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Question 1

- 1.1. A
 1.2. D
 1.3. B
 1.4. C
 1.5. D
 1.6. D
 1.7. B
 1.8. B
 1.9. B
 1.10. C (20)

Question 2**[32]**

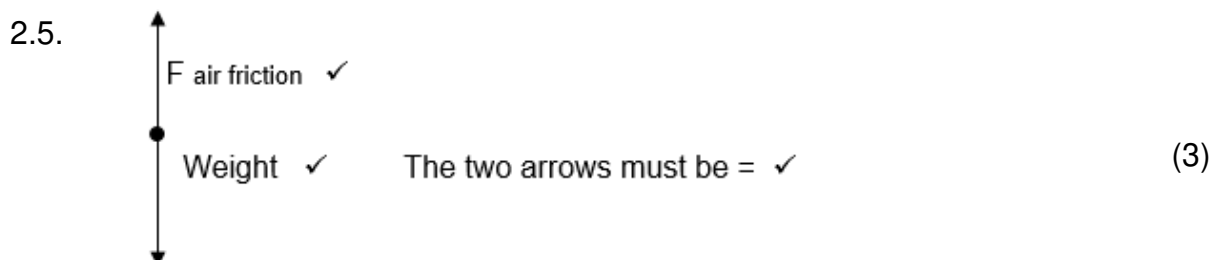
2.1. $F_{\text{net}} = ma$ ✓
 $2\,000 = 1\,250 a$ ✓
 $a = 1,6 \text{ m.s}^{-2}$ ✓ (3)

2.2. $v = u + at$ ✓
 $36 = 0 + (1,6) t$ ✓ (COE in a)
 $t = 22,5 \text{ s}$ ✓ (3)

2.3. $s = ut + \frac{1}{2} at^2$ ✓
 $s = 0 + \frac{1}{2} (1,6)(22,5)^2$ ✓ (COE in t)
 $= 405 \text{ m}$ ✓
 $405 \text{ m} < 525 \text{ m}$
 so the aircraft will lift off before the end of the runway. ✓ (4)

(time could be used or they could work out that the final velocity at 525m is 40,99 m/s which is larger than the 36 m/s needed to lift off)

- 2.4. speed is the rate of change in distance (scalar) ✓ and
 velocity is the rate of change of displacement (vector) ✓ (2)



2.6. 12 seconds ✓ (1)

2.7. Distance = area ✓
 $= 54 \times 12$ ✓ (COE from 2.6)
 $= 648 \text{ m}$ ✓ (3)

2.8. As the parachute opens, the velocity decreases fast. ✓
 Negative acceleration (slope) ✓
 After 25 seconds he reaches a constant velocity again. ✓
 (-1 if no reference is made to the graph) (3)

2.9.

2.9.1. 8 m/s (from the graph) ✓✓ (2)

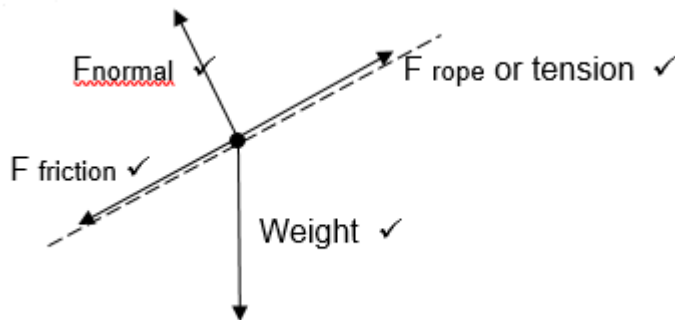
2.9.2. $s = ut + \frac{1}{2} at^2$ ✓
 $32 = 8t + \frac{1}{2} (9,8) t^2$ ✓ (COE from 2.9.1)
 $t = 1,87 \text{ s}$ ✓ (3)

2.9.3. $s = ut + \frac{1}{2} at^2$
 $4 = 0 + \frac{1}{2} (2,4) t^2$ ✓
 $t = 1,83 \text{ s}$ ✓ $t_{\text{total}} = 1,83 + 0,8 = 2,63 \text{ s}$ ✓

$2,63 \text{ s} > 1,87 \text{ s}$
 so he does not catch the phone ✓ (4)

Question 3**[21]**

3.1



(4)

3.2. When a net force acts on an object, the object will accelerate 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. (2)

OR The net force action on an object is equal to the rate of change in momentum.

