



eduresourceza.com



Examiner: Mrs M Lubbe

Time 3 hours

Moderators: Mrs L van Zyl

Total: 200

NAME: MEMORANDUM**TEACHER:** _____**PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY**

1. This question paper consists of 32 pages and a separate Data Sheet of 2 pages (i–ii). Please check that your question paper is complete.
2. Read the questions carefully.
3. Answer ALL the questions on the question paper and hand it in at the end of the examination.
4. Use the data and formulae whenever necessary.
5. Show your working in all calculations.
6. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
7. Answers must be expressed in decimal format, not left as proper fractions.
8. Where appropriate, express answers to TWO decimal places.
9. It is in your own interest to write legibly and to present your work neatly.
10. THREE blank pages (pages 30 to 32) are included at the end of the paper. If you run out of space for a question, use these pages. Clearly indicate the question number of your answer should you use this extra space.

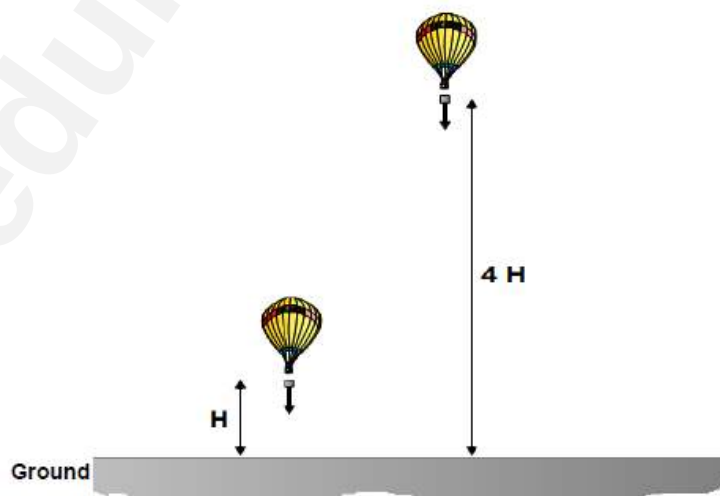
Answer these questions on the multiple-choice answer sheet below. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

A	B	~~C~~	D
---	---	--------------	---

Here the option C has been marked as an example.

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

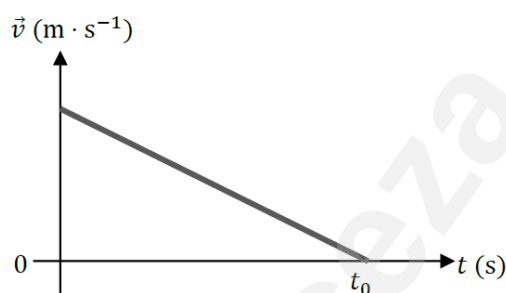
- 1.1 A package is dropped from a hot air balloon from two different heights. In the first instance the height of the balloon from the ground is H and it takes t seconds for the package to reach the ground. In the second instance the package is dropped from a height of $4H$.



The time for the package, dropped from the height of $4H$, to reach the ground compared to the time t of the package dropped from H is:

- A t
- B $2t$
- C $4t$
- D $16t$

1.2 The following velocity-time graph represents the motion of an object moving vertically through the air near the Earth's surface.



Use the graph to identify the positive direction of motion as well as the significance of time t_0 .

	Positive direction	At time t_0 the object...
A	up	... hits the ground
B	down	... hits the ground
C	up	... reaches a maximum height
D	down	... reaches a maximum height

1.3 A ball is rolled up a smooth, inclined plane. The ball stops briefly at some point on its way up and rolls back to the point where it was first released.

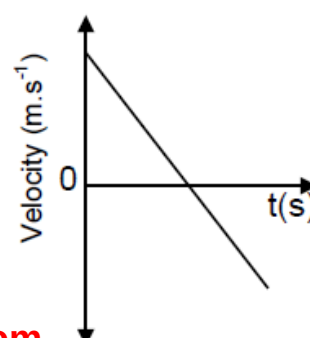
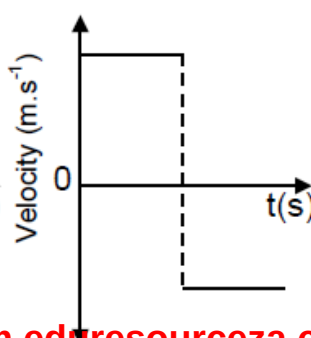
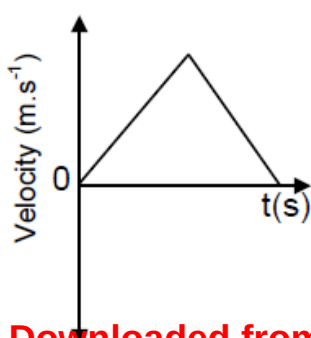
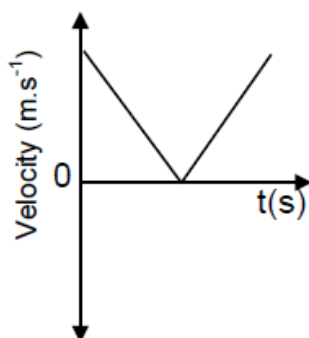
Which one of the following velocity-time graphs best shows the motion of the ball?

A

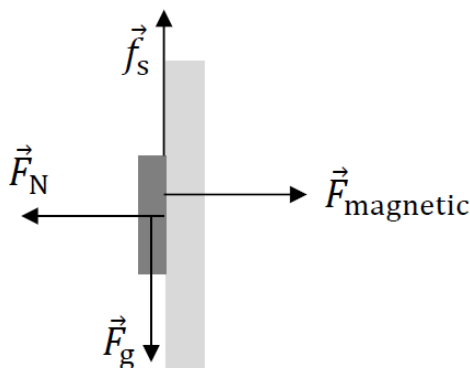
B

C

D



- 1.4 A magnet is stuck on a fridge. The following force diagram shows all four forces acting on the magnet.



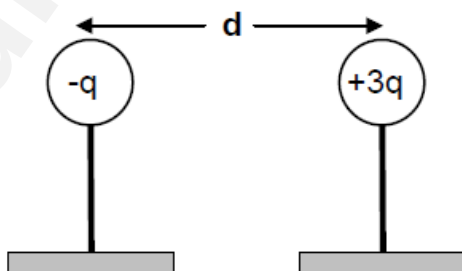
Consider the following two pairs of forces:

- (i) the normal force and the force of magnetic attraction
- (ii) the gravitational force and the static frictional force

Which of the above pair(s) make up a Newton's third law action-reaction pair of forces?

- A (i) only
- B (ii) only
- C both (i) and (ii)
- D neither (i) nor (ii)

- 1.5 Two small identical metal spheres, on insulated stands, carry charges $-q$ and $+3q$ respectively. When the centres of the spheres are a distance d apart, the spheres exert an electrostatic force of magnitude F on each other.



The spheres are now made to touch and are brought back to the same positions as before. The magnitude of the electrostatic force which the spheres now exert on each other, in terms of F , is:

- A. $\frac{4}{3} F$
- B. $\frac{1}{3} F$
- C. $\frac{1}{2} F$
- D. $3 F$

1.6 In the diagram below, Q is a negatively charged object.

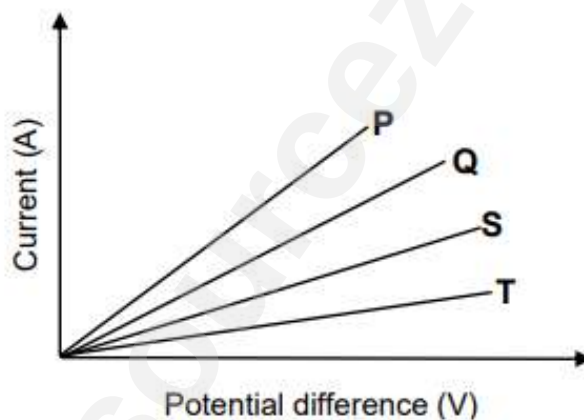


X

The direction of the electric field line at Point X is:

- A to the left
- B up
- C to the right
- D down

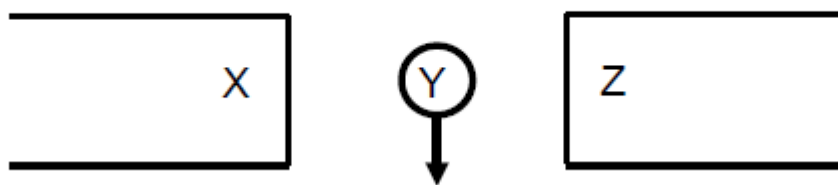
1.7 The current versus potential difference graphs below were obtained for four resistors P, Q, S and T.



