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SAHETI SCHOOL

PHYSICAL SCIENCE

GRADE 12

PAPER 1 : PHYSICS

EXAMINER : C ORCHISON

DATE : 04 JUNE 2023

MODERATORS : M. RAMUTHAGA-MUSAMPA

HOURS : 3 HOURS

J. NAIDU

MARKS : 200

NAME : memo

INSTRUCTIONS AND INFORMATION

1. This question paper consists of 32 pages with 8 questions.
2. A data sheet is provided.
3. Answer all questions on this paper and show all working out.
4. Extra space is provided at the end of the paper should you require it.
5. Use the mark allocation as guide to the maximum time you should spend on a question.
6. Use bullet points for all explanations.
7. Round all answers to 2 decimal places and include the correct SI unit.
8. Answers should be expressed in decimal format and not left as fractions.
9. Read the questions carefully...

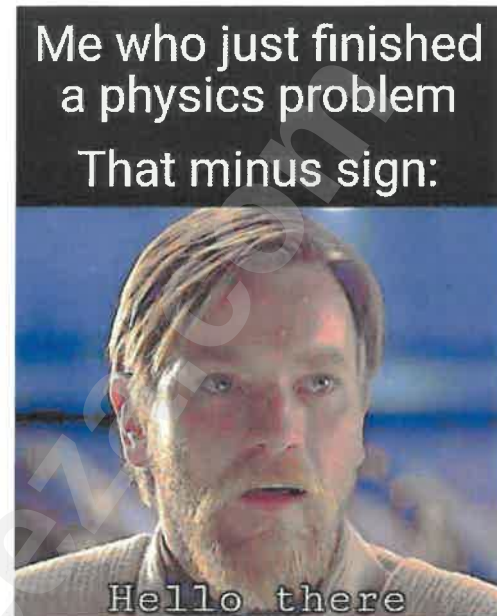
Science students *



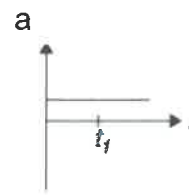
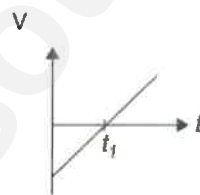
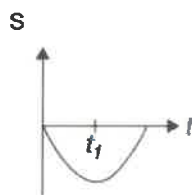
QUESTION 1

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.

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



- 1.1 Consider the three graphs shown below representing the motion of a marble:



Which of the following descriptions correctly matches the information in the graphs?

- A rolling along the floor and rebounding horizontally off a wall
- ☒ B rolling up a ramp and then rolling back down the ramp
- C falling and bouncing elastically off a hard floor
- D thrown vertically downwards and coming to rest on the floor

- 1.2 A ball rolls along a rough surface and comes to rest in a distance, d . If the frictional force acting on the ball is doubled, by what factor will the distance it takes to stop change?

- A d B $2d$ ☒ C $\frac{1}{2}d$ D $\frac{1}{4}d$

F doubled $\therefore a$ doubled

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

$$-u^2 = 2(-a)s$$

$$s = \frac{u^2}{2a}$$

$$s' = \frac{u^2}{4a}$$

$$s' = \frac{1}{2}s$$

- 1.3 Two identical trolleys, A and B, are initially at rest, joined by a spring. The spring then pushes them apart and trolleys A and B move in opposite directions, both with a speed of v .

Which of the statements below are correct?

I – the collision is elastic as kinetic energy is conserved $\times E_k \text{ before} = 0$

II – the magnitude of the total change in momentum of ball A is 0 $\times$

$$\Delta p = m\Delta v = m(v - u) = m(v - 0) = mv$$

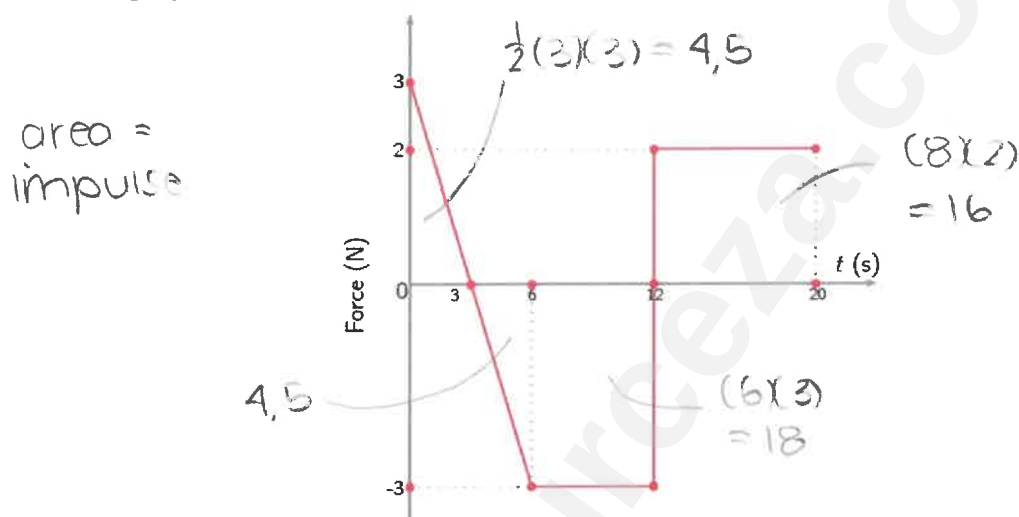
A I only

B II only

C I and II

☒ D neither

- 1.4 The graph below shows how the net force acting on an object changes with time.



Which of the statements about the graph are correct?

