frac{1}{2}(0,4)(5^2)$ ✓
 $= 5 \text{ m}$ ✓ (3)

2.3.2. John

Paul

$s = ut + \frac{1}{2}at^2$ ✓
 $= \frac{1}{2}(0,4)(x+5)^2$ ✓

$s = ut + \frac{1}{2}at^2$ $u = 0$ for both
 $= \frac{1}{2}(1,0)(x^2)$ ✓

when he catches up they have travelled the same distance.

$s_{\text{John}} = s_{\text{Paul}}$ ✓

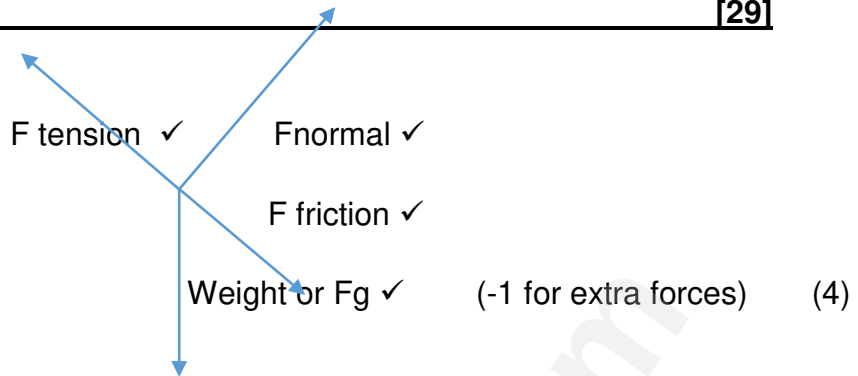
$0,2(x^2 + 10x + 25) = 0,5x^2$
 $0,3x^2 - 2x - 5 = 0$

$x = 8,6 \text{ seconds}$

It takes 8,6 s for Paul to catch John. ✓ (5)

Question 3**[29]**

3.1.



- 3.2. When a net force is applied to an object of mass, the object accelerates in the direction of the net force.
 The acceleration is directly proportional to the net force and inversely proportional to the mass of the object. $\sqrt{\sqrt{}}$
 (if only direction is left give 1) (2)

OR

The net force acting on an object is equal to the rate of change in momentum $\checkmark\checkmark$

3.3. $F_{\text{net}} = ma$ $W - T = ma$ $\checkmark$
 $(2)(9,8) - T = 3(0,25)$ $\checkmark$
 $T = 28,65 \text{ N}$ $\checkmark$ (3)

3.4. $W_{\parallel} = W \sin 32^\circ$ $\checkmark = 4(9,8)(\sin 32^\circ) = 20,77$ $\checkmark$
 $T - F_{\text{fric}} - W_{\parallel} = 4a$ $\checkmark$
 $28,65 - F_{\text{fric}} - 20,77 = 4(0,25)$ $\checkmark$
 $F_{\text{fric}} = 6,88 \text{ N down the slope}$ $\checkmark$ (5)

- 3.5. The perpendicular force exerted by a surface on an object in contact with it. (2)

3.6. $F_{\text{fric}} = \mu F_N$ $\checkmark$ $F_N = W \cos 32^\circ = (4)(9,8)(\cos 32^\circ)$
 $6,88 = \mu (33,24)$ $\checkmark$ $= 33,24 \text{ N}$ $\checkmark$
 $\mu = 0,21$ $\checkmark$ (4)

3.7. $W_{\parallel} = 20,77 \text{ N down the slope}$

$F_{\text{fric}} = \mu F_N = (0,23)(33,24) = 7,645 \text{ N Down the slope}$ $\checkmark$

For the block to be stationary $T = W_{\parallel} + F_{\text{fric}}$
 $= 20,77 + 7,645$ $\checkmark$
 $= 28,42 \text{ N up the slope}$ $\checkmark$ (3)