The resistor with the second largest resistance is:

- A P
- B Q
- C S
- D T

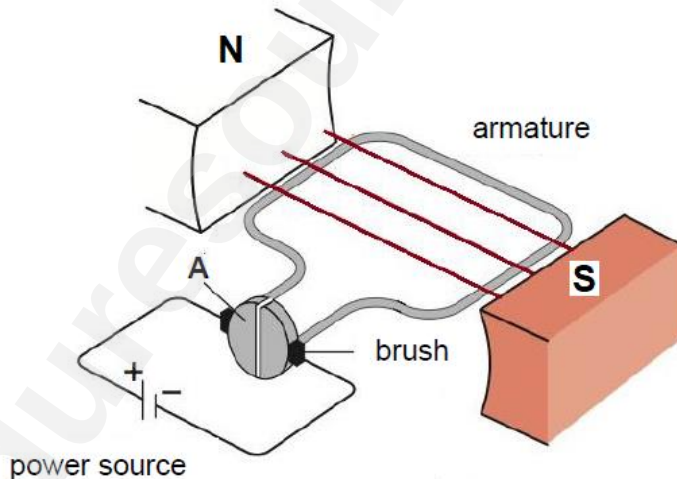
- 1.8 An experiment was carried out to study the effect of a magnetic field on a current carrying conductor Y, placed within a magnetic field. X and Z are poles of magnets.



When a current flows through Y, the conductor moves downwards as shown by the arrow. Which one of the following combinations, regarding the polarities of the magnets and the direction of the current is correct?

	Polarity X	Polarity Z	Current direction in Y
A	South	South	Out of the page
B	North	North	Into the page
C	North	South	Out of the page
D	North	South	Into the page

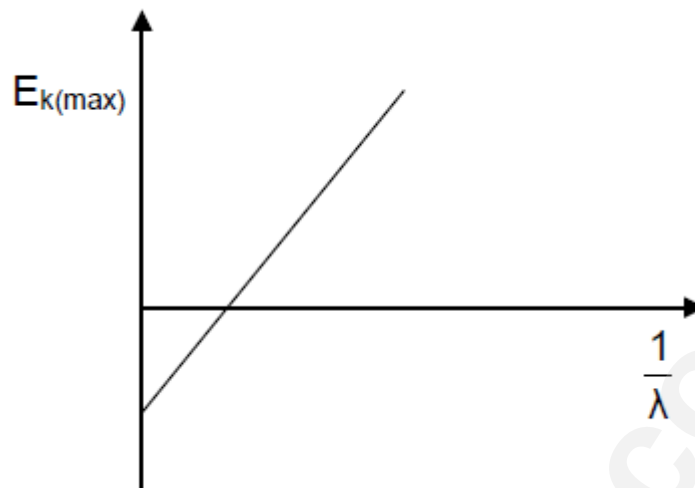
- 1.9 The sketch below represents a DC motor, where the magnetic field lines from the permanent magnet are shown and the polarity of the power source is given.



Choose the correct label for part A and the correct rotation direction of the armature.

	Label – part A	Rotation direction of the armature
A	split ring commutator	clockwise
B	slip ring	clockwise
C	slip ring	anticlockwise
D	split ring commutator	anticlockwise

1.10 The graph below is obtained from an experiment on the photoelectric effect.



Which ONE of the following represents the gradient of the graph?

- A hc
- B h
- C $\frac{E_{k(max)}}{\lambda}$
- D W_o

[20]

QUESTION 2

KINEMATICS

2.1 A car travelling with a speed v_i , accelerates for four seconds at a constant rate. Over the four seconds it travels 104m. It covered 58m in the last two seconds.

2.1.1 Write down the distance the car travels in the first two seconds of the journey. (1)

$$104 - 58 = 46\text{m} \checkmark$$

2.1.2 Write mathematical expressions (in terms of initial velocity and acceleration) for:

i) the displacement of the car during the first two seconds of its journey. (2)

$$46 \checkmark = 2v_i + \frac{1}{2}a(2)^2 \checkmark$$

$$46 = 2v_i + 2a$$

ii) the displacement of the car during the full four second journey. (2)

$$104 \checkmark = 4v_i + \frac{1}{2}a(4)^2 \checkmark$$

$$104 = 4v_i + 8a$$

2.1.3 Hence, calculate the

i) magnitude of the acceleration of the car (3)

$$104 = 4v_i + 8a$$

$$- \quad 46 = 2v_i + 2a \quad (\times 2) \quad \checkmark \checkmark \text{ (simultaneous eqns)}$$

$$12 = 4a \quad \therefore a = 3 \text{ m.s}^{-2} \checkmark$$

ii) the initial speed of the car before it started accelerating (2)

Sub $a = 3$ into either equation above: $\checkmark$

$$v_i = 20 \text{ m.s}^{-1} \checkmark$$

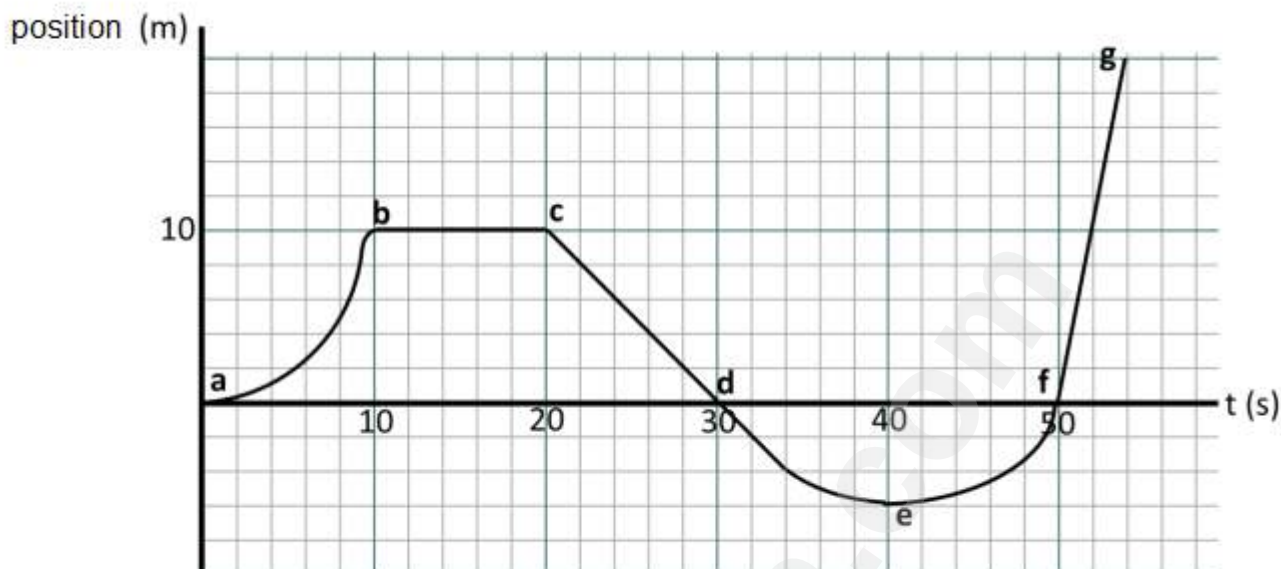
iii) the final speed of the car at the end of the 4 second acceleration. (3)

$$v_f = v_i + a\Delta t \quad \checkmark \quad \text{(other eqns of motion accepted)}$$

$$= 20 + 3(4) \checkmark$$

$$= 32 \text{ m.s}^{-1} \checkmark$$

- 2.2 A tortoise takes off from a stationary position and travels East along a straight path. The position-time graph shows the tortoise's position for the first 54 seconds of this journey.



