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Marking Guidelines

QUESTION 1

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

(10 x 2) [20]

QUESTION 2

2.1.1 Acceleration is the rate of change ✓ of velocity ✓ (2)

2.1.2 Train A ✓ (1)

2.1.3 $a = \text{gradient} \checkmark = \frac{\Delta v}{\Delta t} = \frac{28-0 \checkmark}{960-840 \checkmark} = 0,23 \text{ m} \cdot \text{s}^{-2} \text{ south} \checkmark (\text{mag+dir})$ (4)

OR $a = \frac{v_f - v_i}{\Delta t} \checkmark = \frac{28-0 \checkmark}{120 \checkmark} = 0,23 \text{ m} \cdot \text{s}^{-2} \text{ south} \checkmark (\text{mag+dir})$

2.1.4 $\text{distance between} = \text{area}_A - \text{area}_B \checkmark$ (area statement or equations of motion for both or separately)

$$\text{distance between} = \frac{1}{2}(600)(28) \checkmark - \left(\frac{1}{2}(120)(16) \checkmark + (16)(480) \checkmark \right)$$

$$\text{distance between} = 8400 - (960 + 7680)$$

Therefore, Train B ✓ coe is ahead by 240 m ✓ (6)

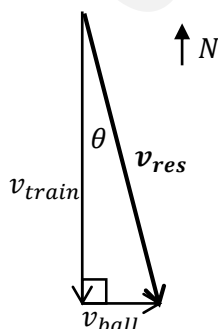
2.1.5 $P_{\text{engine}} = F_{\text{engine}} v \checkmark \quad 2\,000\,000 \checkmark = F_{\text{engine}}(16) \checkmark \quad F_{\text{engine}} = 125\,000 \text{ N}$
at constant velocity: $F_{\text{engine}} = F_{\text{friction}} = 125\,000 \text{ N} \checkmark$ (4)

2.1.6 $v_f^2 = v_i^2 + 2a\Delta x \checkmark$
 $0 = 16^2 + 2(-0,05)\Delta x \quad \checkmark 0 \text{ and } 16 \text{ in correct places} \quad \checkmark \text{sign must be correct}$
 $\Delta x = 2560 \text{ m} \checkmark$ (4)

2.2.1 $\bar{v} = \frac{\Delta x}{\Delta t} \checkmark = \frac{2,8}{2,5} \checkmark = 1,12 \text{ m} \cdot \text{s}^{-1} \checkmark$ (3)

2.2.2 Resultant vector is the single vector which has the same effect ✓ as the original vectors acting together ✓. (2)

2.2.3 $v_{\text{res}} = \sqrt{16^2 + 1,12^2} \checkmark = 16,04 \text{ m} \cdot \text{s}^{-1} \checkmark$



$$\tan \theta = \frac{1,12}{16} \checkmark$$

$$\theta = 4^\circ \text{ east of south} \checkmark (\text{or bearing of } 176^\circ)$$

✓ all vector labels ✓ correct orientation of v_{res} and v_{train} (6)

