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INTERNATIONAL SECONDARY CERTIFICATE EXAMINATION
NOVEMBER 2023

PHYSICAL SCIENCES: PAPER I

MARKING GUIDELINES

Time: 3 hours

200 marks

These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines. It is also recognised that, without the benefit of attendance at a standardisation meeting, there may be different interpretations of the application of the marking guidelines.

QUESTION 1

- 1.1 C Pyth gives 5 km. Direction 37° W of N (not N of W) or bearing 323°
- 1.2 B $T - F_G = ma$ if up is +. Thus $T = F_G + ma$, increasing T if accelerating
- 1.3 C p before = p after, $0 = (1,8)(2) - (x)(6)$, $x = 0,6$ kg
- 1.4 A $g = \frac{Gm}{(d/2)^2}$ and $a = \frac{G(420m)}{(11d/2)^2}$ thus $a = \frac{420 Gm}{11^2(d/2)^2} = \frac{420 g}{11^2}$
- 1.5 D When they touched, they became neutral, thus no force
- 1.6 A Left-hand motor rule
- 1.7 C Current split in 2A per branch, so 4A before final split
- 1.8 D Double current will pass through y only/ path of least resistance.
- 1.9 D $E = mgh = (60)(9,8)(0,2 \times 50) = 5\,880$ J
- 1.10 B unit

QUESTION 2

2.1 2.1.1 ave $v = \frac{\text{distance}}{\text{Time}}$

$$= \frac{100}{10,5}$$

$$= 9,52 \text{ m.s}^{-1}$$

2.1.2 $v = u + at$

$$= 0 + (5,3)(2,3)$$

$$= 12,19 \text{ m.s}^{-1} \quad (12,2 \text{ m.s}^{-1} \text{ acceptable})$$

2.1.3 $s = ut + \frac{1}{2}at^2$

$$= 0 + \frac{1}{2}(5,3)(2,3)^2$$

$$= 14,02 \text{ m}$$

OR $v^2 = u^2 + 2as$

$$(12,19)^2 = 0 + 2(5,3)(x)$$

$$x = 14,02 \text{ m}$$

OR $\Delta x = \left(\frac{v+u}{2}\right)t = (12,19 + 0)(2,3) / 2 = 14,02 \text{ m}$

2.1.4 $s = ut + \frac{1}{2}at^2$

$$= 0 + \frac{1}{2}(11,4/3)(2,3)^2$$

$$= \frac{1}{2}(3,8)(5,29)$$

$$= 10,05 \text{ m}$$

OR gradient = $a = \frac{11,4}{3} = 3,8 \text{ m.s}^{-2}$

$v = u + at$

$$11,4 = 0 + a(3)$$

$$a = 3,8 \text{ m.s}^{-2}$$

- 2.1.5 A already reached max v (simultaneously reach same velocity)
- $$v = u + at$$
- $$12,19 = 0 + (3,8)t$$
- $$t = 3,21 \text{ s}$$
- but max speed at 3s of $11,4 \text{ m.s}^{-1}$, will not catch up with A

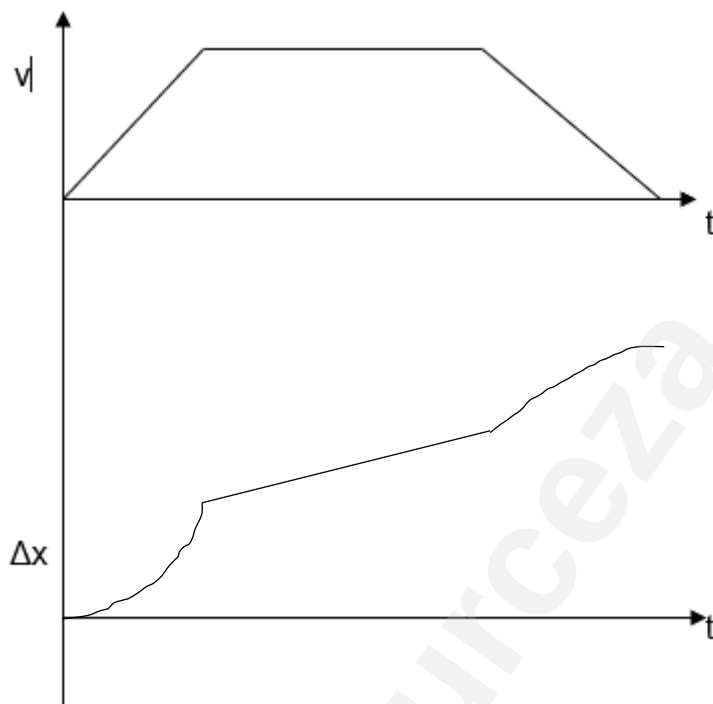
- OR A has bigger acceleration than B
Max speed of B less than that of A
A always faster and in front of B
- OR (A would have reached B's max at a specific time;)
 $v = u + at$
 $11,4 = 0 + (5,3)t$
 $t = 2,15 \text{ s}$