- 2.2.1 Over what interval(s) is the tortoise stationary? Use the letters provided. (1)

bc ✓

- 2.2.2 Identify **two** instances when the tortoise changed direction. Use the letters provided. (1)

c and e ✓ (both)

- 2.2.3 Over which interval is the magnitude of the tortoise's velocity the greatest? (1)

fg ✓

- 2.2.4 What is the tortoise's velocity over the interval c-d? (3)

$$v = \Delta s / \Delta t$$

$$= -10 / 10 \quad \checkmark$$

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

$$\therefore v = 1 \text{ m.s}^{-1} \quad \checkmark \text{ west / backwards } \checkmark$$

- 2.2.5 Define distance. (2)

the length of path travelled ✓✓

2.2.6 Calculate the average speed of the tortoise over the 54 seconds?

(4)

$$\text{distance} = 10 + 10 + 6 + 6 + 20 = 52 \text{ m} \checkmark$$

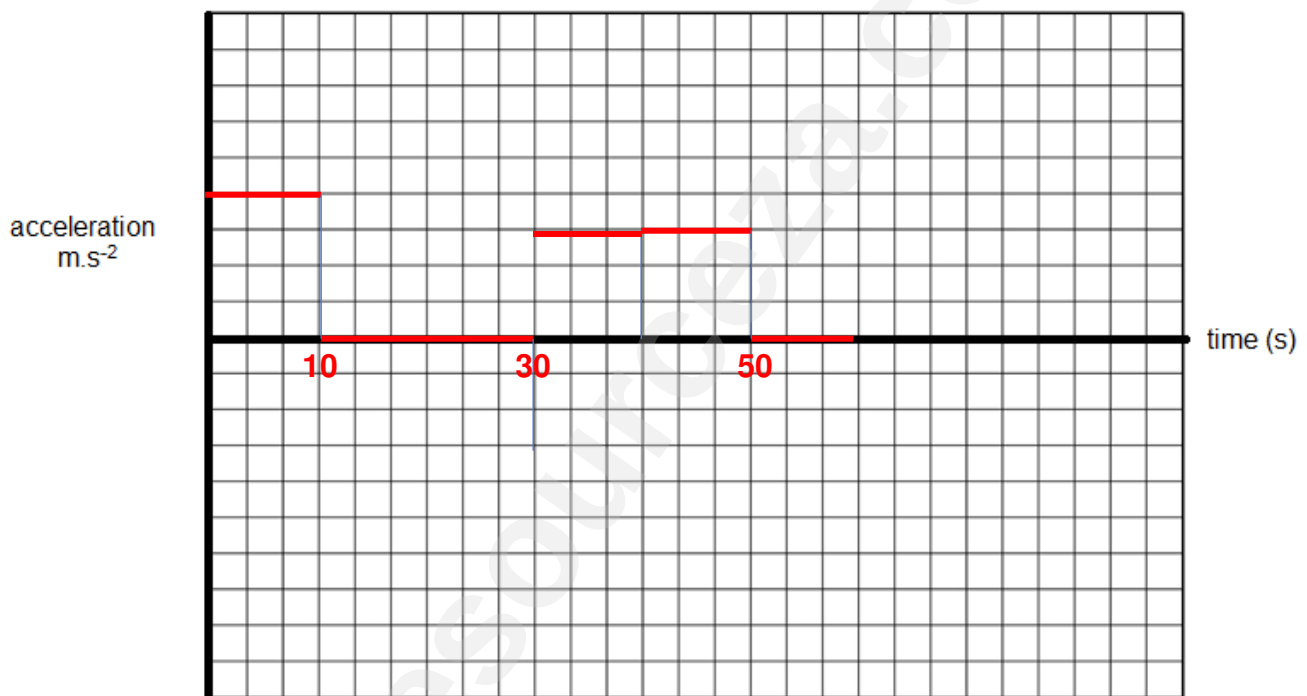
$$v = \Delta x / \Delta t \checkmark$$

$$= 52 / 54 \checkmark$$

$$= 0,96 \text{ m.s}^{-1} \checkmark$$

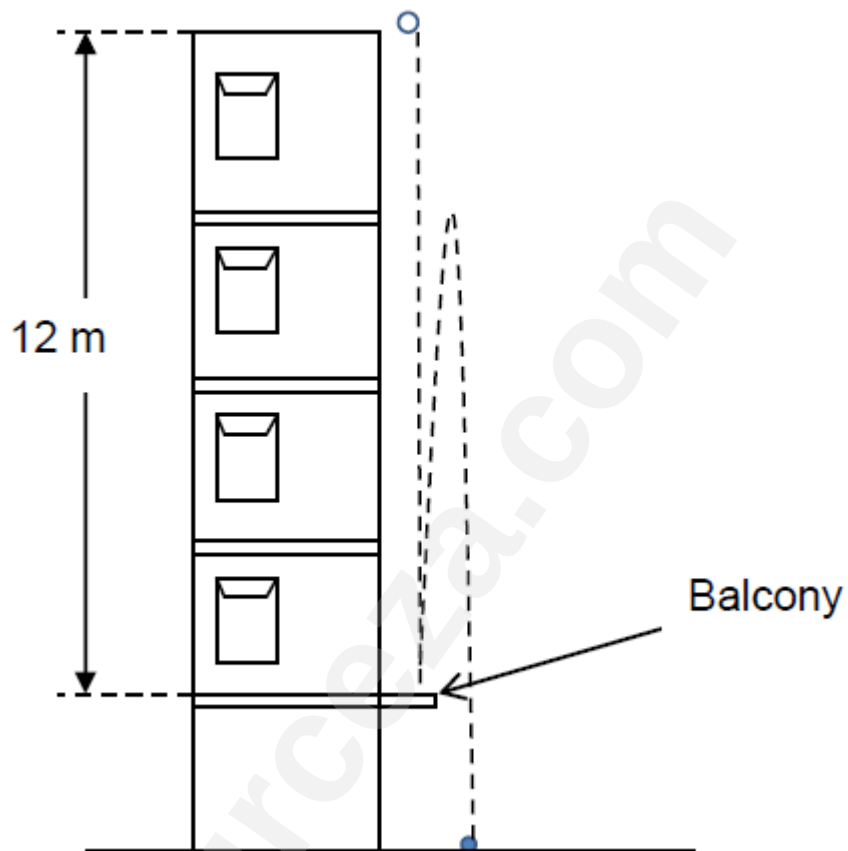
2.2.7 On the axis below, draw an acceleration-time graph for the tortoise. Include ONLY time values on your graph.

(4)



(The second line should go to 34s, but accept 30s)

- 2.3 A 120 g tennis ball is dropped from the top of a building. It bounces off a balcony 12 m below and finally falls to the ground. The diagram below shows the flight of the ball. Ignore all effects of friction as well as any horizontal motion of the ball.



- 2.3.1 Use equations of motion to calculate the speed with which the tennis ball strikes the balcony. (3)

$$\begin{aligned}v_f^2 &= v_i^2 + 2a\Delta y \quad \checkmark \\v_f &= \sqrt{0 + 2(9,8)(12)} \quad \checkmark \\&= 15,34 \text{ m.s}^{-1} \quad \checkmark\end{aligned}$$

- 2.3.2 The energy transformed to other forms when the ball strikes the balcony is 2 J.

Calculate:

- a) The kinetic energy just before the bounce (2)

Energy that the ball has at bouncing:

$$\begin{aligned}E_k &= \frac{1}{2}mv^2 - 0 \\&= 0,5 \times 0,12 \times 15,34^2 \quad \checkmark = 14,12 \text{ J} \quad \checkmark\end{aligned}$$

b) How high the ball rises above the balcony after the bounce (3)

Energy ball has **after** bounce = $14,12 - 2 = 12,12 \text{ J}$ ✓

$E_p = mgh = 12,12 \text{ J}$ (Mechanical energy conserved)

$$12,12 = (0,12) (9,8) h \quad \checkmark$$

$$\therefore h = 10,31 \text{ m} \quad \checkmark$$

OR

$$\begin{aligned} \text{initial velocity after bounce: } E_k &= \frac{1}{2} m v_i^2 \\ 12,12 \quad \checkmark &= 0,5 (0,12) v_i^2 \quad \checkmark \\ v_i &= 14,21 \text{ m.s}^{-1} \text{ (up)} \end{aligned}$$

$$\text{Max height: } v_f^2 = v_i^2 + 2a\Delta y \quad \checkmark$$

$$\text{down = negative} \quad 0 = 14,21^2 + 2 (-9,8) y \quad \checkmark$$

$$y = 10,3 \text{ m} \quad \checkmark$$

(If **up = negative** then $v_i = -14,21 \text{ m.s}^{-1}$ and $g = 9,8 \text{ m.s}^{-2}$. y will be a negative)

2.3.3 The ball finally strikes the ground 3,16 s after the bounce. Calculate the height of the balcony. (5)

$$\begin{aligned} \text{initial velocity after bounce: } E_k &= \frac{1}{2} m v_i^2 \\ 12,12 \quad \checkmark &= 0,5 (0,12) v_i^2 \quad \checkmark \\ v_i &= 14,21 \text{ m.s}^{-1} \text{ (up)} \end{aligned}$$

$$\begin{aligned} \text{Down = negative } \Delta y &= v_i \Delta t + \frac{1}{2} a \Delta t^2 \quad \checkmark \\ &= 14,21 (3,16) + (0,5) (-9,8) (3,16)^2 \quad \checkmark \\ &= -4,03 \text{ m} \end{aligned}$$