3.3. $F_{\text{net}} = ma$ ✓
 $= 45\,000 (0,25)$ ✓
 $= 11\,250 \text{ N}$ ✓ (3)

3.4. $F_{\text{Fric}} = \mu F_N$ ✓
 $= (0,35) (45\,000 \times 9,8 \checkmark) (\cos 52^\circ)$ ✓ Calculating F_N
 $= 95\,027,35 \text{ N}$ ✓ (4)

3.5. $F_{\text{net}} = ma$
 $F_{\text{haulers}} - (W_{\text{parallel}} + F_{\text{Fric}}) = ma$ ✓
 $F_{\text{haulers}} - (45\,000 \times 9,8 \times \sin 52^\circ) \checkmark - (95\,027,35) = 11\,250$ coe from 3.3 and 3.4
 $F_{\text{haulers}} = 453\,790,09 \text{ N}$ ✓

Number of haulers $= \frac{453\,790,09}{9\,075,8} \checkmark$ (for $\div$) $= 50$ haulers ✓ (5)

3.6. The block will continue to move at the velocity it was moving when the haulers let go of the rope ✓.
 This is Newton 1. ✓
 It will reach the top before the force of friction or gravity (New F_{net}) causes it to stop. ✓ (3)

Question 4**[19]**

4.1. This is a force parallel to the surface opposing the motion of the object ✓✓ (2)

4.2. Graph on the grid provided

- ✓ heading (Force vs mass)
- ✓ labels and units on x (mass in kg) and y axis
- ✓ scale
- ✓✓ plotting and accuracy
- ✓ line of best fit (6)

4.3. gradient = $\frac{y_2 - y_1}{x_2 - x_1}$ ✓
 = 2 points from the line of best fit ✓
 clearly marked on the graph ✓
 = ± 4 ✓ (4)

4.4. The force needed to pull the block is directly proportional to the mass of the block. ✓✓ (-1 for wrong order and -1 if no direct proportion)

OR as the mass of the block increases the force needed to pull the block increase in direct proportion. (2)

4.5. $F_{\text{Fric}} = \mu F_N = \mu W$ ✓
 $F_{\text{Fric}} = \mu mg$ ✓ (2)

4.6. gradient = μg ✓
 $4 = \mu (9,8)$ ✓
 $\mu = 0,41$ ✓ no unit (3)

Question 5**[22]**

5.1. In an isolated system ✓ the total linear momentum is conserved ✓ (2)

$$\begin{aligned}
 5.2. \quad m_1 u_1 + m_2 u_2 &= v(m_1 + m_2) \quad \checkmark \\
 (0,04) u_1 + 6(0) &\checkmark = 7,8 (6,04) \quad \checkmark \\
 u_1 &= 1\,177,8 \text{ m.s}^{-1} \quad \checkmark
 \end{aligned}
 \quad (4)$$

$$\begin{aligned}
 5.3. \quad E_k &= \frac{1}{2} m v^2 \quad \checkmark \\
 &= \frac{1}{2} (6,04)(7,8^2) \quad \checkmark \\
 &= 183,74 \text{ J} \quad \checkmark
 \end{aligned}
 \quad (3)$$

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

$$\begin{aligned}
 5.5. \quad W &= \Delta E_k \quad \checkmark \\
 F \Delta x &= \frac{1}{2} (6,04) (4,1^2) - \frac{1}{2} (6,04) (7,8^2) \quad \checkmark \\
 (-195) \Delta x &\checkmark = -132,97 \\
 \Delta x &= 0,68 \text{ m} \quad \checkmark
 \end{aligned}
 \quad (4)$$

Check the signs in this question carefully – negatives cannot just be changed but has to be interpreted.

$$\begin{aligned}
 5.6. \quad E_k &= E_p + W_{\text{done against friction}} \quad \checkmark \\
 \checkmark \frac{1}{2} (6,04) (4,1^2) &= (6,04) (9,8) h + 40 \quad \checkmark \\
 h &= 0,18 \text{ m} \quad \checkmark
 \end{aligned}
 \quad (4)$$

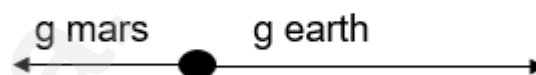
$$\begin{aligned}
 5.7. \quad F \Delta t &= m \Delta v \\
 F &= m \Delta v / \Delta t \quad \text{So force is inversely proportional to the time} \quad \checkmark \\
 \therefore \text{the longer the time (because of vest)} &\checkmark \\
 \text{the smaller the force on the police officer} &\checkmark
 \end{aligned}
 \quad (3)$$