I – the change in momentum of the object between 0-3 seconds is $4,5 \text{ kg.m.s}^{-1}$ ✓

II – the impulse the object experiences between 3-12 seconds is $22,5 \text{ J.s}$ ✓

III – the change in momentum of the object between 6 and 20 seconds is 34 J.s $\times$

A I and III

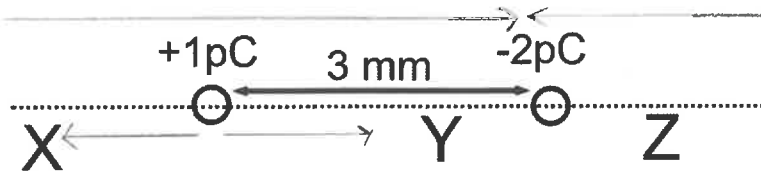
☒ B I and II

C II and III

D I, II and III

Use the diagram below to answer both question 1.5 and 1.6

$E = kQ/r^2$
 ↑
 causing



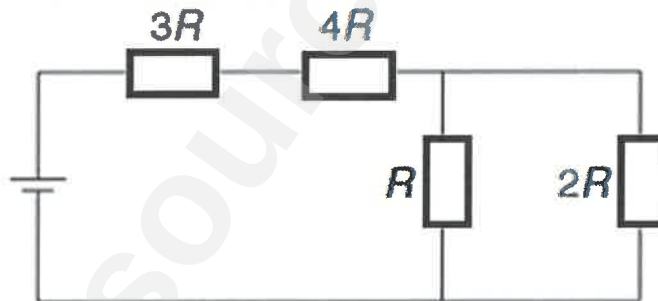
1.5 Which of the following correctly gives the electric field experienced by the -2pC charge?

- A 1000 N.C⁻¹ left ☒ B 1000 N.C⁻¹ right
 C 2000 N.C⁻¹ left D 2000 N.C⁻¹ right

1.6 At which position(s) would it be possible to have a zero net electric field?

- ☒ A X only B Y only C Z only D X and Z

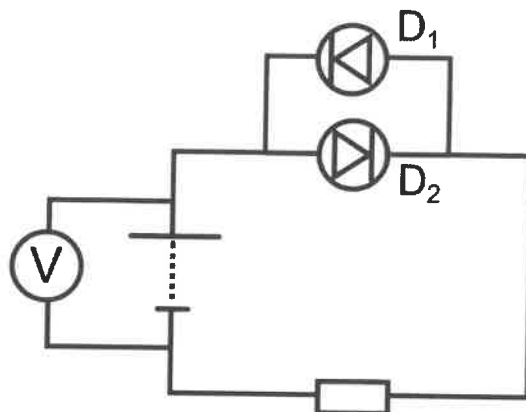
1.7 In the circuit below, 4 resistors with resistances of R, 2R, 3R and 4R are connected as shown:



Which correctly ranks the current through the resistors and the voltage across the resistors?

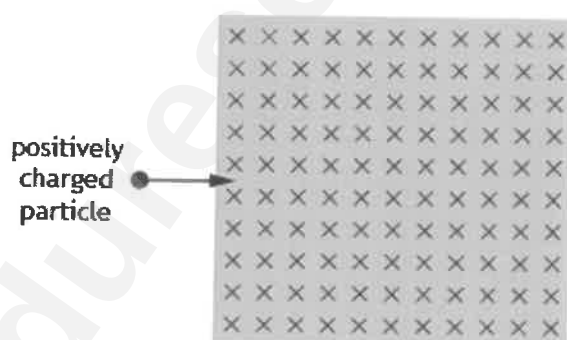
	Current	Voltage
A	$I_{3R} = I_{4R} > I_{2R} > I_R$	$V_{4R} > V_{3R} > V_R = V_{2R}$
B	$I_R > I_{2R} > I_{3R} > I_{4R}$	$V_{4R} < V_{3R} < V_R = V_{2R}$
C	$I_{3R} < I_{4R} > I_R > I_{2R}$	$V_{4R} > V_{3R} > V_R > V_{2R}$
☒ D	$I_{3R} = I_{4R} > I_R > I_{2R}$	$V_{4R} > V_{3R} > V_R = V_{2R}$

- 1.8 In the circuit below the battery has significant internal resistance, and an emf of 12 V.



When component D₂ is turned around... ∴ reverse biased ∴ no current

- A the reading on the voltmeter increases but is less than 12 V
 B the reading on the voltmeter decreases but is greater than 0 V
 C the reading on the voltmeter reads 0 V
 (D) the reading on the voltmeter reads 12 V
- 1.9 You are given the following diagram showing a positively charged particle entering a magnetic field.



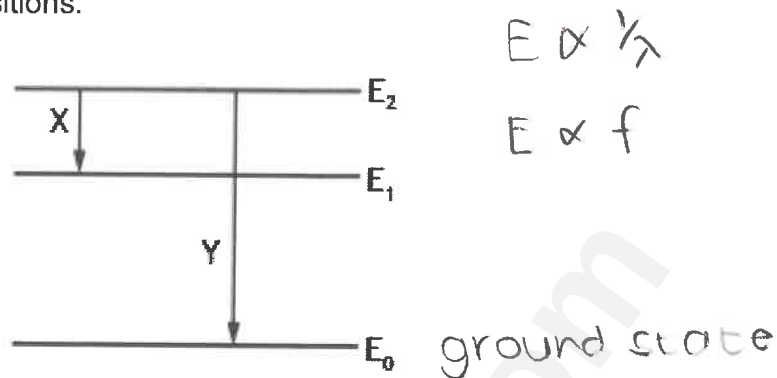
magnetic field
into the page

use left hand
rule

In which direction does the particle experience a force?

- (A) upwards B downwards C to the left D to the right

- 1.10 Part of the energy level diagram for an atom is given below, showing that an electron could make two possible transitions.



Consider the statements regarding this diagram:

- I – photons with the greatest wavelength correspond to the change marked X ✓
- II – E_0 represents the ionization on the atom and E_1 and E_2 represent excited states X
- III – photons will have a greater frequency with the change marked Y ✓

Which of the statements are correct?