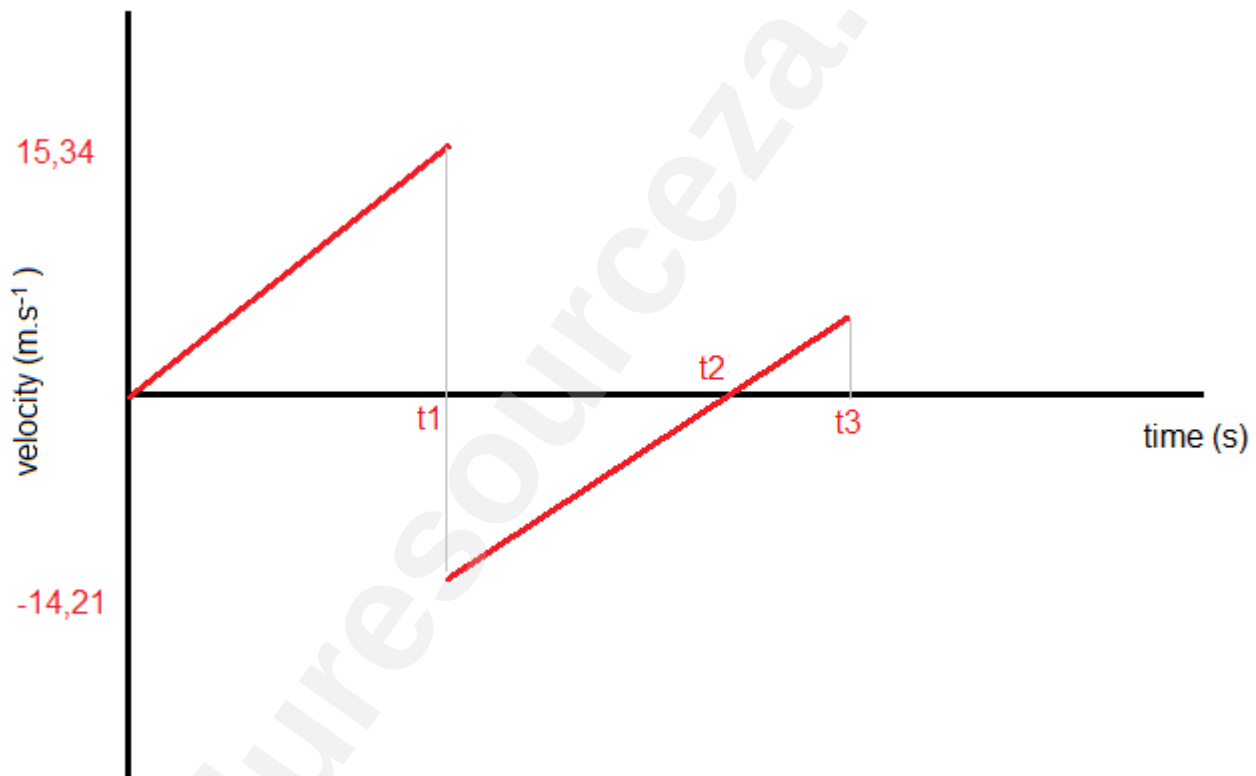
$$\therefore h = 4,03 \text{ m} \quad \checkmark$$

(For Up = negative, v_i = negative and g = positive. Y is then positive)

2.3.4 On the axis provided, sketch the velocity versus time graph of the ball's entire flight.

Show the following points on your sketch:

- Velocity with which the ball hits the balcony
 - Time of flight of the ball to reach the balcony (Mark as t_1 only.)
 - Velocity with which the ball leaves the balcony
 - Time the ball reaches maximum height after bouncing off the balcony (Mark as t_2 only.)
 - Total time of flight of the ball (Mark as t_3 only.)
- (4)



[46]

QUESTION 3

NEWTON'S LAWS

- 3.1 A farmer has two boxes of seeds that are to be planted. One box is 5kg and the other is 2kg, as shown in the diagram below. He places the two boxes on the ground so that they are in contact with each other and he pushes on the 5 kg box with a force labelled F that acts at an angle of 30° to the horizontal. While moving, each box experiences a kinetic friction force of 1,8 N.



The system accelerates at $1,2 \text{ m} \cdot \text{s}^{-2}$ to the left.

- 3.1.1 Write an expression for the horizontal component of F . (1)

$$F_x = F \cos 30^\circ \checkmark$$

- 3.1.2 Define the term net (or resultant) force. (2)

The net force is the single force $\checkmark$ that has the same effect as the original forces acting together. $\checkmark$

- 3.1.3 Write an expression for the net force in terms of the horizontal forces acting on the 5 kg box. (2)

$$F_{\text{net}} = F \cos 30^\circ - F_{\text{(due to 2kg)}} - F_f \checkmark \checkmark$$

- 3.1.4 Write an expression for the net force in terms of the horizontal forces acting on the 2 kg box. (2)

$$F_{\text{net}} = F_{\text{(due to 5kg)}} - F_f \checkmark \checkmark$$

3.1.5 Hence, calculate the magnitude of the force F that causes the acceleration of the system. (5)

$$2\text{kg: } F_{\text{net}} = m a \checkmark$$

$$2 (1,2) = F_{\text{due to 5kg}} - 1,8 \checkmark$$

$$\therefore F_{\text{due to 5kg}} = 4,2 \text{ N left} = F_{\text{due to 2kg}}$$

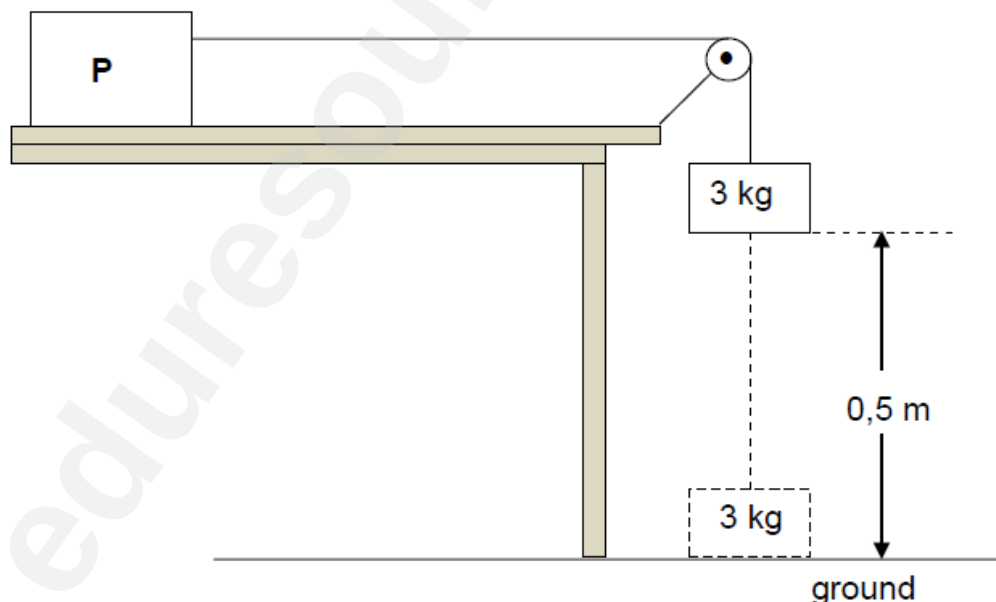
$$5\text{kg: } 5 (1,2) \checkmark = F \cos 30^\circ - 1,8 - F_{\text{due to 2kg}} \checkmark$$

$$6 = F \cos 30^\circ - 1,8 - 4,2$$

$$\therefore F = 13,86 \text{ N} \checkmark$$

3.2 Block P, of unknown mass, is placed on a rough horizontal surface. It is connected to a second block of mass 3 kg, by a light inextensible string passing over a light, frictionless pulley, as shown below.

Initially the system of masses is held stationary with the 3 kg block, 0,5 m above the ground. When the system is released the 3 kg block moves vertically downwards and strikes the ground after 3 s. Ignore the effects of air resistance.