2.2.4 C ✓✓ (2)

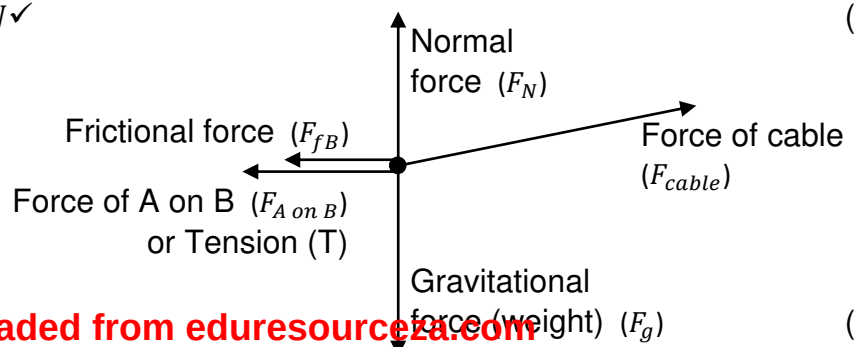
QUESTION 3

- 3.1 Displacement is a change in position ✓ (1)
- 3.2 up ✓ is positive (1)
- 3.3 $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2 \checkmark = 0 + \frac{1}{2} (-9,8 \checkmark) (0,85 \checkmark)^2 = -3,54 \text{ m}$
Height = 3,54 m ✓ (4)
- 3.4 $v_f = v_i + a \Delta t \checkmark = 0 \checkmark + (-9,8)(0,85) \checkmark = -8,33 \text{ m.s}^{-1} \therefore 8,33 \text{ m.s}^{-1} \checkmark$ (4)
- 3.5 Impulse is the product of the net force ✓ and the contact time ✓. (-1 if product not mentioned) (2)
- 3.6 $J = \Delta p \checkmark = m v_f - m v_i$
 $0,61 = 0,058 v_f - 0,058 (-8,33) \checkmark \checkmark \text{subs} + \text{coe}$
 $v_f = 2,19 \text{ m.s}^{-1} \checkmark$ (4)
- 3.7 $v_f = v_i + a \Delta t$ (no mark for equation here)
 $0 = 2,19 + (-9,8) \Delta t \checkmark \checkmark \text{subs} + \text{coe}$
 $\Delta t = 0,22 \text{ s} \checkmark \therefore t_x = 0,86 + 0,22 = 1,08 \text{ s} \checkmark$ (4)
- 3.8 $J = F_{net} \Delta t = (F_{floor} - F_g) \Delta t \checkmark$ equ or separate equations
 $0,61 \checkmark = (F_{floor} - (0,058)(9,8) \checkmark) (0,01 \checkmark)$
 $F_{floor} = 61,57 \text{ N up} \checkmark$ including direction (5)

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QUESTION 4

- 4.1 Normal force is the perpendicular force exerted by a surface ✓ on an object in contact with it ✓. (2)
- 4.2 There is an upward force on B – the vertical component of the force applied by the cable at an angle ✓
Thus the normal force is reduced ✓
Thus according to $F_{fk} = \mu_k F_N$ when F_N decreases, so does F_{fk} (directly proportional) – when μ_k is constant which it is. ✓ use of formula for linking friction to normal (3)
- 4.3 For Crate A: $F_{fk} = \mu_k F_N$ and $F_N = F_g = mg$
 $607,6 \checkmark = \mu_k (100)(9,8) \checkmark$
 $\mu_k = 0,62 \checkmark$ (3)
- 4.4 For Crate B: $F_N = F_g - F_y = F_g - F_{cable} \sin \theta$
 $F_N = 980 \checkmark - (1300 \sin 7^\circ \checkmark) = 821,57 \text{ N}$
 $F_{fk} = \mu_k F_N$
 $F_{fk} = (0,62 \checkmark) (821,57)$
 $F_{fkB} = 509,37 \text{ N} \checkmark$ (4)
- 4.5 Key needed if symbols used
(-1 if not named properly)
✓ for each force named correctly and placed correctly



4.6 Solve for a using full system: $F_{net} = F_{x(cable)} - F_{fA} - F_{fB} = m_{total}a$
 $1300\checkmark\cos7^\circ\checkmark - 509,37 - 607,6 = 200a\checkmark\checkmark$ rest of subs – 1 per error (signs are critical)
 $a = 0,87\text{ m}\cdot\text{s}^{-2}\checkmark$ $\hookrightarrow$ coe for friction of B (5)

4.7 For Crate A: $F_{net} = ma$
 $T - F_{fA} = m_A a$ $(T - 607,6)\checkmark$ NB signs = $100(0,87)\checkmark$ $T = 694,6N\checkmark$
 Or use equation for crate B instead (3)

4.6 & 4.7 Alternative: Use simultaneous equations with crate A and B:

Crate A: $F_{net} = ma$

$T - F_{fA} = m_A a$ $T - 607,6 = 100a\checkmark\checkmark$ subs and signs

Crate B: $F_{net} = ma$

$F_{cable\ x} - F_{fB} - T = m_B a$

$1300\cos7^\circ - 509,37 - T = 100a\checkmark\checkmark\checkmark$ subs (signs are NB and coe for friction of B)

Equate in some way $\checkmark$

$a = 0,87\text{ m}\cdot\text{s}^{-2}\checkmark$ $T = 694,27N\checkmark$ (8)

4.8 $W = F_{x(cable)}\Delta x\checkmark$
 $W = (1300\cos7^\circ)(8)\checkmark$
 $W = 10322,48\text{ J}\checkmark$ (3)

QUESTION 5

5.1 The principle of conservation of mechanical energy: In the absence of air resistance or any external forces $\checkmark$, the mechanical energy of an object is constant $\checkmark$ (2)