- A II and III B I and II ☒ C I and III D I, II and III

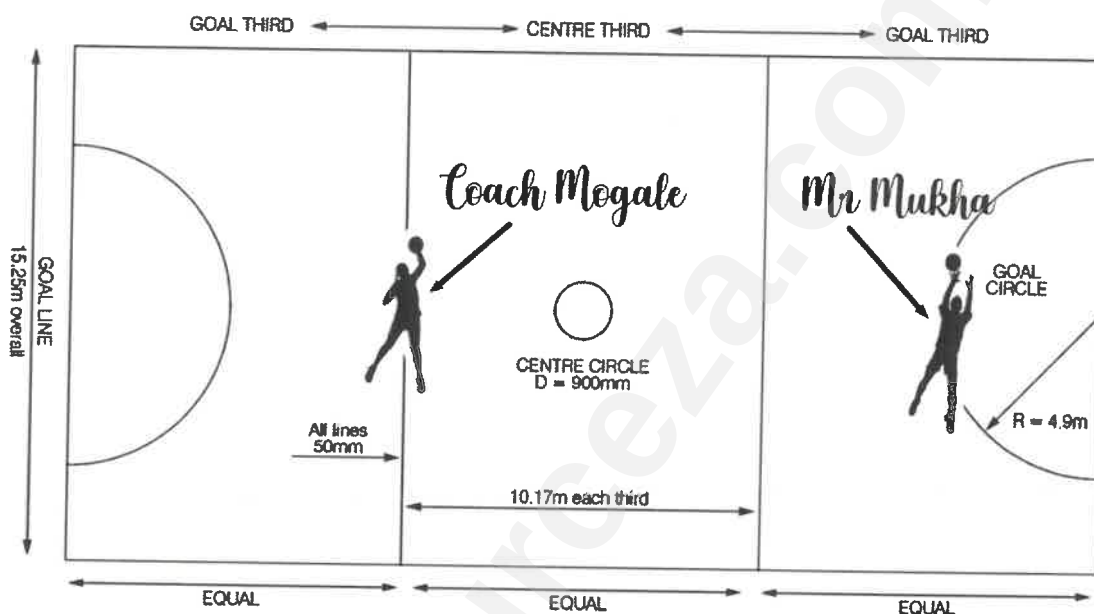
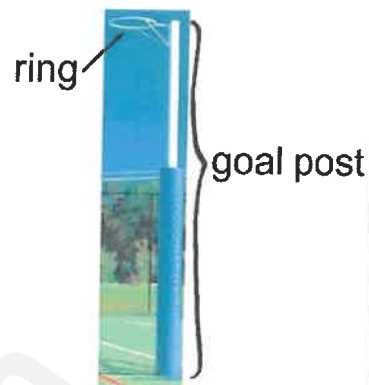
20 MARKS

Me: *struggles to remember the direction of magnetic forces*
My physics Teacher:



QUESTION 2

The floodlights are shining down on the netball court as the legendary Mr Mukha takes a shot at scoring a goal in the staff vs matrices netball match at the stay-awake. Coach Mogale is waiting on the other side of the court. The ring and goal post are labelled alongside and the dimensions of the court, as a top view, are shown below. Ignore air resistance.



After Mr Mukha takes his shot, the ball bounces vertically upwards from the top of the ring and reaches a height of 0,95 m above the goal post.

- 2.1 Calculate the velocity with which the ball left the top of the ring. (4)

$$v^2 = u^2 + 2gs$$

$$0 = u^2 + 2(-9,8)(0,95)$$

$$u = 4,31 \text{ m.s}^{-1} \text{ upwards}$$

- 2.2 If the ball reaches the ground 1,34 seconds after it left the top of the ring, calculate the height of the goal post. (4)

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

$$= (4,31)(1,34) + \frac{1}{2}(-9,8)(1,34)^2$$

$$= -3,02 \text{ m}$$

$$\therefore 3,02 \text{ m high}$$

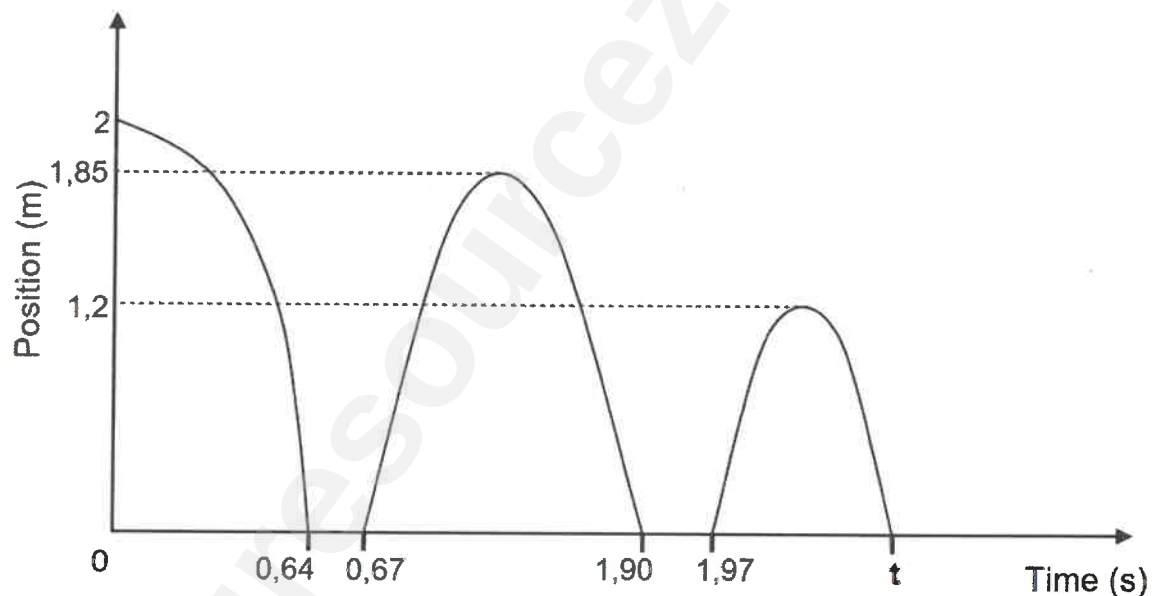
- 2.3 If Coach Mogale was running towards Mr Mukha at an initial velocity of 2 m.s^{-1} as she passed the goal third line as shown in the diagram, prove that she would need to accelerate at $0,39 \text{ m.s}^{-2}$ in order to reach Mr Mukha (who is standing on the edge of the goal circle) with a final velocity of 4 m.s^{-1} . (3)

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

$$(4)^2 = (2)^2 + 2a(10,17 + 5,27)$$

$$\therefore a = 0,39 \text{ m.s}^{-2}$$

As Mr Mukha holds the ball above his head, the floodlights shine directly into his eyes, so he drops the ball from rest and it bounces several times on the court as shown in the position-time graph below. The mass of the ball is 400 g.