3.2.1 Define the term acceleration in words. (2)

the rate of change of velocity

3.2.2 Calculate the **magnitude** of the:

- i) Acceleration of the 3 kg block using equations of motion (3)

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$0,5 \checkmark = (0)(3) + (0,5) a (3^2) \checkmark$$

$$a = 0,11 \text{ m.s}^{-2} \checkmark$$

- ii) Tension in the string while the system is accelerating. (3)

For the 3 kg mass

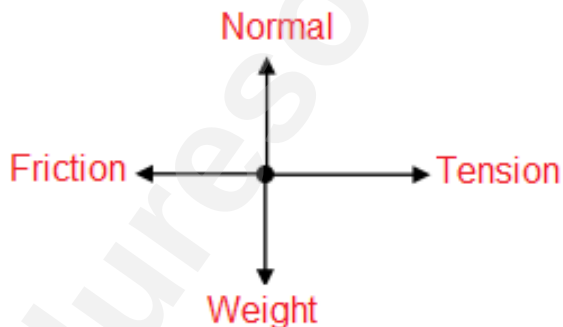
$$F_{\text{net}} = ma$$

$$(mg - T) = ma \checkmark$$

$$(3)(9,8) - T = (3)(0,11) \checkmark$$

$$T = 29,07 \text{ N} \checkmark$$

3.2.3 Draw a labelled free-body diagram for block P, while it is accelerating. (2)



✓ horizontal forces

✓ vertical forces

3.2.4 If the mass of block P is now given as 19 kg, calculate the coefficient of kinetic friction, μ_k , for the surface on which block P slides during the acceleration. (4)

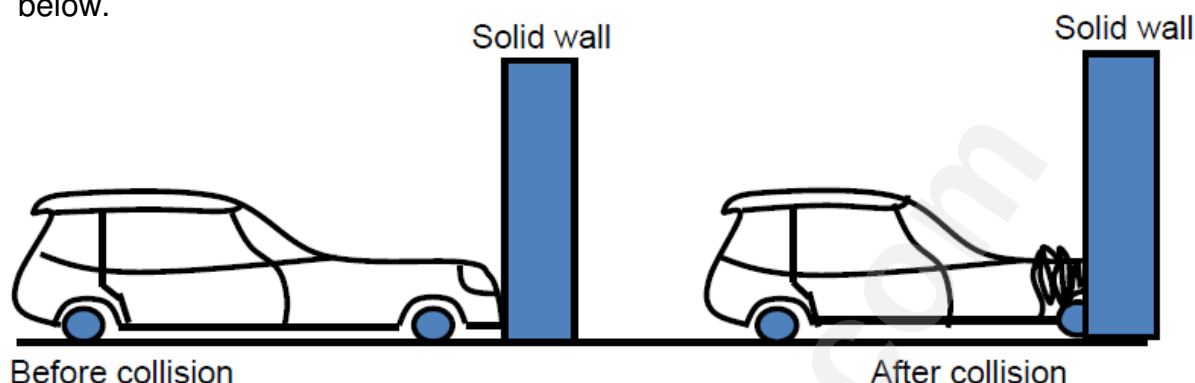
$$F_{\text{net}} = ma$$

$$T - \mu_k (m)(g) = ma \checkmark$$

$$29,07 - \mu_k (19)(9,8) \checkmark = (19)(0,11) \checkmark$$

$$\mu_k = 0,14 \checkmark$$

- 4.1 Most modern cars incorporate safety features that are designed to protect the driver and passengers in the event of a head-on collision. In testing one of such safety features, a car is crashed into a rigid concrete wall and its front crumples as shown in the diagram below.



The results of one such test are shown below.

Data: Car mass = 1000 kg

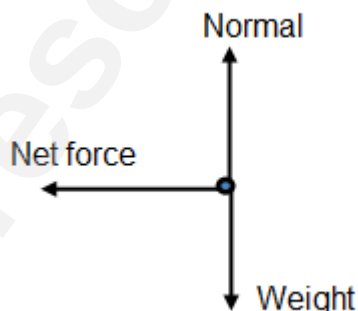
Speed of car at impact = $120 \text{ km} \cdot \text{h}^{-1}$

Original length of car = $d_1 = 2,8 \text{ m}$

Crushed length of car = $d_2 = 2,0 \text{ m}$

Ignore the effects of friction. Assume that there is no loss in mass as a result of the collision.

- 4.1.1 Draw a labelled, free-body diagram of all the forces acting on the car during impact. (3)



✓✓✓

(Don't penalise if Fengine drawn)

- 4.1.2 Convert $120 \text{ km} \cdot \text{h}^{-1}$ to SI units. (1)

$$(120 \times 1000) \div 3600 = 33,33 \text{ m} \cdot \text{s}^{-1} \quad \checkmark$$

- 4.1.3 State the WORK-ENERGY theorem. (2)

The net work done on an object is equal to the change in the object's kinetic energy. ✓✓

Assume that the force acting on the car is constant throughout the collision.

4.1.4 Use the WORK-ENERGY theorem to calculate the net force acting on the car during the collision. (5)

$$\begin{aligned}
 W_{\text{net}} &= E_{\text{kf}} - E_{\text{ki}} \checkmark \\
 &= 0 - (0,5) (1000) (33,33)^2 \checkmark \\
 &= - 555\,444,45 \text{ J} \\
 F_{\text{net}} \Delta x \cos \theta &= - 555\,444,45 \checkmark \\
 F_{\text{net}} (0,8) \cos 180 \checkmark &= - 555\,444,45 \\
 F_{\text{net}} &= 694\,305,56 \text{ N} \\
 \therefore F_{\text{net}} &= 694\,305,56 \text{ N left / away from wall} \checkmark
 \end{aligned}$$

4.1.5 Calculate the time taken for the car to come to rest. (4)

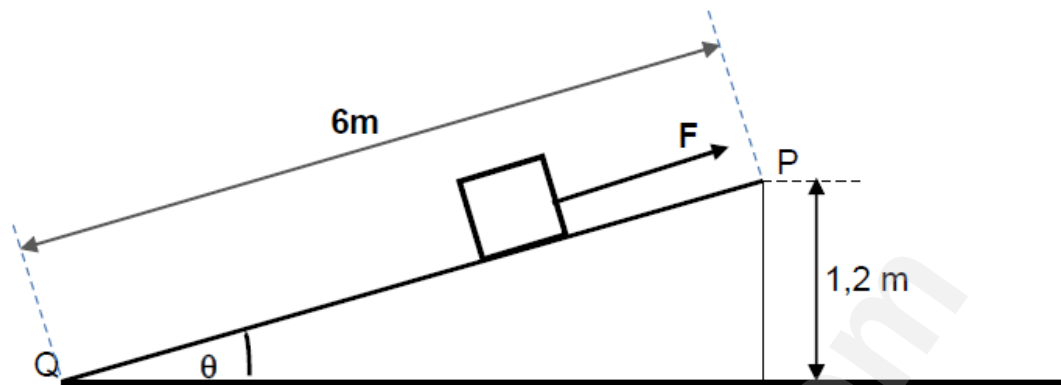
$$\begin{aligned}
 \Delta x &= \left(\frac{v_i + v_f}{2} \right) \Delta t \checkmark \\
 (0,8) \checkmark &= \left(\frac{33,33 + 0}{2} \right) \Delta t \checkmark \\
 \therefore \Delta t &= 0,05 \text{ s} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \text{OR } F_{\text{net}} \Delta t &= \Delta p \\
 &= m (v_f - v_i) \checkmark \\
 \Delta t &= \frac{1000 (0 - 33,33)}{- 694\,305,56} \checkmark \checkmark \\
 &= 0,05 \text{ s} \checkmark
 \end{aligned}$$

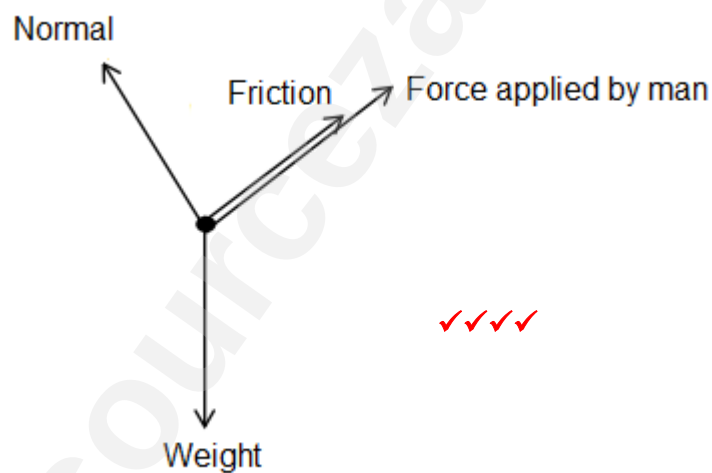
4.1.6 Explain the purpose of a crumple zone in modern cars (3)

- Crumpling increases stopping time / time of impact $\checkmark$
- thus reducing F_{net} (and therefore injury) $\checkmark$
- $F_{\text{net}} = \frac{\Delta p}{\Delta t}$ and Δp is constant $\checkmark$

- 4.2 A 100 kg box slides down a rough inclined plane. A man applies a constant force F on the box such that it slides down the inclined plane at constant velocity.