3.8. For the 3 kg block: $W - T = 0$ ✓
 $T = W = (3)(9,8) = 29,4 \text{ N}$ ✓

For the 4 kg block: $T - F_{\text{fric}} - W_{\text{II}} = 0$ ✓
 $29,4 - (0,23)(W \cos 32^\circ) - W \sin 32^\circ = 0$ ✓
 $W = 40,55 \text{ N}$

mass = $W / 9,8$ ✓ (using 9,8)
 $= 4,14 \text{ kg}$

Therefore 0,14 kg must be added to the 4 kg block ✓ (6)

(mg could be used in the force equation and mass will then be determined directly)

Question 4

[40]

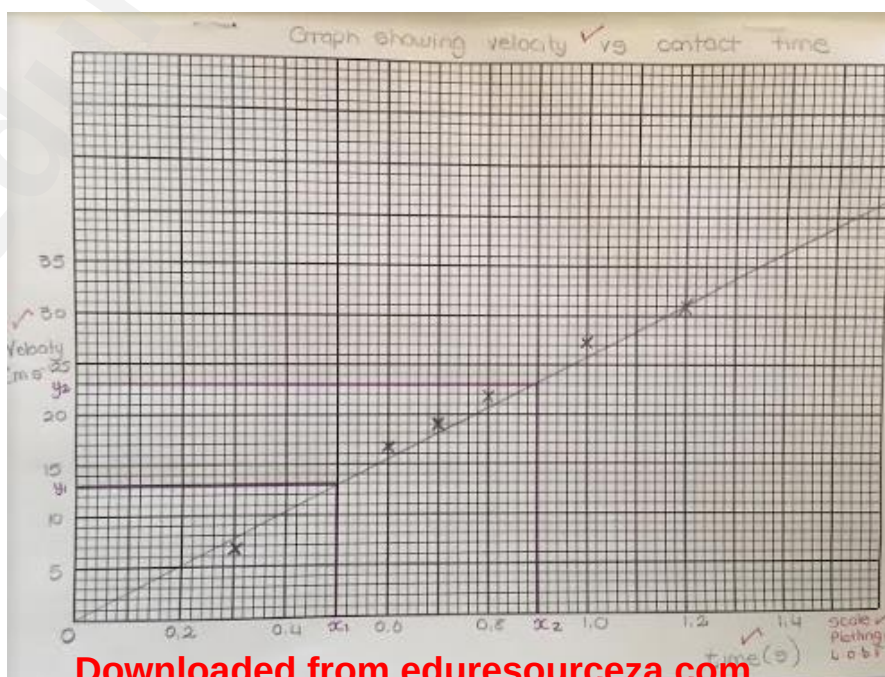
4.

4.1.1. As the contact time increases (decreases) the velocity of the javelin will increase (decrease). ✓✓ (2)

4.1.2. The product of the net force and the contact time. ✓✓ (2)

4.1.3. Graph paper at the back of the answer booklet

- ✓ heading
 - ✓ labels on x and y axis with units
 - ✓ scale (more than half the grid used in x and y direction and no odd scale)
 - ✓ plotted all points and crosses used
 - ✓ accuracy of plotting
 - ✓ line of best fit
- (6)



$$4.1.4. \text{ Gradient} = \frac{y_2 - y_1}{x_2 - x_1} \checkmark = \frac{23 - 13}{0,9 - 0,5} \checkmark \quad (\text{both points must be on the l.o.b.f})$$

$$= 25 \quad \checkmark \quad \text{points shown on graph} \quad \checkmark \quad (\text{range between 24 and 28}) \quad (4)$$

$$4.1.5. \quad m \Delta v = F \Delta t \quad v_f - v_i = \frac{F \Delta t}{m} \checkmark \quad \text{but } v_i = 0$$

$$v_f = \frac{F \Delta t}{m} \checkmark \quad (2)$$

$$4.1.6. \quad y = m x + c \quad c = 0 \text{ because the line passes through the origin}$$