- 2.4 Calculate the velocity with which the ball hits the ground the first time. (4)

$$v = u + gt$$

$$= 0 + (-9,8)(0,64)$$

$$= -6,27 \text{ m.s}^{-1}$$

$$\therefore 6,27 \text{ m.s}^{-1} \text{ downwards}$$

- 2.5 Define displacement. (1)

change in position

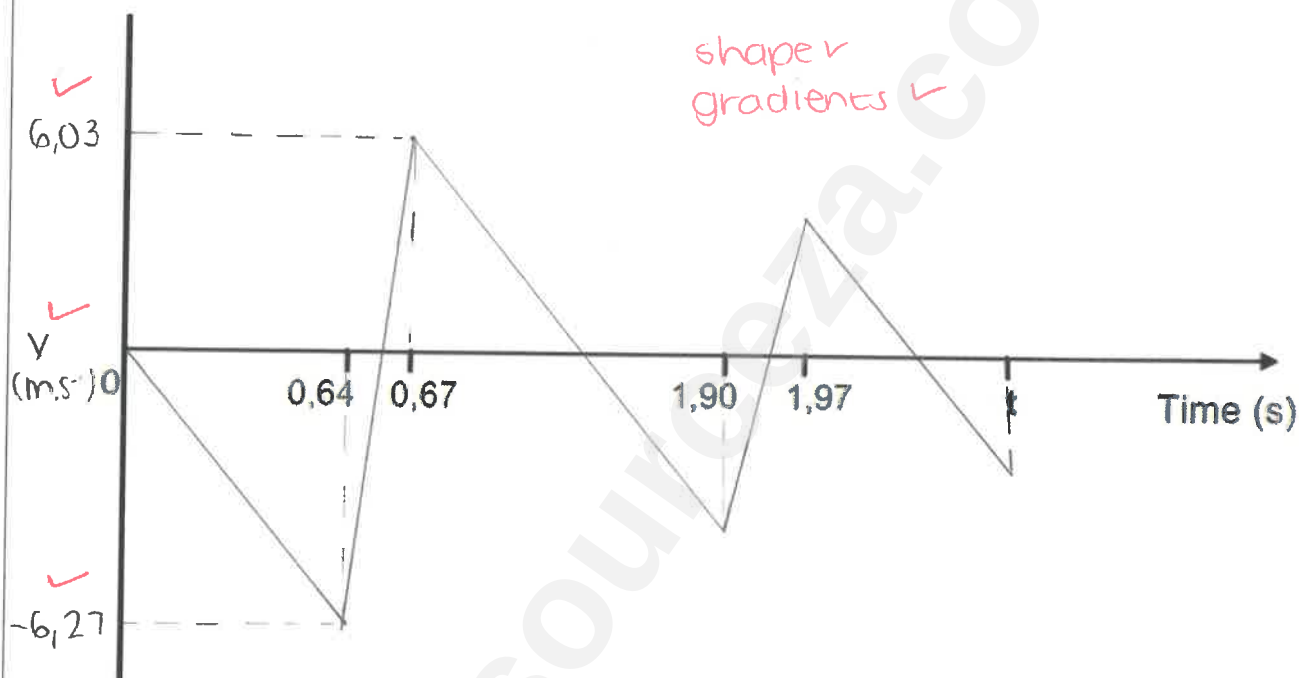
- 2.6 Calculate the magnitude of the velocity with which the ball leaves the ground at 0,67 seconds. (3)

$$v = u + gt$$

$$0 = u + (-9,8) \left(\frac{1,9 - 0,67}{2} \right)$$

$$u = 6,03 \text{ m.s}^{-1}$$

- 2.7 Sketch the corresponding velocity-time graph for the full motion of the ball, indicating the relevant velocities you have calculated and taking upwards to be positive. (5)



- 2.8 Use your graph to calculate the magnitude of the acceleration of the ball when it was in contact with the court. (3)

$$a = \Delta y / \Delta x = \frac{6,03 - (-6,27)}{0,67 - 0,64}$$

$$= 410 \text{ m.s}^{-2}$$

- 2.9 Hence calculate the magnitude and direction of the force applied by the court on the ball. (5)

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

$$= (0,4 \times 410)$$

$$= 164 \text{ N}$$

$$F_{\text{net}} = F_{\text{court}} - F_g$$

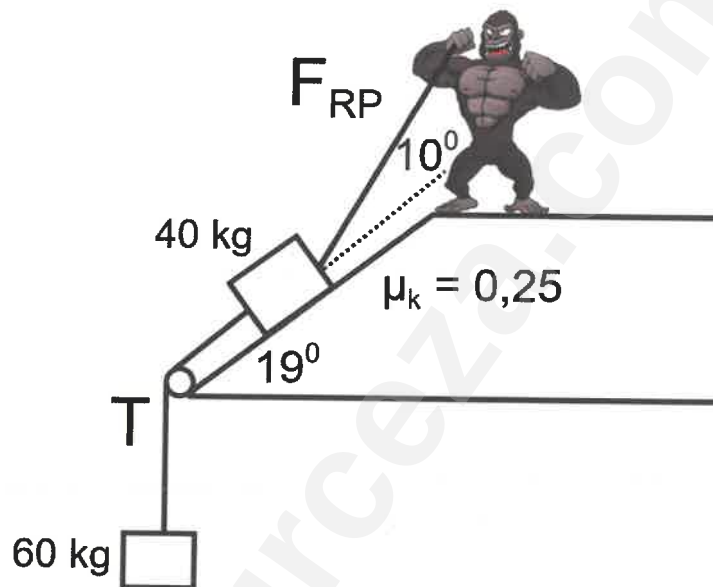
$$164 = F_{\text{court}} - (0,4 \times 9,8)$$

$$F_{\text{court}} = 167,92 \text{ N Upwards}$$

QUESTION 3

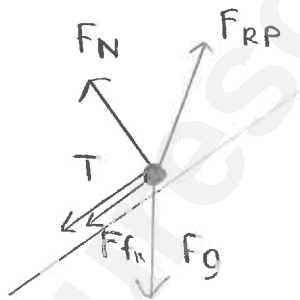
Rich Piana is known to many for his steroid-enabled body-building titles. Since taking drugs is not something to be celebrated, we will focus on the fact that he was a stuntman credited with the role of 'adult gorilla' in the movie Planet of The Apes.

In one of the scenes, Piana (in costume) has to pull two heavy boxes upwards as shown in the diagram below. The rough surface has a coefficient of kinetic friction of 0,25 and the angle of the slope is 19° . The boxes are joined by a strong, light, inextensible cable.