2.1.6 Acceleration is the rate of change of velocity.

- 2.2 2.2.1 (a) Velocity is the rate of change of displacement
(b) Distance covered is the road length travelled

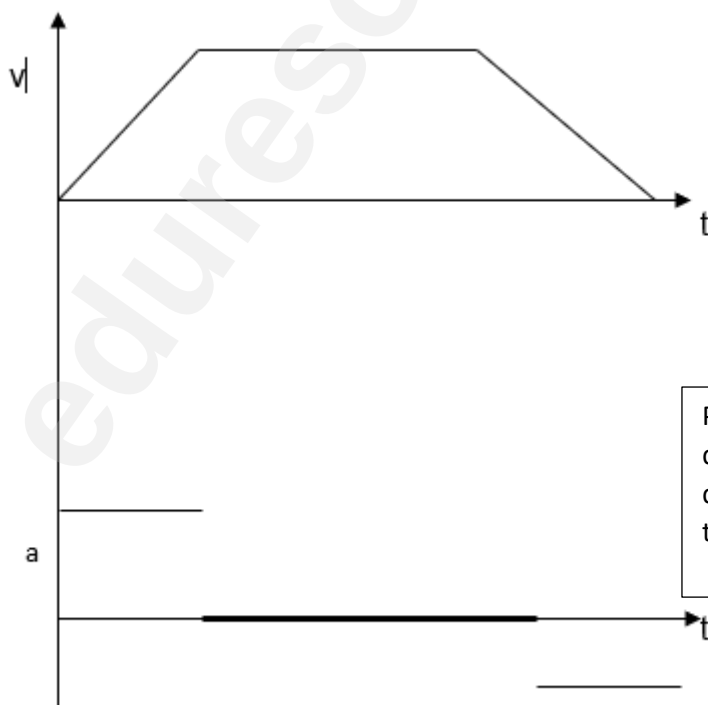
2.2.2 $v_f = v_i + at$
 $22 = 0 + a(10)$
 $a = 2,2 \text{ m.s}^{-2} \text{ west}$

2.2.3



3 different gradients, each
 Moving further away each time
 Corresponds with times on v-t

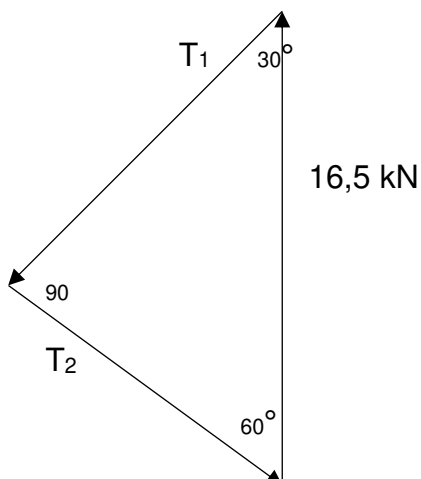
2.2.4



Position of each line –
 deceleration opposite
 direction and little less
 than acceleration

QUESTION 3

3.3 3.1.1



for 3 angles

for directions

for naming forces

$$3.1.2 \quad \sin 60^\circ = \frac{T_1}{16500} \quad \text{OR} \quad \cos 30^\circ$$

$$T_1 = 14289,42 \text{ N}$$

$$\sin 30^\circ = \frac{T_2}{16500} \quad \text{OR} \quad \cos 60^\circ \quad \text{OR Pyth}$$

$$T_2 = 8250 \text{ N}$$

$$3.2 \quad 3.2.1 \quad \cos 20^\circ = F_{\text{horizontal}} / F$$

$$F = 250 / \cos 20^\circ$$

$$= 266,04 \text{ N}$$

3.2.2 The force and distance covered must be in the same direction./F not horizontal

$$3.2.3 \quad P = \frac{F \Delta x}{t}$$

$$184,75 = \frac{266,04 \times 5000}{t} \quad t = 7200 \text{ s}$$

$$t = 2 \text{ hours}$$

$$3.2.4 \quad F_N + F_y = F_G \quad (\text{OR two forces acting upwards and one downwards})$$