$$v_f = \frac{F}{m} \Delta t + 0$$

$$\text{therefore the gradient} = \frac{F}{m} = 25 \checkmark \quad \text{coe}$$

$$F = (25)(0,85) \checkmark$$

$$= 21,25 \text{ N} \checkmark \quad (3)$$

$$4.2.$$

$$4.2.1. \quad p_i = p_f$$

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v \checkmark$$

$$(0,04)(45) + (0,085)(-2) \checkmark = (0,125) v \checkmark$$

$$1,8 - 0,17 = 0,125 v$$

$$v = 13,04 \text{ m.s}^{-1} \checkmark \text{ to the right} \quad (4)$$

(Wrong conversion -1 only once)

$$4.2.2. \text{ Determine the total kinetic energy of the system before the collision and the total kinetic energy after the collision. } \checkmark$$

$$\text{If } E_{ki} = E_{kf} \text{ then the collision is elastic. } \checkmark \quad (2)$$

$$4.2.3. \quad F_{\text{net}} = \frac{\Delta p}{\Delta t} \checkmark$$

$$F \text{ of ball on block} = - F \text{ block on ball according to N3 } \checkmark$$

$$\text{Therefor the ball and the block will have the same rate of change of momentum, just in opposite directions. } \checkmark \quad (3)$$

Only 1 of N3 is just stated.

$$4.2.4. \text{ In the absence of air resistance or any external forces, the mechanical energy of an object is constant. } \checkmark \checkmark \quad (2)$$

$$4.2.5. \quad E_{\text{mech at the bottom}} = E_{\text{mech at the top}}$$

$$E_p + E_k = E_p + E_k \checkmark$$

$$0 + \frac{1}{2} m v^2 = m g h + 0$$

$$\frac{1}{2} (13,04)^2 \checkmark = (9,8) h \checkmark$$

$$h = 8,68 \text{ m } \checkmark \quad (4)$$

4.2.6. The work done by a **net force** on an object is equal to the **change** in kinetic energy of the object ✓✓ (net work only one) (2)

$$\begin{aligned} 4.2.7. \quad W &= \Delta E_k \quad \checkmark \\ F \Delta x \quad \checkmark &= \Delta E_k \\ F(0,32) &= 0 - \frac{1}{2}(0,125)(13,04)^2 \quad \checkmark \\ F &= -33,21 \text{ N} \end{aligned}$$

Therefore the net force = 33,21 N down the slope ✓ (4)

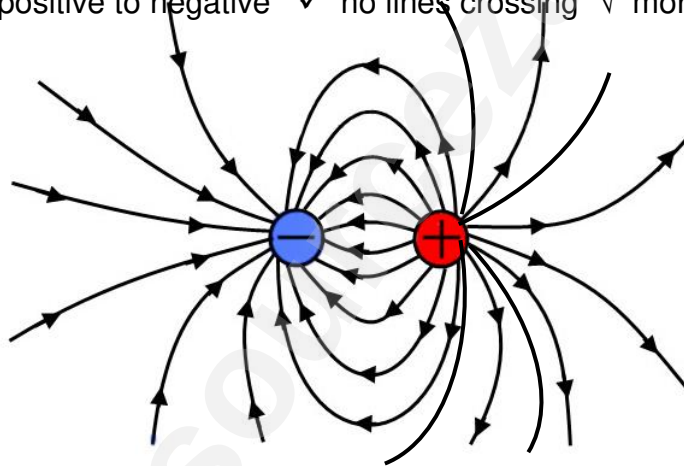
$$\begin{aligned} \text{or work done against gravity} &= 10,62 \text{ J} \quad W = F_{\text{net}} \Delta x \\ 10,62 &= F_{\text{net}}(0,32) \\ F_{\text{net}} &= 33,31 \text{ N downwards} \end{aligned}$$

Question 5

[28]

5.