- 4.2.1 Draw a labelled, free-body diagram showing all the forces acting on the box as it slides down the inclined plane. (4)



- 4.2.2 Write down the magnitude of the net force acting on the box as it slides down the inclined plane. Give a reason for the answer. (2)

0 N ✓

Box slides at constant velocity / $\Delta E_k = 0$ / acceleration = 0 ✓

The frictional force between the box and the inclined plane is 60 N. The vertical height is 1,2 m.

- 4.2.3 What is a non-conservative force? (1)

A force that causes a change in mechanical energy ✓

$$\theta = \sin^{-1} \frac{12}{6} \quad \checkmark = 11,537^\circ$$

Option 1

$$W_{\text{net}} = \Delta E_k \quad \checkmark$$

$$W_A + W_f + W_N + W_\perp + W_{//} = 0 \quad \checkmark$$

$$W_A + F_f \Delta x \cos 180^\circ + 0 + 0 + 100 \times 9,8 \sin 11,537^\circ \times 6 \cos 0^\circ = 0$$

$$W_A + 60 \times 6 \cos 180^\circ + 100 \times 9,8 \sin 11,537^\circ \times 6 \cos 0^\circ = 0$$

$$W_A = -816 \text{ J} \quad \checkmark$$

Option 2

$$F_{\text{net}} = F_A + f + F_{//} + N + F_\perp$$

$$= F_A + f + F_{//}$$

$$0 = F_A - 60 + 100 \times 9,8 \times \sin 11,537^\circ$$

$$= F_A + 136$$

$$F_A = -136 \text{ N}$$

$$\therefore W_A = F_A \times \Delta x$$

$$= -136 \times 6$$

$$= -816 \text{ J}$$

Option 3

$$W_{\text{nc}} = \Delta E_k + \Delta E_p$$

$$W_{\text{man}} + W_f = 0 + mg(h_f - h_i)$$

$$W_{\text{man}} + 60 \times 6 \times (-1) = 100 \times 9,8 (0 - 1,2)$$

$$W_{\text{man}} = -1176 + 360$$

$$= -816 \text{ J}$$

4.2.5 Calculate the magnitude of force F exerted by the man on the box.

(3)

$$W_{\text{man}} = F_{\text{man}} \Delta x \cos \theta = -816$$

$$F \times 6 \cos 180^\circ = -816$$

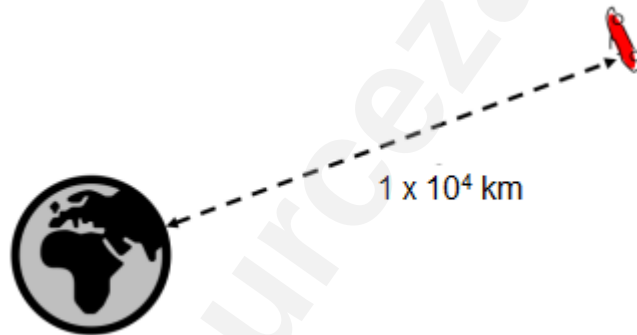
$$F_{\text{man}} = 136 \text{ N}$$

Force applied by man is 136 N.

[34]

QUESTION 5 FIELDS

- 5.1 Elon Musk used his car as a test weight for one of his rockets and sent the car into orbit. The car has a mass of 1305 kg and is currently at an approximate distance of 1×10^4 km from the surface of the Earth. The Earth has a mass of 6×10^{24} kg and a radius of $6,4 \times 10^6$ m.



- 5.1.1 What is the magnitude of Earth's gravitational force on Musk's car at its current position?

(4)

$$F = \frac{GM_E M_C}{r^2}$$

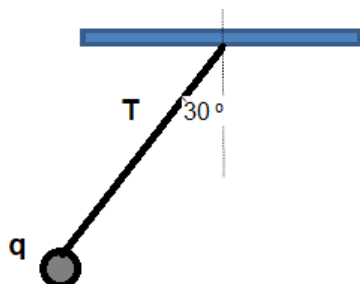
$$= \frac{(6,7 \times 10^{-11})(6 \times 10^{24})(1305)}{(6,4 \times 10^6 + 1 \times 10^7)^2} \quad \checkmark \quad \checkmark \quad \text{(add)} \quad \checkmark \quad \text{(convert km - m)}$$

$$= 1,95 \times 10^3 \text{ N} \quad \checkmark$$

- 5.1.2 How would Earth's gravitational force on the car change when the distance between the car and the centre of the Earth is doubled? Write your answer in terms of F .

$$\frac{1}{4} F \quad \checkmark \checkmark$$

- 5.2 A small charged polystyrene ball, carrying a charge q , is suspended in equilibrium by a string in a uniform electric field of $2 \times 10^5 \text{ N} \cdot \text{C}^{-1}$ to the left. The horizontal electrostatic force experienced by the ball is 0,065 N to the left. The string experiences a tension T when the ball is experiencing the electrostatic force and the angle between the tension and the vertical is 30° , as indicated in the sketch.



- 5.2.1 Define the magnitude of an electric field. (2)

The force per unit positive charge. ✓✓

- 5.2.2 Calculate the magnitude of the charge q on the polystyrene ball and state whether the charge q is positive or negative. (4)

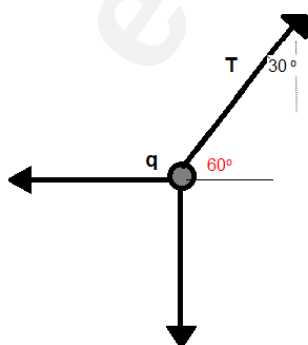
$$q = \frac{F}{E} \quad \checkmark \quad = \quad \frac{0,065}{2 \times 10^5} \quad \checkmark \quad = \quad 3,25 \times 10^{-7} \text{ C} \quad \checkmark$$

q is positive ✓ (E and F in same direction)

- 5.2.3 State the magnitude of the resultant (net) force on the polystyrene ball. (1)

Zero (in equilibrium) ✓

- 5.2.4 Calculate the magnitude of the tension T in the string. (3)



$$\cos 60^\circ \quad \checkmark \quad = \quad \frac{0,065}{T} \quad \checkmark$$

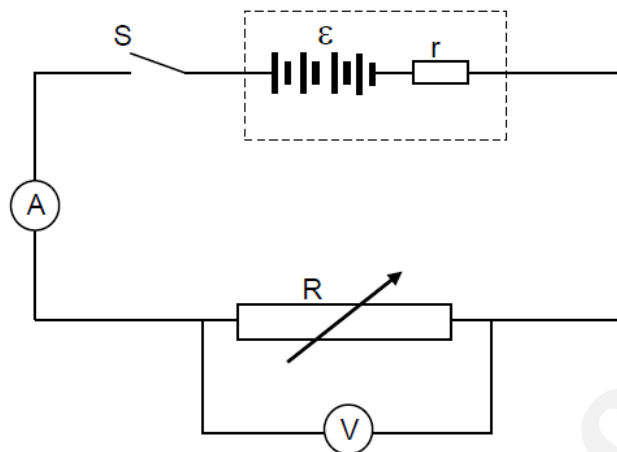
$$T = \frac{0,065}{\cos 60^\circ}$$

$$\therefore T = 0,13 \text{ N} \quad \checkmark$$

QUESTION 6

ELECTRIC CIRCUITS

6.1 Learners set up a circuit, as shown below, to investigate the relationship between the potential difference across a variable resistor, R , and the current through the resistor.



6.1.1 In this experiment, name the ...

a) independent variable. (1)

Current ✓

b) dependent variable. (1)

Potential difference ✓

The learners obtain a set of corresponding readings of potential difference and current. Two of the readings are shown in the table below.