- 3.1 Draw a fully-labelled free body diagram of all forces acting on the 40 kg box. (4)

-1 per mistake



F_N - normal force
 F_{RP} - force applied by Rich Piana
 T - tension
 F_{fk} - kinetic frictional force
 F_g - weight

- 3.2 Define normal force. (1)

the perpendicular force exerted by a surface on an object in contact with it ✓

- 3.3 What is the reaction force to the weight of the 40 kg box on the slope? (1)

the force of the box on the earth ✓

- 3.4 Write a mathematical expression for the magnitude of the normal force experienced by the 40 kg box and substitute all known values. (2)

$$\begin{aligned} F_N &= F_{g\perp} - F_{RP\perp} \\ &= (40)(9,8) \cos 19^\circ - F_{RP} \sin 10^\circ \\ &= 370,64 - 0,17 F_{RP} \end{aligned}$$

- 3.5 If the force applied by Piana causes the 40 kg block to accelerate up the slope at $1,3 \text{ m.s}^{-2}$, calculate the tension in the cable joining the two boxes. (3)

60 kg

$$\begin{aligned} T - F_g &= m \cdot a \\ T - (60)(9,8) &= 60(1,3) \\ T &= 666 \text{ N} \end{aligned}$$

- 3.6 Hence, calculate the magnitude of the force Piana, F_{RP} , is applying to the 40 kg box. (6)

40 kg: $F_{RP} - F_{g\parallel} - F_f - T = ma$

$$F_{RP} \cos 10^\circ - 127,62 - 0,25(370,64 - 0,17 F_{RP}) - 666 = 40(1,3)$$

$$0,99 F_{RP} - 127,62 - 92,7 + 0,043 F_{RP} - 666 = 52$$

$$1,03 F_{RP} = 938$$

$$F_{RP} = 911 \text{ N}$$

$$(912,53)$$

$$F_{g\parallel} = F_g \sin \theta$$

$$= (40)(9,8) \sin 19^\circ$$

$$= 127,62 \text{ N}$$

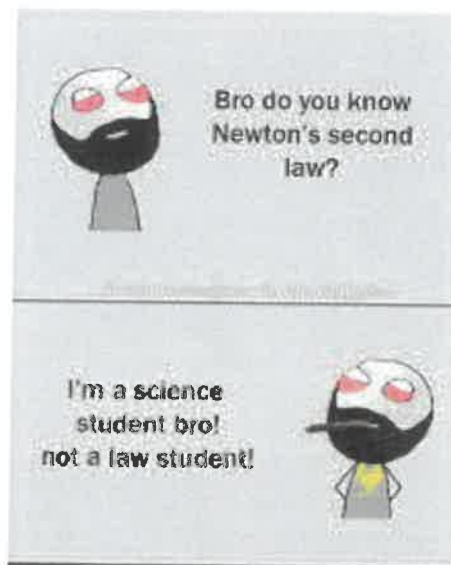
- 3.7 Piana's stunt coordinator recommends that he decreases the angle at which he is applying the force to the 40 kg box. He says although this will decrease the frictional force acting on the box, it will increase the force in the direction of motion of the box. Criticize his statement, and refer to relevant equations to support your answer. (3)

- F_f would increase as F_N increases $F_f = \mu F_N$
- force in dir of motion increase is correct

- 3.8 The cable between the two boxes suddenly snaps. Describe and explain ~~how~~ the motion of the 60 kg box **immediately after** the snap by making reference to a relevant Newtonian law. (2)

- continues moving up the slope due to inertia
- Newton's first law

22 MARKS

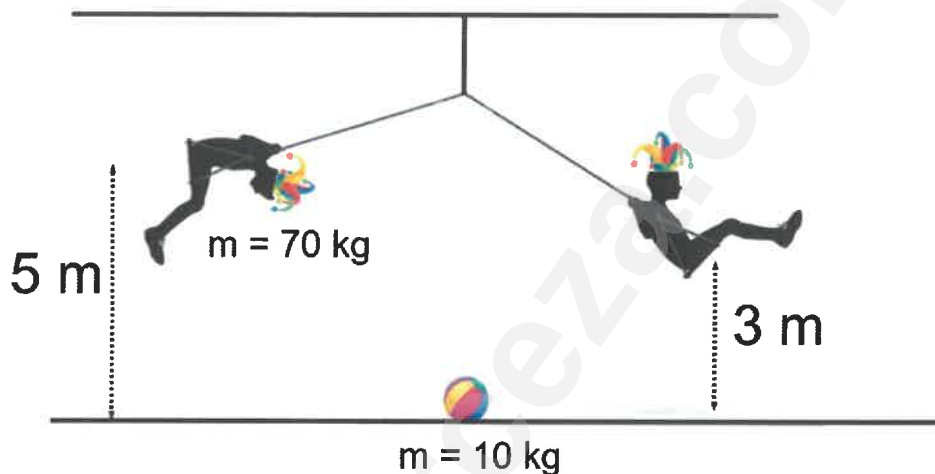


QUESTION 4

The Circus is back in town, and some eager matrics are spending the day with the performers to see if they have what it takes to be professional clowns.

First up is the trapeze test, and Timon volunteers.

Timon is held at rest on a swing 5 m above the ground and instructed to keep his legs horizontal as he reaches the floor so that he will knock the ball placed directly in his path forwards. It is filled with sand and has a mass of 10 kg. Ignore air resistance.



- 4.1 Calculate Timon's gravitational potential energy just before he is released to swing downwards. (3)

$$\begin{aligned} E_p &= mgh \\ &= (70)(9,8)(5) \\ &= 3430 \text{ J} \end{aligned}$$

- 4.2 State the law of conservation of energy. (1)

the total energy in a system cannot be created or destroyed, only transformed from one form to another

- 4.3 Calculate the speed with which Timon reaches the lowest point of his swing, just above the floor. (3)

$$\begin{aligned} E_k &= \frac{1}{2}mv^2 \\ 3430 &= \frac{1}{2}(70)v^2 \\ v &= 9,90 \text{ m.s}^{-1} \end{aligned}$$

Timon successfully knocks the ball forwards and then continues to swing upwards, but only reaches a height of 3 m above the floor.