$$F_N = (45)(9,8) - 250 \tan 20^\circ \quad (\text{or } 266,04 \sin 20^\circ)$$

$$= (441 - 90,99)$$

$$= 350,01 \text{ N}$$

QUESTION 4

4.1 4.1.1 $108 \times 1000 \div 3600 = 30 \text{ m.s}^{-1}$ OR $108 \div 3.6 = 30 \text{ m.s}^{-1}$

4.1.2 (a) no horizontal forces/ F_G and F_N vertical

(b) The force that the block exerts on the cab simultaneously equals the force that the cab exerts on block opposite direction

4.1.3 $v^2 = u^2 + 2as$ OR $t = \frac{v-u}{a} = \frac{0-30}{-4500} = 6,67 \times 10^{-3} \text{ s}$
 $(0)^2 = (30)^2 + 2a(0,1)$ $F\Delta t = \Delta p$
 $a = -900 / 0,2$ $F = \frac{(400)(0-30)}{6,67 \times 10^{-3}}$
 $a = -4\,500 \text{ m.s}^{-2},$ $= 1799100 \text{ N}$

$F_R = ma$
 $= (400)(-4\,500) \text{ eco}$
 $= -1\,800\,000 \text{ N}$
 $= 1\,800\,000 \text{ (or } 1,8 \times 10^6 \text{) N, against direction of motion}$

4.1.4 $v = u + at$
 $0 = 30 - 4\,500 t$
 $t = 0,0067 \text{ s } (6,70 \times 10^{-3} \text{ s})$

OR

$F\Delta t = m(v - u)$
 $-1,8 \times 10^6 t = 400(0 - 30)$
 $t = -12000 / -1,8 \times 10^6$
 $= 0,0067 \text{ s } (0,1 \text{ s for 2 d.p})$

QUESTION 5

5.1 Kinetic energy is not conserved but momentum is conserved / initial and final velocity different

5.2 5.2.1 $\Delta p = p_2 - p_1$
 $= (0,12)(-15) - (0,12)(18)$
 $= -1,8 - 2,16$
 $= -3,96 \text{ kg.m.s}^{-1}$
 $= 3,96 \text{ kg.m.s}^{-1} \text{ away from the bat}$

5.2.2 $F\Delta t = \Delta p$
 $F = \frac{-4,0}{0,14}$
 $= -28,6 \text{ N} \quad (28,57 \text{ or } 28,29 \text{ N})$

5.3 Zero work
 Force is acting vertical
 Distance covered is horizontal

5.4 5.4.1 The principle of conservation of mechanical energy: *In the absence of air resistance or any external forces, the mechanical energy of an object is constant*

5.4.2 $(E_p + E_k)_{\text{initial}} = (E_p + E_k)_{\text{final}} \quad \text{OR } v^2 = u^2 + 2as$
 $(9,8)(2) + 0 = 0 + \frac{1}{2}(3)v^2 \quad = 0 + 2(9,8)(2)$
 $58,8 = 1,5v^2 \quad v = 6,26 \text{ m.s}^{-1}$
 $v = 6,26 \text{ m.s}^{-1}$

5.4.3 $s = ut + \frac{1}{2}at^2 \quad \text{OR } \Delta x = \left(\frac{v+u}{2}\right)t$
 $8 = 6,26(2) + \frac{1}{2}a(2)^2 \quad (\text{eco } 5.4.2) \quad v = \frac{2x}{t} - u$
 $8 = 12,52 + 2a \quad = \frac{(2)(8)}{2} - 6,26$
 $a = -2,26 \text{ m.s}^{-2} \quad (-2,3 \text{ m.s}^{-1}) \quad = 1,74 \text{ m}$
 $v = u + at$
 $= 6,26 + (-2,26)(2)$
 $= 1,74 \text{ m.s}^{-1} \quad (1,7 \text{ m.s}^{-1})$

5.4.4 $W_f = E_{\text{mech bottom}} - E_{\text{mech top}}$
 $= [(3)(9,8)(-0,1) + \frac{1}{2}(3)(0)^2] - [(3)(9,8)(0) + \frac{1}{2}(3)(0,84)^2]$
 $= -2,94 - 1,06$
 $= -3,998 \text{ J}$