Reading number	Current (A)	Potential difference (V) For external resistor
1	0,3	2,52
2	1,6	0,71

6.1.2 By means of a calculation, determine the internal resistance of the battery. (4)

$$\varepsilon = I(R + r) = V_{ext} + Ir$$

$$\varepsilon = 2,52 + 0,3r \dots (i) \quad \checkmark$$

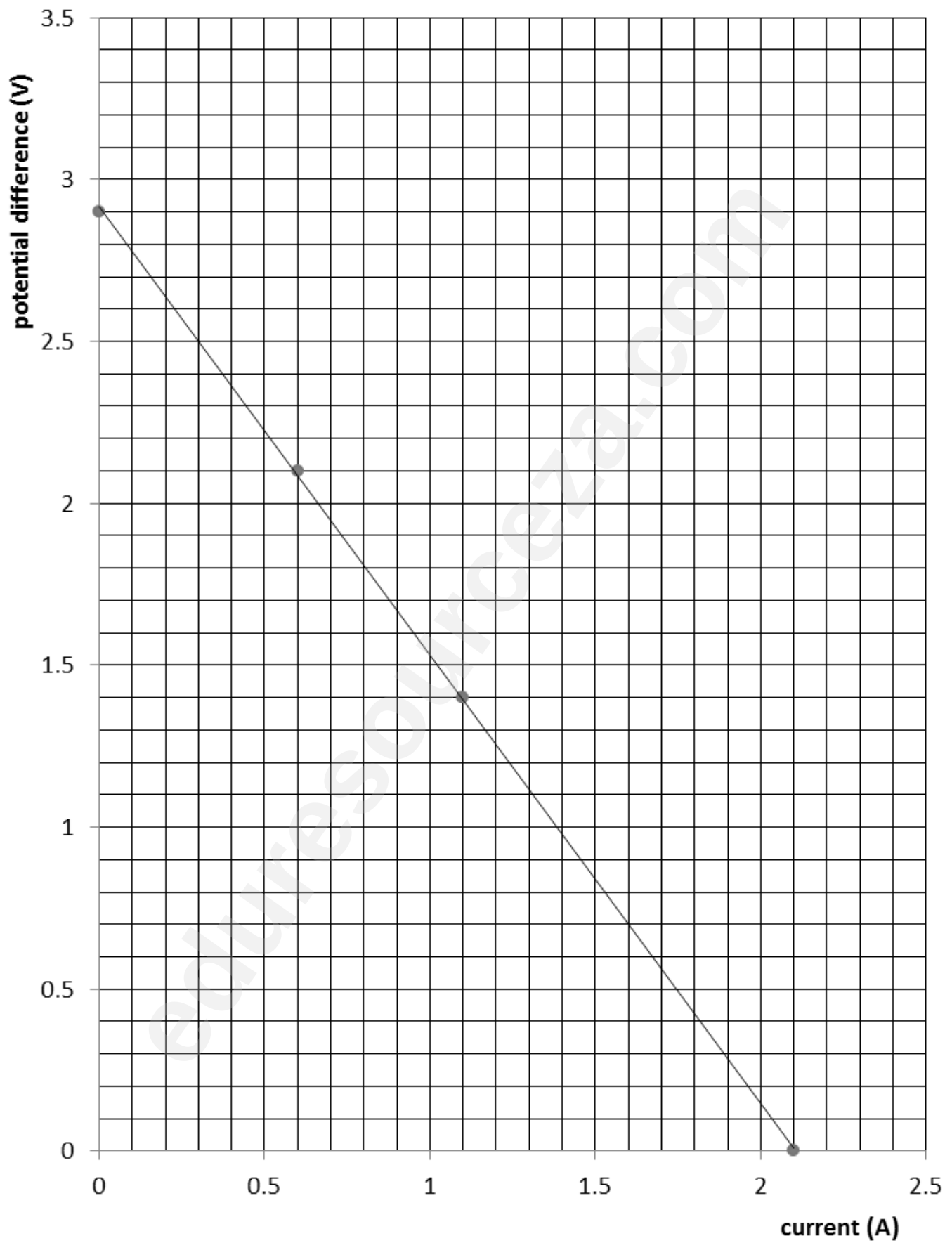
$$\varepsilon = 0,71 + 1,6r \dots (ii) \quad \checkmark$$

Sub (i) into (ii)

$$2,52 + 0,3r = 0,71 + 1,6r \quad \checkmark$$

$$\therefore r = 1,39 \, \Omega \quad \checkmark$$

The learners now used their results to draw the following graph.



6.1.3 determine emf of the battery (no calculation is necessary). (1)

$$\text{EMF} = y \text{ int} = 2,9 \text{ V} \checkmark$$

6.1.4 calculate the internal resistance of the battery. (2)

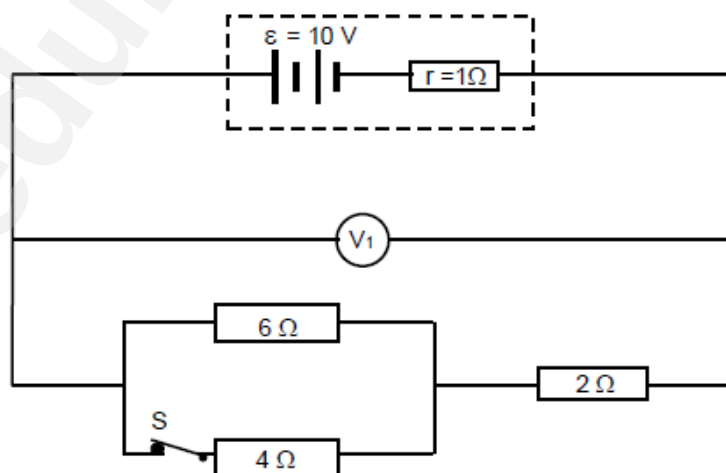
$$\begin{aligned} r &= \text{gradient of graph} \\ &= \frac{2,5 - 0,7}{0,3 - 1,6} \checkmark \\ &= -1,38 \quad (\text{accept any viable calculation of gradient}) \\ \therefore r &= 1,38 \, \Omega \checkmark \end{aligned}$$

6.1.5 Give a reason for the slight deviation in the answers from Questions 6.1.2 and 6.1.4 (1)

The graph is an average line through the points/learners drew line of best fit $\therefore$ gives an average value for r $\checkmark$

OR The calculation from the readings in the table does not take into account instrument reading errors, and any other small errors that arise. $\checkmark$

6.2 A battery with an emf of 10 V and an internal resistance of $1 \, \Omega$ is connected to three external resistors as shown in the circuit below.



6.2.1 Calculate the current flowing in the circuit.

(5)

For the parallel network $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{6} + \frac{1}{4} \checkmark$ $R_{//} = 2,4 \Omega$

Option 1

$$\begin{aligned} R_{\text{circuit}} &= R_{//} + R_{\text{series}} \checkmark \\ &= 2,4 + 2 + 1 \checkmark \\ &= 5,4 \Omega \\ I &= \frac{\varepsilon}{R_{\text{circuit}}} \checkmark \\ I &= \frac{10}{5,4} \checkmark \\ I &= 1,85 \text{ A} \checkmark \end{aligned}$$

Option 2

$$\begin{aligned} \varepsilon &= IR_{\text{ext}} + Icr \checkmark \\ &= I (R_{\text{ext}} + r) \\ 10 \checkmark &= I (2,4 + 2 + 1) \checkmark \\ I &= 1,85 \text{ A} \checkmark \end{aligned}$$

6.2.2 Determine the reading of V_1 .

(2)

$$R_{\text{ext}} = 2,4 + 2 = 4,4 \Omega$$

OR $\varepsilon = V_{\text{ext}} + Ir$

$$V_{\text{ext}} = I R_{\text{ext}} = 1,85 (4,4) \checkmark = 8,14 \text{ V} \checkmark$$

$$10 = V_{\text{ext}} + (1,85) (1) \checkmark$$

$$\therefore V_{\text{ext}} = 8,15 \text{ V} \checkmark$$

6.2.3 What happens to the reading of V_1 if switch S is opened? Choose from STAYS THE SAME, INCREASES or DECREASES. Explain the answer without any calculation.