Question 6**[19]**

6.1.1. Every particle attracts every other particle with a force that is directly proportional to the **product** of their masses ✓ and inversely proportional to the **square** of the distance **between** their centers. ✓ (2)

$$\begin{aligned}
 6.1.2. F_g &= \frac{G m_C m_E}{r^2} \quad \checkmark \\
 &= \frac{(6,7 \times 10^{-11})(1300)(6 \times 10^{24})}{[(4,5 \times 10^6)(10^3)]^2} \quad \checkmark \checkmark \\
 &= 0,026 \text{ N} \quad \checkmark \quad (4)
 \end{aligned}$$

$$\begin{aligned}
 6.1.3. g_{\text{Earth}} &= \frac{G m_E}{r^2} \quad \checkmark \\
 &= \frac{(6,7 \times 10^{-11})(6 \times 10^{24})}{[(4,5 \times 10^6)(10^3)]^2} \\
 &= 1,99 \times 10^{-5} \text{ N/kg} \quad \checkmark
 \end{aligned}$$



$$\begin{aligned}
 g_{\text{mars}} &= \frac{G m_M}{r^2} \\
 &= \frac{(6,7 \times 10^{-11})(6,39 \times 10^{23})}{(216,1 \times 10^9)^2} \quad \checkmark \\
 &= 9,17 \times 10^{-10} \text{ N/kg} \quad \checkmark
 \end{aligned}$$

$$\therefore \text{Resultant field} = (1,99 \times 10^{-5}) - (9,17 \times 10^{-10}) = 1,99 \times 10^{-5} \text{ N/kg} \quad \checkmark \quad (5)$$

Towards Earth

6.2.1. The negatively charged sphere will repel electrons in the neutral sphere to the left ✓ inducing a positive charge on the side of A closest to B ✓
The positive side of A will be attracted by the negative B ✓ (3)

6.2.2. Electrons move from B to A ✓
The two spheres will end up with the same negative charge ✓
Two negative charges repel ✓ (3)

$$\begin{aligned}
 6.2.3. F &\propto \frac{1}{r^2} \quad \rightarrow \quad F_{\text{new}} \rightarrow 4 (56) \propto \frac{1}{(\frac{1}{2}r)^2} = \frac{1}{\frac{1}{4}r^2} = 4 \frac{1}{r^2} \quad \checkmark \\
 F_{\text{new}} &= 224 \text{ N} \quad \checkmark \quad (2)
 \end{aligned}$$

Question 7

[18]

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

$$7.2. \frac{1}{R_p} = \frac{1}{3} + \frac{1}{6} \quad \checkmark \quad R_p = 2 \, \Omega \quad \checkmark$$

$$R_{\text{total}} = 2 + 2 \quad \checkmark$$

$$= 4 \, \Omega \quad \checkmark \quad (4)$$

OR: $R_{\text{total}} = 2 + \left(\frac{1}{3} + \frac{1}{6}\right)^{-1} \quad \checkmark \checkmark$

$$= 2 + 2 \quad \checkmark = 4 \, \Omega \quad \checkmark$$

7.3. $V_{\text{ext}} = IR_{\text{ext}} \quad \checkmark \quad \therefore V_{\text{int}} = 12 - 8,8$

$$= (2,2)(4) \quad \checkmark \quad = 3,2 \, \text{V} \quad \checkmark$$

$$= 8,8 \, \text{V} \quad \checkmark$$

$$r = V_{\text{int}} / I = 3,2 / 2,2 = 1,45 \, \Omega \quad \checkmark \quad (4)$$

OR: $\text{emf} = I(r + R) \quad \checkmark$

$$12 = 2,2(r + 4) \quad \checkmark \checkmark$$

$$r = 1,45 \, \Omega \quad \checkmark$$

7.4. $V_{2\Omega} = IR = (2,2)(2) = 4,4 \, \text{V} \quad \checkmark \quad \text{OR: } V_p = 12 - 4,4 - 3,2 = 4,4 \, \text{V} \quad \checkmark$

$$W = \frac{V^2 t}{R} \quad \checkmark$$

$$= \frac{4,4^2 (5 \times 60)}{6} \quad \checkmark$$

$$= 968 \, \text{J} \quad \checkmark \quad (4)$$

OR: Calculate $I = \frac{3}{9} \times 2,2 = 0,733 \, \text{A} \quad \text{OR: } V = IR \rightarrow 4,4 = I(6)$

$$I = 0,733 \, \text{A} \quad \checkmark$$

$$W = I^2 R t \quad \checkmark$$

$$= (0,733)^2 (6)(5 \times 60) \quad \checkmark$$

$$= 968 \, \text{J} \quad \checkmark$$

The answers may vary due to rounding.