- 4.4 Calculate the magnitude of his velocity immediately after making after contact with the ball. (4)

$$\begin{aligned}
 E_{p \text{ top}} &= E_{k \text{ bottom}} \checkmark \\
 mgh &= \frac{1}{2}mv^2 \checkmark \\
 (70)(9,8)(3) &= \frac{1}{2}(70)v^2 \checkmark \\
 v &= 7,67 \text{ m.s}^{-1} \checkmark
 \end{aligned}$$

- 4.5 State the law of conservation of momentum. (1)

the total linear momentum of an isolated system remains constant $\checkmark$

- 4.6 Hence calculate the velocity of the ball immediately after Timon came into contact with it. (4)

$$\begin{aligned}
 p_i &= p_f \checkmark \\
 m_1 u_1 + m_2 u_2 &= m_1 v_1 + m_2 v_2 \checkmark \\
 (70)(9,9) + 0 &= (70)(7,67) + 10v_2 \checkmark \\
 v &= 15,61 \text{ m.s}^{-1} \text{ right} \checkmark
 \end{aligned}$$

- 4.7 State Newton's second law. (1)

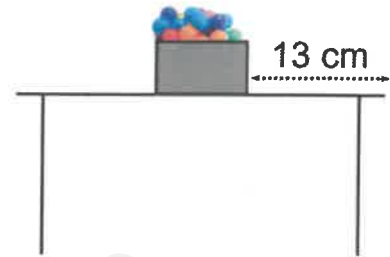
the net force acting on an object is equal to the rate of change of momentum $\checkmark$

- 4.8 If the contact time between Timon's foot and the ball was 0,7 seconds, calculate the magnitude of the net force his foot exerted on the ball. (3)

$$\begin{aligned}
 F_{\text{net}} \Delta t &= m \Delta v \checkmark \\
 F_{\text{net}} (0,7) &= 10(15,61 - 0) \checkmark \\
 F_{\text{net}} &= 223 \text{ N} \checkmark
 \end{aligned}$$

Not to be outdone, Dimitri is working with another of the clowns who is teaching him to throw water balloons at a box of very light plastic juggling balls.

The box is at rest on a rough table surface, and if balloons are thrown at just the right speed, the box stops at the edge of the table. The mass of the box and the plastic balls is 600 g.



4.9 State the *work-energy theorem*.

(1)

the work done by a net force on an object is equal to the change in kinetic energy of the object ✓

4.10 Dimitri's water balloon causes the box to start moving at $1,2 \text{ m.s}^{-1}$ and he does indeed get the box to just reach the end of the table. Calculate the magnitude of the frictional force the table exerts on the box.

(3)

$$W_{\text{net}} = \Delta E_k \quad \therefore F_{\text{net}} \cdot s = \Delta E_k \quad \checkmark$$

$$F_f (13 \times 10^{-2}) = \frac{1}{2} (0,6) (1,2)^2 \quad \checkmark$$

$$F_f = 3,32 \text{ N} \quad \checkmark$$

Dimitri decides he would rather try two new strategies to hit and stop the box :

Plan A: He throws a heavy piece of clay against the box. It sticks to the box and they move off together on the same table as before

Plan B: He applies a force of 5 N at an angle of 30° to the horizontal to the box over a distance of 13 cm on a different table with a frictional force of 2 N

4.11 If the box of plastic balls starts to move at the same velocity as before, will it still just reach the edge of the table in plan A? Explain your answer fully.

(2)

no; mass has increased $\therefore F_N$ increased

$\therefore F_f$ increased ✓

4.12 Define the work done on an object by a force. (1)

the product of the displacement and the component of the force parallel to the displacement

4.13 Calculate the work done by Dimitri in pushing the box in plan B. (3)

$$\begin{aligned} W_D &= F_{\text{ph}} \cdot s \\ &= F_D \cos \theta \cdot s \\ &= 5 \cos 30^\circ (13 \times 10^{-2}) \\ &= 0,56 \text{ J} \end{aligned}$$

30 MARKS

QUESTION 5

It just wouldn't be a physics paper without Star Wars. We journey back to the Clone Wars, where a young Jedi, Anakin Skywalker, is training his padawan Ahsoka on his home planet of Tatooine.



5.1 Define gravitational field. (1)

force acting per unit mass

5.2 Calculate the gravitational field on Tatooine which has a mass half of that of Earth and a diameter $\frac{3}{4}$ of the diameter of Earth. (3)

$$g = \frac{GM}{R^2}$$

$$g' = \frac{G(\frac{1}{2}M)}{(\frac{3}{4}R)^2}$$

$$\therefore g' = \frac{8}{9} \left(\frac{GM}{R^2} \right)$$

$$= \frac{\frac{1}{2}G}{\frac{9}{16}R^2}$$

$$= 8,71 \text{ m.s}^{-2}$$

5.3 If Anakin has a weight of 784 N on Earth, calculate his weight on Tatooine. (2)

$$F_g = mg$$

$$784 = m(9,8)$$

$$\therefore m = 80 \text{ kg} \quad \checkmark$$

$$F_g' = mg'$$

$$= (80)(8,71)$$

$$= 696,8 \text{ N} \quad \checkmark$$

Upon receiving a distress call from Master Windu, Anakin and Ahsoka board the Twilight and Obi-Wan climbs into his Delta 7 and they take to the skies. At a point in their journey they are on either side of an asteroid as indicated below, and at that exact position the net gravitational force on the asteroid is zero.



5.4 Calculate the distance that Delta 7 is from the asteroid at that instant. (4)

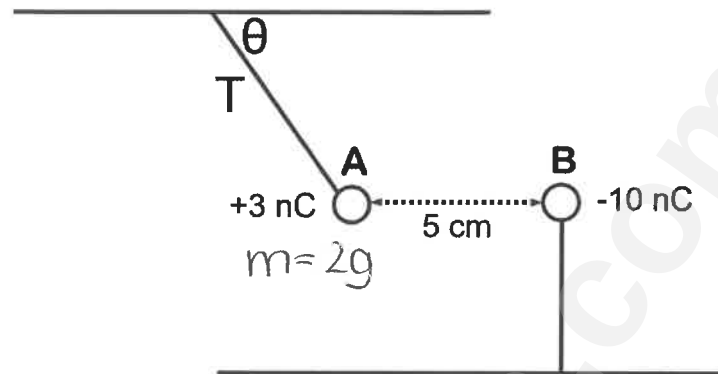
$$F_1 = F_2$$

$$\frac{Gm_1m_2}{r^2} = \frac{Gm_1m_2}{r^2} \quad \checkmark$$

$$\frac{(6,7 \times 10^{-11})(70\,000)}{(10 \times 10^3)^2} = \frac{(6,7 \times 10^{-11})(30\,000)}{x^2} \quad \checkmark$$

$$x = 6546,54 \text{ m} \quad \checkmark$$

They return to Tatooine after rescuing Master Windu and continue Ahsoka's training. Anakin charges two spheres A and B as shown below. He mounts Sphere B on an insulated stand and attaches sphere A, with a mass of 2 g, to a light inextensible string, making angle θ with the roof due to its attraction to sphere B.