5.2 $E_{mech\ top} = E_{mech\ bottom} \therefore E_{p\ top} = E_{k\ bottom} \therefore mgh_{top} = \frac{1}{2}mv_{bottom}^2\checkmark$
 $(9,8)(1) = \frac{1}{2}v^2\checkmark$ $v = 4,43\text{ m}\cdot\text{s}^{-1}\checkmark$ (3)

5.3 The forces are equal $\checkmark$ and opposite in direction $\checkmark$ - Newton's third law $\checkmark$ (3)

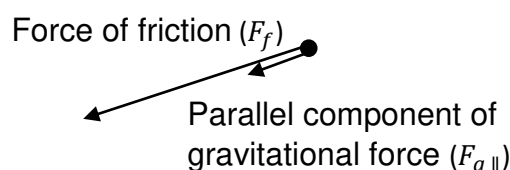
5.4 The law of conservation of linear momentum: The total (linear) momentum of an isolated system $\checkmark$ remains constant (is conserved) $\checkmark$ (the rest) (2)

5.5 $p_{before} = p_{after}\checkmark$
 $m_p v_{ip} + m_b v_{ib} = m_p v_{fp} + m_b v_{fb}$
 $(1)(4,43) + 0 = (1)(0,8) + (0,5)v_{fb}\checkmark\checkmark$ subs (coe 4,43)
 $v_{fb} = 7,25\text{ m}\cdot\text{s}^{-1}\checkmark$ (4)

5.6 The work-energy theorem states that the work done by a net force on an object $\checkmark$ is equal to the change in the kinetic energy of the object $\checkmark$ (2)

5.7 $\checkmark$ for each force

No penalty if names not used as long as forces are distinctly labelled with symbols.



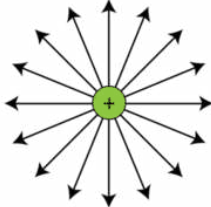
(2)

5.8 $(F_f + mg \sin \theta) \Delta x = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$ ✓ formula (or can use 3 separate formulae in steps)
 $(F_f + (0,5)(9,8)(\sin 11^\circ))(2,1) = 0 - \frac{1}{2} (0,5)(7,25^2)$ ✓✓✓✓ (-1 per error or omission)
 $2,1 F_f + 1,96 = -13,14$
 $F_f = -7,19 \text{ N}$ ✓ thus magnitude of $F_f = 7,19 \text{ N}$ (or $7,2 \text{ N}$ if carry all decimals) (6)

[24]

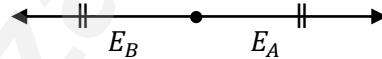
QUESTION 6

6.1.1 ✓ radial field ✓ arrows away from positive charge (2)



6.1.2 positive ✓ (1)

6.1.3 ✓ E labels used (not F)
 ✓ directions of fields for A and B correct
 ✓ equal in magnitude (3)



6.1.4 Coulomb's law states that the attractive or repulsive force between two point charges (OR two point charges in free space or air exert forces on each other.) -1 if incorrect or missing
 (The force) is directly proportional to the product of the charges ✓ and inversely proportional to the square of the distance between the charges ✓. (3)

6.1.5 $F_{A \text{ on } q} = F_{B \text{ on } q}$ ✓ (or implied = values)

$$\frac{k Q_A \cdot q}{r_A^2} = \frac{k Q_B \cdot q}{r_B^2} \quad \checkmark$$

$$\frac{60 \times 10^{-6}}{\left(\frac{1}{3} r_B\right)^2} = \frac{Q_B}{r_B^2} \quad \checkmark \checkmark$$

$$Q_B = 5,4 \times 10^{-4} \text{ C} \quad \checkmark \quad (5)$$

6.2 $F_{\text{electrostatic}} = F_{\text{gravitational}}$

$$\frac{k Q_1 \cdot Q_2}{r^2} = \frac{G m^2}{r^2} \quad \checkmark \text{ or separate formulae in step calculation}$$

$$(9 \times 10^9)(1,1 \times 10^{-11})(1,69 \times 10^{-10}) = (6,7 \times 10^{-11}) m^2 \quad \checkmark \checkmark$$

$$m = 0,499 \text{ kg} = 0,5 \text{ kg} \quad \checkmark \quad (4)$$

[18]

QUESTION 7

$$7.1 \quad V_{ext} = IR_{ext} \checkmark \quad V_1 = 0,0198(300) \checkmark \quad V_1 = 5,94 \text{ V} \checkmark \quad (3)$$

$$7.2 \quad V_{lost} = emf - V_1 = Ir$$

$$6 - 5,94 = 0,0198r \checkmark \checkmark \text{subs+coe}$$

$$r = 3,03 \Omega \checkmark \quad \therefore r_{cell} = 0,76 \Omega \checkmark \text{method of } \div \text{ by } 4$$