7.5. Constant $V \therefore P = \frac{V^2}{R} \therefore P \propto \frac{1}{R} \quad \checkmark$

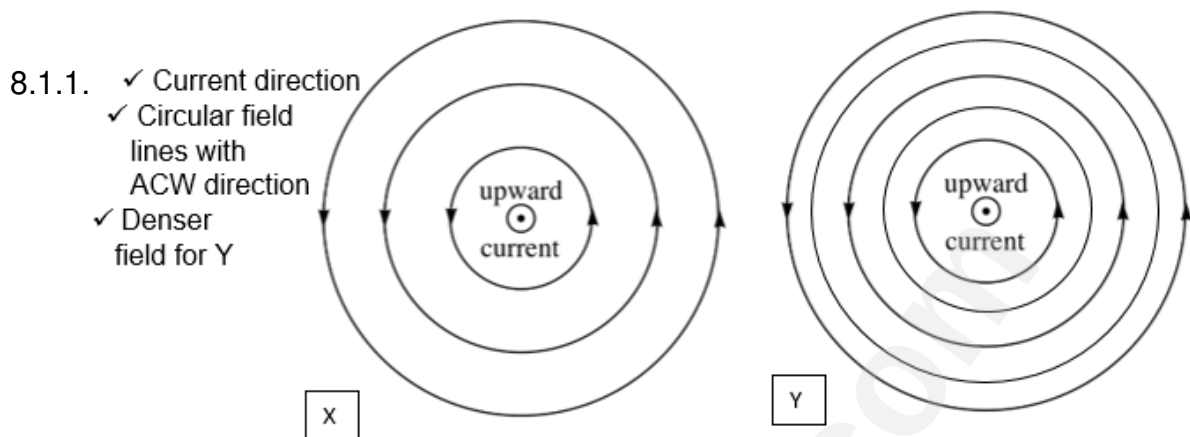
Power is the rate of energy conversion ✓ (shown somewhere)

The higher the resistance the smaller the power ✓

$\therefore$ the $3 \, \Omega$ resistor has the highest rate of energy conversion ✓ (4)

Question 8

[29]



(Combined effect could have been shown – do not penalize) (3)

8.1.2. Attraction ✓ (1)

8.1.3. Same force ✓✓ (2)

8.2.1. (Iron core is also magnetized)
∴ Denser field and stronger magnet created ✓✓ (2)

Note: Explanation was not asked – so stronger field scores 2 marks. Change question in future

8.2.2. North ✓ (1)

8.3.1. $\text{emf} = \frac{\Delta\Phi}{\Delta t}$ ✓
There has to be a change in the magnetic flux ✓ for an emf to be induced
therefore it must keep turning ✓ (3)

8.3.2. Faster speed of rotation, Stronger magnets, increased windings
(Any 2) ✓✓ (2)

8.3.3. Higher voltage will allow less energy lost due to high currents causing
heat energy lost. ✓
 $P = V \times I$ ✓
so for constant power if voltage increase the current will decrease. ✓ (3)

8.4.1. No loss in energy – power in = power out ✓✓ (2)

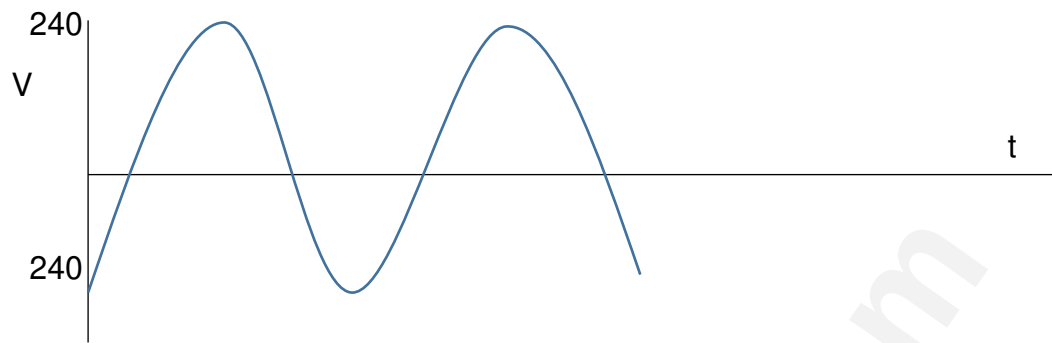
8.4.2. $\frac{N_P}{N_S} = \frac{V_P}{V_S}$ ✓
 $= \frac{240}{9}$ ✓
 $= 26,67$ ✓ (no unit) The final order must be correct as asked
They cannot just use equation as info sheet (3)