(3)

INCREASES $\checkmark$

- Switch S opened $\rightarrow$ Total resistance of circuit increases $\checkmark$
- $\rightarrow$ Total current decreases $\checkmark$
- $\rightarrow \varepsilon = V_{\text{ext}} + Ir$
- $\rightarrow$ EMF & r constant, so a smaller current leads to a greater V_{ext} $\checkmark$

6.3 A tumble dryer is marked 220 V : 1 800 W and a dishwasher is marked 220 V : 1 200 W.

6.3.1 Explain in terms of energy what is meant by the information 1 200 W. (1)

It means that **1 200 J** of energy is transferred per second. ✓

6.3.2 Calculate the total current flowing in the circuit when the tumble dryer and dishwasher are connected in parallel. (4)

$P = V I$. ✓ Since $V = 220\text{V}$ for both appliances (in parallel)

$$I_{\text{total}} = I_{\text{tumble}} + I_{\text{dish}}$$

$$= P/V + P/V$$

$$= (1800/220) \checkmark + (1200/220) \checkmark$$

$$= 13,64 \text{ A } \checkmark$$

$$\begin{aligned} \text{OR: } R_{\text{tumble}} &= V^2/P \checkmark \quad \text{and} \quad R_{\text{dish}} = V^2/P \\ &= 26,88\Omega \quad \quad = 40,33\Omega \end{aligned}$$

$$R_{\text{parallel}} = 16,13\Omega \checkmark$$

$$\begin{aligned} I_{\text{total}} = V/R &= 220/16,13 \checkmark \\ &= 13,64 \text{ A } \checkmark \end{aligned}$$

6.3.3 Which appliance, the tumble dryer or dishwasher, has the highest electrical resistance? Justify your answer using a Physics formula but without doing a calculation. (Assume that the appliances are always connected in parallel.) (3)

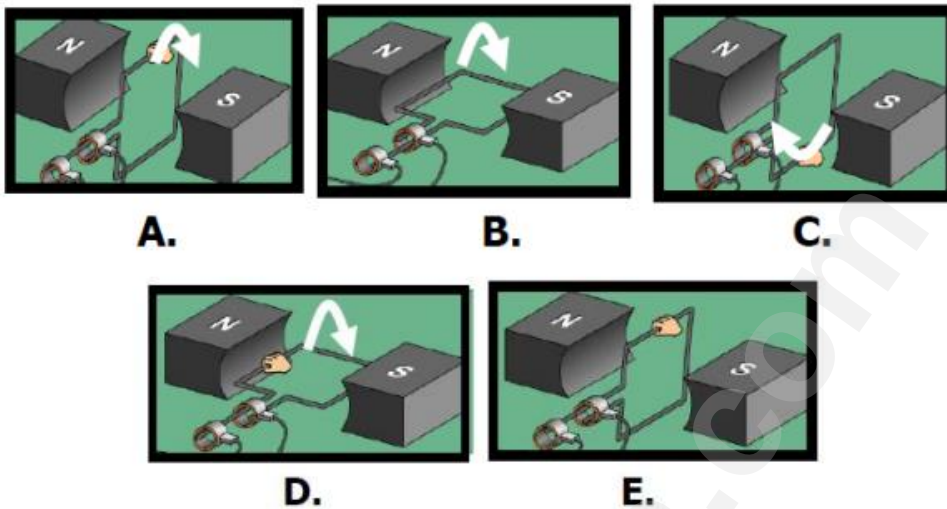
The dishwasher ✓

$$R = \frac{V^2}{P} \checkmark \quad V \text{ is constant,}$$

the appliance with the lowest P will be that with the highest R ,
since power is inversely proportional to resistance. ✓

QUESTION 7

An AC current is generated by rotating a coil in a magnetic field. The images A to E below show the successive positions of the coil as it is turned.



7.1 State Lenz's Law. (2)

the induced current flows in a direction so as to set up a magnetic field to oppose the change in magnetic flux ✓✓

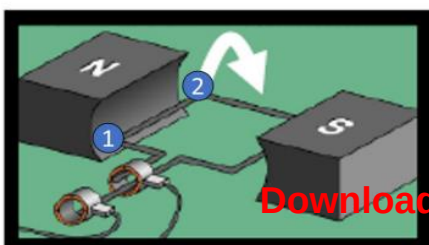
7.2 In which position(s) is the magnetic flux at a minimum? (2)

B and D ✓✓

7.3 State two ways to increase the maximum magnetic flux linkage. (2)

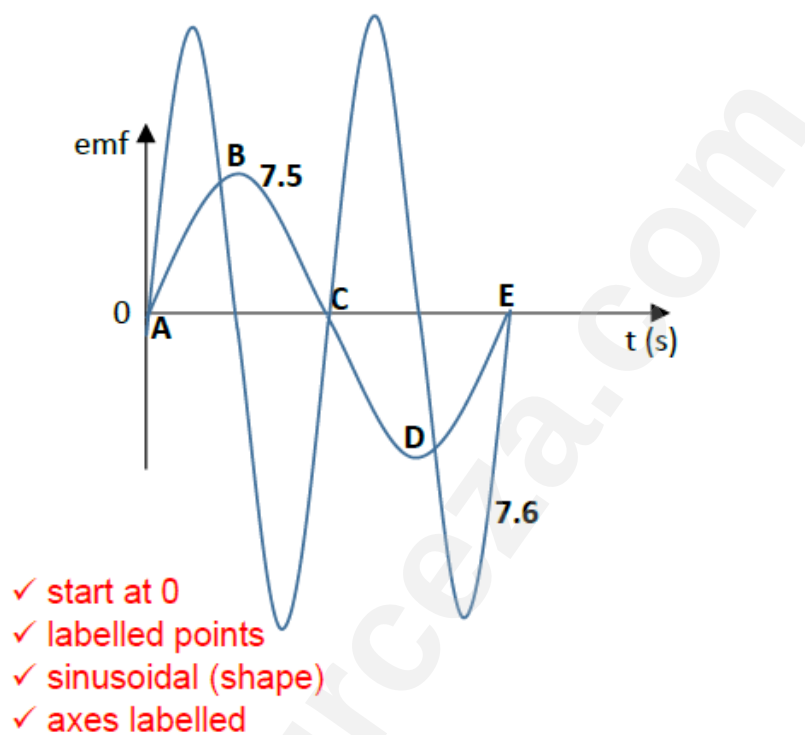
- Increase the number of turns on the coil in the field
- Increase the strength of the magnetic field
- Increase the rate of change of flux (rate of rotation)
- Increase the area of the coil ✓✓ (any two)

7.4 In position B of this generator (enlarged below), does the current flow from 1 to 2, or 2 to 1, or not at all? (1)



From 1 to 2 ✓

- 7.5 On the axis below, plot the emf as it changes with time for one complete turn of the armature shown starting with the armature in **position A**. Use the letters identified in the images to mark the corresponding points on the graph and label the line as “7.5”. (4)



- 7.6 If the armature was turned at twice the speed as in 7.5, identify how the graph of emf versus time would change by drawing a new line on your graph. Clearly label the new line “7.6”. (2)

(on graph)

- ✓ twice the amplitude
 ✓ half the frequency

The AC current generated by this apparatus is then sent to a transformer to step up the voltage.

- 7.7 Why would it be useful to increase the voltage of an AC current? Explain. (3)

Long distance transmission of electrical energy is done at high voltage✓
 high voltage transmission involves low current ✓ ($P = VI$: V inversely proportional to I)
 which means smaller rate of loss of energy as heat ✓ ($P = I^2R$)

- 7.8 If the original voltage is V and the primary coil has 100 turns, how many turns must the secondary coil have in order to triple the voltage? (2)

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$\frac{100}{N_s} = \frac{V}{3V} \checkmark$$

$$N_s = 300 \text{ turns } \checkmark$$

- 7.9 Explain why a DC current cannot be transformed by a transformer. (2)

There must be a changing magnetic field $\checkmark$ to generate a current. DC has a steady magnetic field. $\checkmark$

[20]

QUESTION 8 PHOTONS AND ELECTRONS

The photoelectric effect is applied in the operation of certain light-sensitive photovoltaic cells that power calculators and other low-power devices.

- 8.1 Describe what is meant by the photoelectric effect. (2)

The process that occurs when light shines on a metal and electrons are ejected $\checkmark\checkmark$

The work function of a certain cell where the metal emission surface is made from magnesium is 3,66 eV.

- 8.2 Convert 3,66 eV to Joules. (round to two decimal places) (1)

$$5,86 \times 10^{-19} \text{ J } \checkmark$$

8.3 Calculate the threshold frequency of magnesium.

(3)

$$W_o = hf_o \quad \checkmark$$

$$5,86 \times 10^{-19} = 6,6 \times 10^{-34} f_o \quad \checkmark$$

$$\therefore f_o = 8,88 \times 10^{14} \text{ Hz} \quad \checkmark$$

8.4 Calculate the velocity of an emitted electron when UV light of frequency $9,2 \times 10^{14} \text{ Hz}$ is shone onto the magnesium surface.

(4)

$$E = W_o + \frac{1}{2}mv^2$$

$$hf = W_o + \frac{1}{2}mv^2 \quad \checkmark$$

$$6,6 \times 10^{-34} (9,2 \times 10^{14}) \checkmark = 5,86 \times 10^{-19} + (0,5)(9,1 \times 10^{-31})v^2 \quad \checkmark$$

$$\therefore v = 2,16 \times 10^5 \text{ m.s}^{-1} \quad \checkmark \text{ or } 215\,855,06 \text{ m.s}^{-1}$$

[10]