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

$$6 = 0,0198(300 + r) \checkmark \checkmark \text{subs + coe}$$

$$r = 3,03 \Omega \checkmark \quad \therefore r_{cell} = 0,76 \Omega \checkmark \text{method of } \div \text{ by } 4 \quad (4)$$

$$7.3 \quad W = \frac{V^2 t}{R} \checkmark = \frac{3,4^2 (10)}{170} \checkmark \checkmark \text{subs} = 0,68 \text{ J} \checkmark \quad \text{or alt calc} \quad (4)$$

$$7.4.1 \quad \text{potential difference} \checkmark \text{ of the cells/circuit } \checkmark \text{ (number of cells } \checkmark \text{ max 1)} \quad (2)$$

$$7.4.2 \quad \text{current in the circuit } \checkmark \quad -1 \text{ if variables are correct but swapped} \quad (1)$$

$$7.5 \quad \text{directly proportional } \checkmark \quad (1)$$

$$7.6 \quad \text{temperature (of the circuit)/duration circuit connected for to ensure T constant } \checkmark \quad (1)$$

$$7.7 \quad \frac{1}{R_{\parallel}} = \frac{1}{R_{series}} + \frac{1}{R_{buzzer}} \checkmark$$

$$\frac{1}{R_{\parallel}} = \frac{1}{(130 + 170)} + \frac{1}{75} \quad \checkmark$$

$$R_{\parallel} = 60 \Omega$$

$$emf = I(R + r) \checkmark$$

$$6 = I(60 + (0,15 \times 4)) \checkmark \checkmark \text{subs}$$

$$I = 0,099 \text{ A} \checkmark \quad (6)$$

$$7.8 \quad \frac{R_{top}}{R_{bottom}} = \frac{300}{75} \therefore \frac{I_{top}}{I_{bottom}} = \frac{75}{300} \text{ or } 75:300 \text{ or } \frac{1}{4} \text{ or } 1:4 \text{ or } 0,2:0,8 \text{ or } 0,0198:0,0792 \checkmark \checkmark \quad (2)$$

$$7.9 \quad P = emf \cdot I \checkmark = 6 \checkmark (0,099 \checkmark \text{coe}) = 0,59 \text{ W} \checkmark \quad (4)$$

$$7.10 \quad \text{Circuit resistance increases} \checkmark, \text{ current decreases} \checkmark$$

$$V_1 = emf - Ir \checkmark \text{equation use (any link between I and r and emf)}$$

$$\text{thus voltmeter reading increases} \checkmark \quad (4)$$

QUESTION 8

8.1.1 From $N \rightarrow S$ ✓; straight and parallel to each other (internal space between poles) ✓ (2)

8.1.2 $X \rightarrow Y$ ✓ (1)

8.1.3

- Close switch and read/measure the current (I) ✓ on the ammeter (which can be adjusted with the variable resistor, so that more than one test can be done – not assessed).
- Balance the wire by adding mass pieces/weights to the insulating bar in order to restore balance and make the wire XY move back up in to its original horizontal position. ✓
- Use $F_g = mg$ ✓ because when balanced, $F_{EM} = F_g$
- Use $F = IB\ell \sin\theta$ to solve for B ✓
- when $\theta = 90^\circ$ and $\ell = 15\text{cm}$ ($1/2$ ✓ each) (5)

8.2.1 Faraday's law of electromagnetic induction: the emf induced is directly proportional to the rate ✓ of change of magnetic flux ✓ (flux linkage) (2)

8.2.2 (a) position (b) ✓ and (e) ✓ (-1 per additional position beyond two given answers to a minimum of zero) (2)

(b) (b) anti-clockwise ✓
(e) clockwise ✓ (2)

(c) Lenz's Law ✓ (1)

8.2.3 at (b) there is an emf because:

- $emf = -N \frac{\Delta\phi}{\Delta t}$
- $\Delta area \propto \Delta\phi$ ✓ (because $\phi = BA \cos\theta$) link to flux/change in flux
- Thus if $\Delta area$ happens over time: $\frac{\Delta\phi}{\Delta t}$ ✓ there is a rate of change of flux and hence an emf is induced. (3)

8.2.4 (e) ✓ (1)

[19]