8.4.3. To convert alternating current (AC) into direct current (DC) ✓✓ (2)

8.4.4. Q to P ✓ (1)

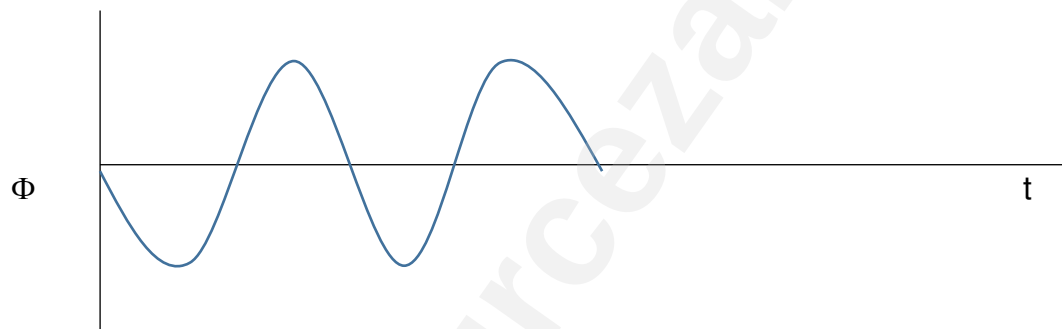
8.4.5.1. ✓ 2 full cycles ✓ labels for 240 V

(2)



8.4.5.2. ✓ start at 0 (or max if V was 0) and opposite direction to V slope
✓ labels

(2)



Question 9

[21]

9.1. Photo electric effect ✓✓ (2)

9.2. Photons of red does not have energy higher than the work function for sodium but those of violet light does. ✓✓
 $\therefore$ violet emits electrons ✓ (3)

OR: $f < f_0$ for red ✓ $\therefore$ no emission ✓ and $f > f_0$ for violet $\therefore$ electrons are emitted ✓

9.3. $W_0 = 2,28 \text{ eV} = 2,28 \times 1,6 \times 10^{-19} \text{ J} \checkmark = 3,648 \times 10^{-19} \text{ J}$ (1)

9.4. $E_{\text{photon}} = W_0 + E_k$

$$\frac{hc}{\lambda} = (3,648 \times 10^{-19}) + E_k \quad (\text{COE}) \checkmark$$

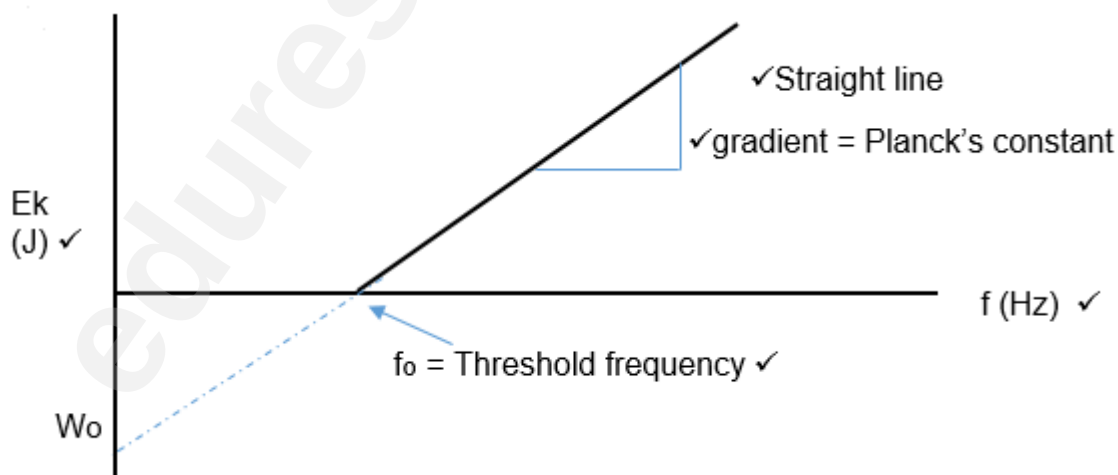
$$\frac{(6,6 \times 10^{-34})(3 \times 10^8)}{\checkmark \text{conversion}(300 \times 10^{-9})} = (3,648 \times 10^{-19}) + E_k \checkmark$$

$$E_k = 2,952 \times 10^{-19} \text{ J} \checkmark \quad (4)$$

9.5.1. Red - stay the same ✓
 Violet – increase ✓ (2)

9.5.2. Red – no electrons are emitted because $f < f_0$ ✓
 Intensity increase has no effect.
 Violet – Intensity increasing means more photons per second ✓
 $\therefore$ more electrons emitted per second ✓
 $I = Q/t$ so current increases ✓ (4)

9.6.



They could state that W_0 is hf_0 if no y intercept is shown.

(5)