OR $W_R = \Delta E_k$
 $(3)(9,8)(0,1) + W_f = 0 - \frac{1}{2}(3)(0,84)^2$
 $2,94 + W_f = -1,06$
 $W_f = -3,998 \text{ J}$

5.4.5 $W_f = F_f \Delta x \cos \theta$
 $-3,998 \quad (\text{eco } 5.4.4) = F_f(0,1)(-1)$
 $F_f = 39,98 \text{ N, up}$

QUESTION 6

$$6.1 \quad Q = \frac{3 \times 10^{-9} + (-6 \times 10^{-9})}{2}$$

$$= -1,5 \times 10^{-9} \text{ C}$$

$$6.2 \quad T \text{ to } P \quad (1)$$

$$6.3 \quad 3 \times 10^{-9} - (-1,5 \times 10^{-9}) = 4,5 \times 10^{-9} \text{ C}$$

$$\text{OR} \quad -6 \times 10^{-9} - (-1,5 \times 10^{-9}) = -4,5 \times 10^{-9} \text{ C}$$

$$\text{Number of } e^- = 4,5 \times 10^{-9} / 1,6 \times 10^{-19}$$

$$= 2,81 \times 10^{10} \text{ } e^-$$

$$6.4 \quad P \quad 50 \text{ cm} \quad R \quad 100 \text{ cm} \quad T$$

$$F_{\text{ponR}} = \frac{kQ_p Q_R}{r^2}$$

$$= \frac{(9 \times 10^9)(1,5 \times 10^{-9})(3 \times 10^{-9})}{(0,5)^2} = \frac{4,05 \times 10^{-8}}{0,25}$$

$$= 1,62 \times 10^{-7} \text{ N, right}$$

$$F_{\text{T on R}} = \frac{(9 \times 10^9)(1,5 \times 10^{-9})(3 \times 10^{-9})}{(1,0)^2}$$

$$= 4,05 \times 10^{-8} \text{ N, left}$$

$$F_{\text{Net}} = 1,62 \times 10^{-7} - 4,05 \times 10^{-8} = 1,22 \times 10^{-7} \text{ , right}$$

OR (if learners did not use new charges, but used given original charges)

$$F = \frac{kqQ}{r^2} = (9 \times 10^9)(3 \times 10^{-9})(3 \times 10^{-9}) = 3,24 \times 10^{-7} \text{ N right}$$

$$(0,5)^2$$

$$F = \frac{kqQ}{r^2} = (9 \times 10^9)(6 \times 10^{-9})(3 \times 10^{-9}) = 1,62 \times 10^{-7} \text{ N right}$$

$$(1,0)^2$$

$$F_R = 3,24 \times 10^{-7} + 1,62 \times 10^{-7} = 4,86 \times 10^{-7} \text{ N right}$$

QUESTION 7

$$\begin{array}{ll} 7.1.1 & P = V I \\ & 36 = 18 I \\ & I = 2 \text{ A for X} \end{array} \quad \begin{array}{ll} P = V I \\ 18 = 6 I \\ I = 3 \text{ A for Y} \end{array}$$

$$7.1.2 \quad 18 \text{ V}$$

$$\begin{array}{l} 7.1.3 \quad V \text{ over } R_2 : 18 - 6 = 12 \text{ V} \\ \quad R_2 = V / I \\ \quad = 12 / 3 \\ \quad = 4 \Omega \end{array}$$

$$7.1.4 \quad 30 - 18 \text{ V} = 12 \text{ V}$$

$$7.1.5 \quad I = 2 + 3 = 5$$

$$\begin{aligned} R_1 &= V / I \\ &= 12 \text{ V} / 5 \\ &= 2.4 \, \Omega \end{aligned}$$

- 7.2 7.2.1 Switch closed: there is internal resistance in battery
Energy is used to move electrons inside the battery

$$7.2.2 \quad R = \frac{V}{I} = \frac{5.5}{0.5} = 11 \, \Omega$$

$$\begin{aligned} 7.2.3 \quad \text{Emf} &= I (R + r) \\ 6 &= 0.5 (11 + r) \\ 12 &= 11 + r \\ r &= 1 \, \Omega \end{aligned}$$