5.5 State Coulomb's law.

(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 ✓

5.6 Calculate the electrostatic force sphere B exerts on sphere A.

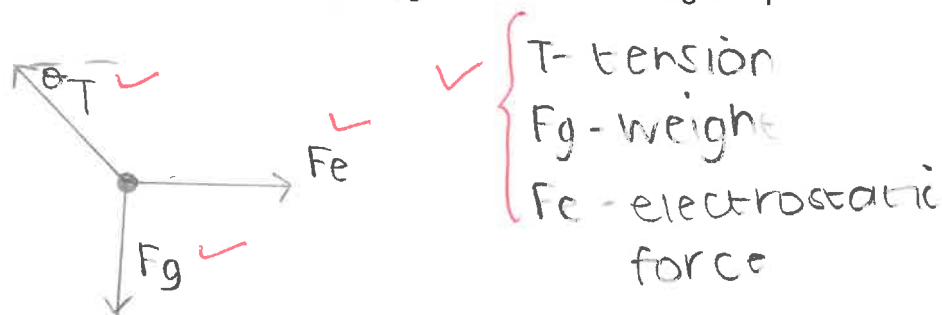
(4)

$$F = \frac{kq_1q_2}{r^2} \quad \checkmark$$

$$= \frac{(9 \times 10^9)(3 \times 10^{-9})(10 \times 10^{-9})}{(5 \times 10^{-2})^2} \quad \checkmark$$

$$= 1,08 \times 10^{-4} \text{ N} \quad \text{attractive right} \quad \checkmark$$

- 5.7 Draw a full-labelled free body diagram showing all the forces acting on sphere A. (4)



- 5.8 Calculate the angle, θ . (4)

$$F_e = T \cos \theta$$

$$F_g = T \sin \theta$$

$$1,08 \times 10^{-4} = T \cos \theta$$

$$(2 \times 10^{-3}) 8,71 = T \sin \theta$$

$$\therefore 1,74 \times 10^{-2} = T \sin \theta$$

$$\therefore 1,74 \times 10^{-2} = \frac{1,08 \times 10^{-4}}{\cos \theta} \cdot \sin \theta$$

$$161,30 = \tan \theta$$

$$\therefore \theta = 89,64^\circ$$

23 MARKS

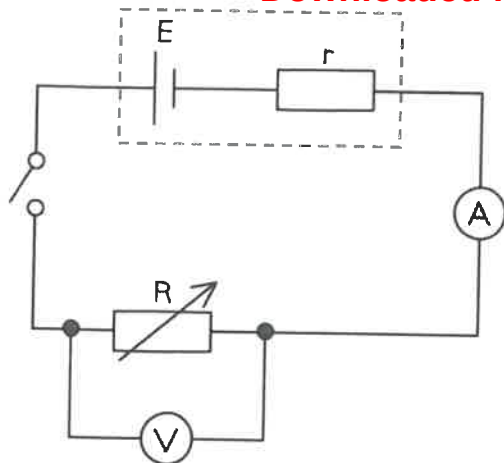
QUESTION 6

It's 1989, and at the High School science fair, 9 year old Sheldon Cooper is devastated when his asteroid impact avoidance project loses to another student's Van de Graaf generator and vows to quit science. His brother Georgie knows it helps Sheldon when he gets to explain things, so he asks for help with understanding internal resistance.

Sheldon sets up a circuit, which includes a rheostat, allowing him to vary the resistance.

He tabulates the data he has gathered as shown when the switch is closed:



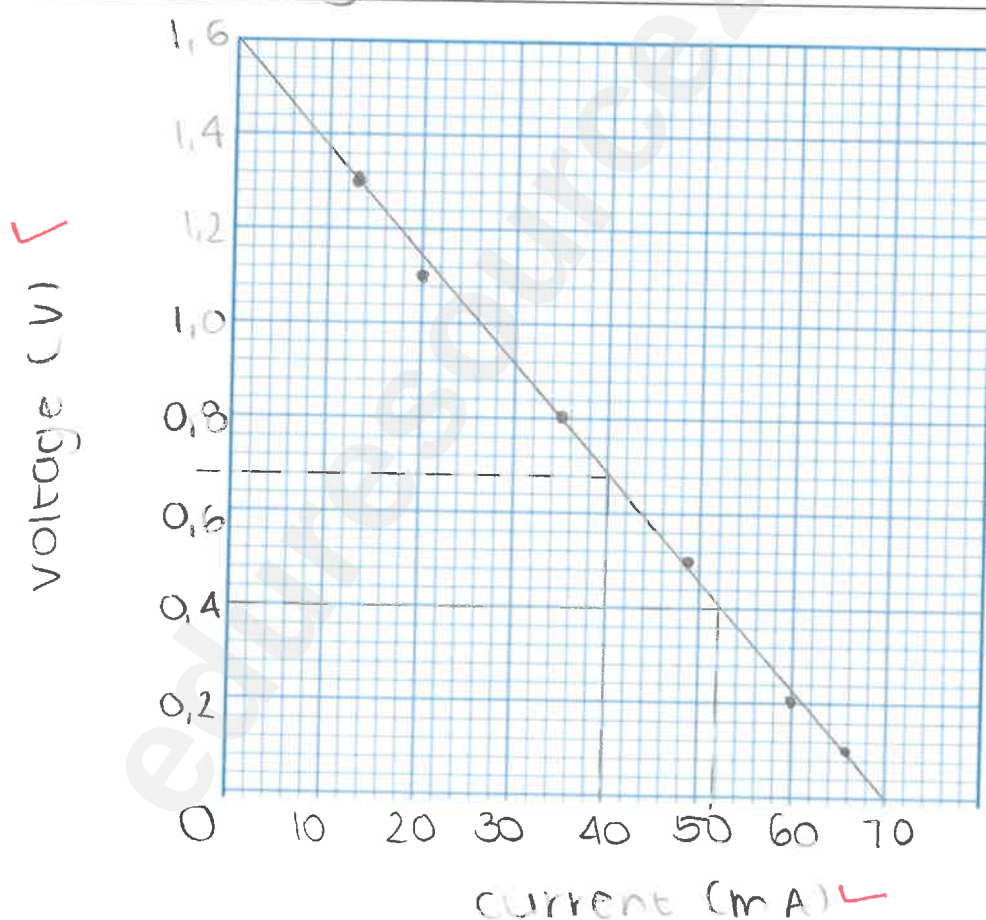


Voltage (V)	Current (mA)
1,3	13
1,1	20
0,8	35
0,5	49
0,2	60
0,1	66

6.1 Plot Sheldon's results on the graph paper below, with current as the independent variable.

(7)