5.1.1. ✓ from positive to negative ✓ no lines crossing ✓ more dense around J (+)



(3)

5.1.2. D to J ✓✓

(2)

$$5.1.3. \quad (-9+15) / 2 \text{ nC} = +3 \text{ nC}$$

✓✓

(2)

$$5.1.4. \quad \Delta Q = 12 \text{ nC} \quad \checkmark$$

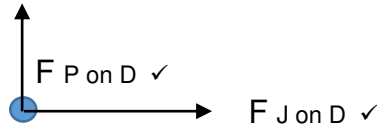
$$\text{Number of electrons} = \frac{12 \times 10^{-9}}{1,6 \times 10^{-19}} \quad \checkmark = 7,5 \times 10^{10} \quad \checkmark$$

(3)

5.2.

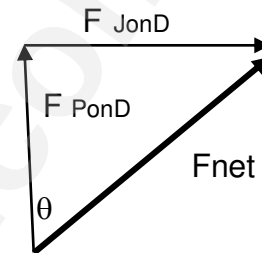
- 5.2.1. Two point charges in free space or air exert forces on each other. The force is directly proportional to the **product** of the charges ✓ and inversely proportional to the **square** of the distance **between the** charges. ✓ (2)

5.2.2.



(2)

$$\begin{aligned} 5.2.3. \quad F_{P \text{ on } D} &= \frac{k Q_1 Q_2}{r^2} \quad \checkmark \\ &= \frac{(9 \times 10^9)(9 \times 10^{-9})(12 \times 10^{-9})}{0,6^2} \quad \checkmark \\ &= 2,7 \times 10^{-6} \text{ N} \quad \checkmark \end{aligned}$$



$$\begin{aligned} F_{J \text{ on } D} &= \frac{k Q_1 Q_2}{r^2} \\ &= \frac{(9 \times 10^9)(9 \times 10^{-9})(15 \times 10^{-9})}{0,8^2} \\ &= 1,9 \times 10^{-6} \text{ N} \quad \checkmark \end{aligned}$$

$$\begin{aligned} \tan \theta &= 1,9 \times 10^{-6} / 2,7 \times 10^{-6} \\ \theta &= 35,13^\circ \quad \checkmark \end{aligned}$$

$$\begin{aligned} F_{\text{net}}^2 &= (2,7 \times 10^{-6})^2 + (1,9 \times 10^{-6})^2 \\ F_{\text{net}} &= 3,3 \times 10^{-6} \text{ N at an angle of } 35,13^\circ \text{ to the vertical} \quad \checkmark \end{aligned} \quad (6)$$

5.3.

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

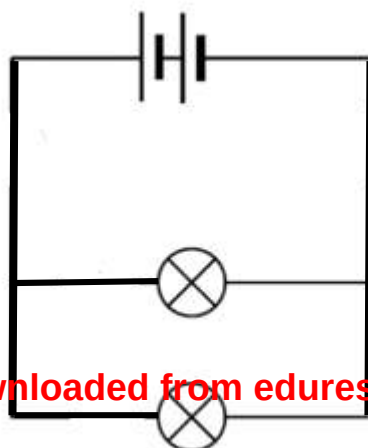
$$\begin{aligned} 5.3.2. \quad g &= \frac{G m_1 m_2}{r^2} \quad \checkmark = \frac{(6,7 \times 10^{-11})(3,285 \times 10^{23})}{(2439,7 \times 10^3)^2} \quad \checkmark \text{ conversion} \checkmark \\ &= 3,7 \text{ N.kg}^{-1} \quad \checkmark \end{aligned} \quad (4)$$

$$5.3.3. \quad 2500 \text{ kg} \quad \checkmark \checkmark \quad (2)$$

Question 6

6.

- 6.1.1. ✓✓ (2)



6.1.2. The rate of flow of charge ✓✓ (2)

6.1.3. a) $V = IR$ ✓
 $12 = I(6)$ ✓ $I = 2 \text{ A}$ ✓ (3)

b) $P = W / t$ ✓
 $36 = W / (20 \times 60 \times 60)$ ✓
 $W = 2,59 \times 10^6 \text{ J}$ ✓ (3)

6.2.