OR

$$\begin{aligned} \text{Emf} &= V_{\text{ext}} + V_{\text{int}} \\ 6 &= 5.5 + V_{\text{int}} \\ V_{\text{int}} &= 0.5 \text{ V} \end{aligned}$$

$$\begin{aligned} V_{\text{int}} &= I r \\ 0.5 &= 0.5 r \\ r &= 1 \, \Omega \end{aligned}$$

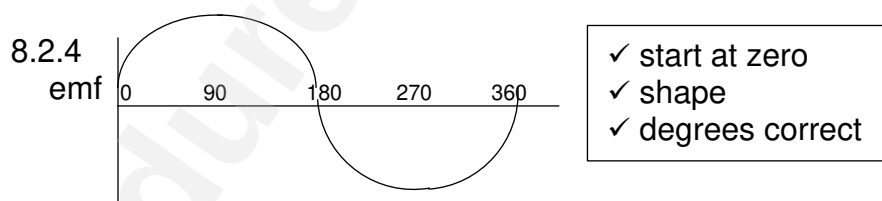
$$\begin{array}{lll} 7.2.4 \quad P = I^2 R & \text{OR} \quad P = V I & \text{OR} \quad P = V^2 / R \\ & = (0.5)^2 (11) & = (5.5)(0.5) \\ & = 2.75 \text{ W} & = 2.75 \text{ W} \\ & & = (5.5)^2 / (11) \\ & & = 2.75 \text{ W} \end{array}$$

$$\begin{aligned} 7.2.5 \quad W &= V I t \\ &= (6)(0.5) (300) \\ &= 900 \text{ J} \end{aligned}$$

- 7.2.6 Bigger resistance, thus smaller current
 V_{int} therefore smaller
 V_{ext} bigger
As emf remains the same

QUESTION 8

- 8.1 8.1.1 The induced current flows in a direction so as to set up a magnetic field to oppose the change in magnetic flux
- 8.1.2 Ammeter deviates to one side
Then deviates to other side
- 8.1.3 As magnet enters coil – change in magnetic field
Inducing emf in coil so that change is opposed
Current flows in one direction – needle to one direction
When magnet leaves coil, change cause emf (thus current) in opposite direction
- 8.1.4 Induced N-pole closest to magnet,
repelling force up, decreasing F_G
- 8.1.5 Magnet now falls at acceleration $g = 9,8 \text{ m.s}^{-2}$ right through
Still induced emf
But no current
No induced magnetic field causing opposing forces
- 8.1.6 No, there is no change in magnetic flux
- 8.2 8.2.1 Yes, a potential difference still induced
There is a change in magnetic flux through the loop, causing an emf
- 8.2.2 There will be a current flowing / the electrons will start flowing in the conductor
- 8.2.3 Farady's Law: $\text{emf} \propto \frac{\Delta\Phi}{\Delta t}$ or
Induced emf is directly proportional to the *rate of change of magnetic flux*
Faster rotation gives a bigger emf and thus a bigger current.



QUESTION 9

- 9.1 9.1.1 inelastic collision between electrons and atoms
Atom gains energy and its electrons move up to higher energy levels
Electrons fall back to ground state, releasing photons of energy as light
- 9.1.2 Lines always at the same specific wavelength (or frequency) per element and not continuous colour
- 9.2 Electromagnetic waves have wave and particle properties at the same time
Each property is dominant in certain circumstances
- 9.3 9.3.1 $hf = W + E_k$
 $(6,6 \times 10^{-34})(1,57 \times 10^{15}) = W + (2,8 \times 10^{-19}) \checkmark$
 $W = 10,36 \times 10^{-19}$ (OR $1,036 \times 10^{-18}$) – $2,8 \times 10^{-19}$
 $= 7,56 \times 10^{-19} \text{ J}$
- 9.3.2 $E_k = \frac{1}{2} mv^2$
 $2,8 \times 10^{-19} = \frac{1}{2} (9,1 \times 10^{-31}) v^2$
 $v^2 = 6,154 \times 10^{11}$
 $v = 784\,464,54$ ($7,844 \times 10^5$) m.s^{-1}
- 9.3.3 $W = hf_0$
 $f_0 = 7,56 \times 10^{-19} / 6,6 \times 10^{-34}$
 $= 1,15 \times 10^{15} \text{ Hz (or s}^{-1}\text{)}$
- 9.3.4 (a) The amount of photons doubled
And double the amount of e^- can therefore absorb energy
 (b) No
 (c) e^- have insufficient energy to leave the new metal
the work function is greater

Total: 200 marks