6.2.1. $I_{\text{total}} = I_x + I_y$ ✓
 $= \frac{V}{R_x} + \frac{V}{R_y} = \frac{6}{2,4} + \frac{6}{1,2} = 2,5 + 5 = 7,5 \text{ A}$ ✓

$V_{\text{variable}} = 9 - 6 = 3 \text{ V}$ ✓

$R = \frac{V}{I} = \frac{3}{7,5} = 0,4 \Omega$ ✓ (4)

6.2.2. Rate of energy conversion = Power ✓

$P = \frac{V^2}{R}$ ✓ and V is constant therefore P is inversely proportional to Resistance ✓

Therefore the lower the resistance the higher the rate of energy conversion.
 The $1,2 \Omega$ resistor will therefore have a higher rate of energy conversion and not lower... ✓ (4)

6.3.

6.3.1. The total energy supplied per coulomb of charge, by the cell ✓✓ (2)

6.3.2. $R_{\text{II}} = \left(\frac{1}{3} + \frac{1}{4}\right)^{-1}$ or $\frac{1}{R} = \frac{1}{3} + \frac{1}{4}$ (-1 for wrong math) ✓✓
 $= 1,71 \Omega$ ✓ (3)

6.3.3. a) For the open switch circuit

$\text{Emf} = 2,2 r + 2,2 (3)$ ✓

For the closed switch circuit

$\text{Emf} = 2,6 r + 2,6 (1,71)$ ✓ coe

The emf and the internal resistance is constant

$2,2 r + 2,2 (3) = 2,6 r + 2,6 (1,7)$ ✓
 $r = 5,39 \Omega$ ✓

b) $\text{emf} = 2,2 (5,39) + 2,2 (3)$ ✓ or $2,6(5,39) + (2,6)(1,71)$

$$= 18,46 \text{ V} \checkmark \quad \quad \quad = 18,46 \text{ V} \quad (6)$$

6.3.4. Decrease $\checkmark$ (1)

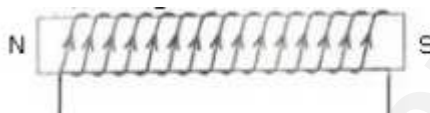
6.3.5. When the switch is closed the total resistance decreases that causes the current to increase in the circuit $\checkmark$

$$\begin{aligned} \text{Emf} &= V_{\text{ext}} + V_{\text{int}} \\ &= V_{\text{ext}} + Ir \quad \checkmark \quad \text{Emf and } r \text{ is constant therefore } Ir \text{ increases} \end{aligned}$$

V_{external} will decrease when V_{internal} decreases to keep emf constant. $\checkmark$ (3)

Question 7

7.

7.1.1.  $\checkmark$ (1)

7.1.2. Increase the current $\checkmark$ increase the number of windings $\checkmark$ (2)

7.2.

7.2.1. A motor $\checkmark$ (1)

7.2.2. There is a battery therefore electrical energy is converted into mechanical energy $\checkmark\checkmark$ (2)

7.2.3. Anti Clockwise $\checkmark$ (1)

7.2.4. The split ring commutator $\checkmark$ allows the current to change direction every 180° $\checkmark$ keeping the armature rotating anticlockwise $\checkmark$ (3)

7.3.

7.3.1. The AC $\checkmark$ in the primary coil provides the change in magnetic flux $\checkmark$ that will induce a voltage directly proportional to the change in flux. $\checkmark$ (3)

7.3.2. $P_{\text{out}} = 90\%$ of P_{in} $\checkmark$

$$P_{\text{out}} = 0,9 P_{\text{in}} \checkmark$$

$$V_s I_s = 0,9 V_p I_p$$

$$\frac{0,9 I_p}{I_s} = \frac{V_s}{V_p} = \frac{N_s}{N_p} \checkmark = \frac{910}{650} \checkmark$$

$$\frac{910}{650} I_s = (0,9)(15) \quad I_s = 9,64 \text{ A} \checkmark \quad (5)$$

7.3.3. $P = VI$ For constant power we need to keep the current low and therefore increase the voltage ✓

Lower current means less energy lost due to friction and heat ✓ (2)

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