Graph showing relationship between voltage and current



scale ✓
plotting ✓✓
LOBF ✓

6.2 Define *emf*.

(1)

the total energy supplied per coulomb of charge by the cell ✓

6.3 Determine the emf of the battery from your graph. (1)

$$y\text{-axis} = 1,6 \text{ V} \checkmark$$

6.4 Calculate the gradient of your graph, showing clearly which points you used. Use this value and a suitable equation to determine the internal resistance of the battery. (3)

$$y = mx + c$$

$$\begin{aligned} \text{emf} &= I(R+r) \\ &= IR + Ir \end{aligned}$$

$$\therefore IR = -Ir + \text{emf}$$

$$\begin{array}{cccc} y & x & m & c \\ \downarrow & \downarrow & \downarrow & \downarrow \\ & & & \checkmark \end{array}$$

$$\therefore \text{grad} = -r$$

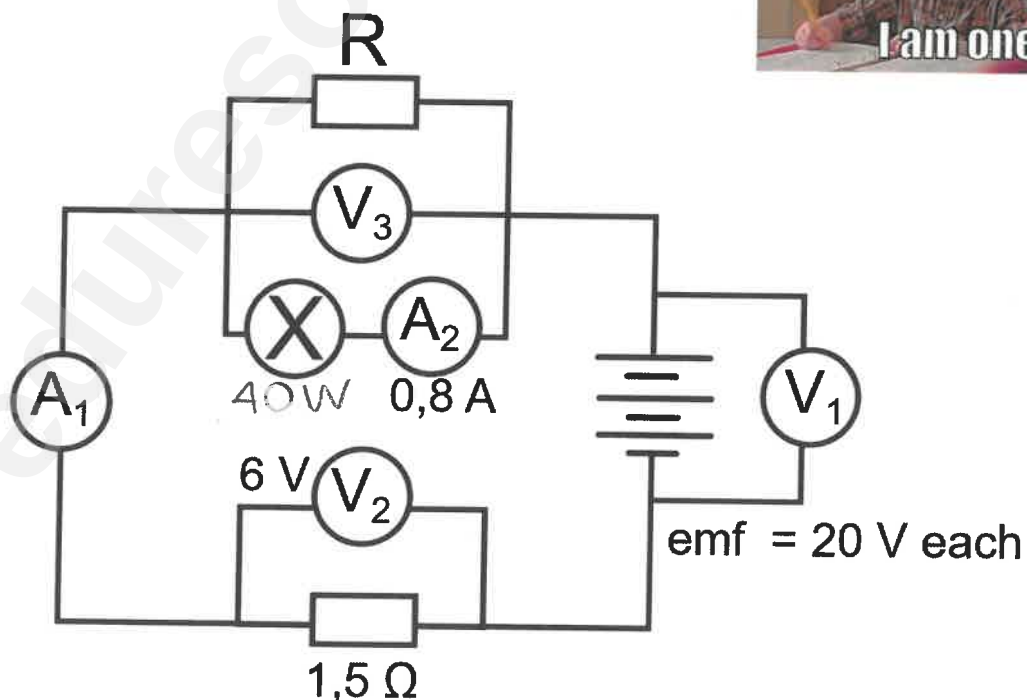
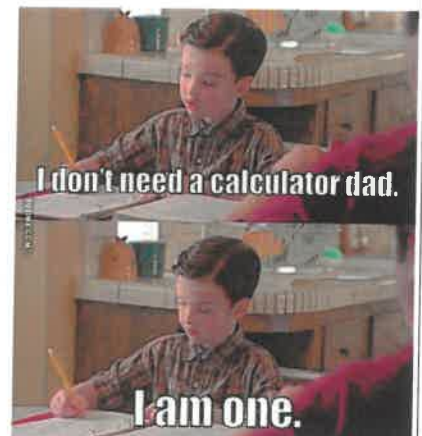
$$-r = \Delta y / \Delta x$$

$$= \frac{0,4 - 0,1}{(52 - 40) \times 10^{-3}} \checkmark$$

$$-r = -25$$

$$\therefore r = 25 \, \Omega \checkmark$$

Not realizing that Georgie is even more confused than before, Sheldon continues with the next circuit. The battery has an internal resistance, r , and an emf of 20 V per cell. The reading on ammeter A_2 is 0,8 A and the voltage across the $1,5 \, \Omega$ resistor is 6V. R is a resistor of unknown value and the power rating of the bulb is 40 W.



6.5 Define power.

(1)

rate at which work is done ✓

6.6 Calculate the resistance of the bulb.

(3)

$$P = I^2 R \quad \checkmark$$

$$40 = (0,8)^2 R \quad \checkmark$$

$$R = 62,5 \, \Omega \quad \checkmark$$

6.7 Calculate the reading on V_3 .

(3)

$$V_3 = IR \quad \checkmark$$

$$= (0,8)(62,5) \quad \checkmark$$

$$= 50 \, V \quad \checkmark$$

6.8 Calculate the reading on ammeter A_1 .

(2)

$$R = V/I \quad \checkmark$$

$$1,5 = 6/I \quad \checkmark$$

$$I = 4 \, A \quad \checkmark$$

6.9 Calculate the value of resistor R .

(3)

$$R = V/I \quad \checkmark$$

$$= \frac{50}{(4-0,8)} \quad \checkmark$$

$$= 15,63 \, \Omega \quad \checkmark$$

6.10 Define potential difference.

(1)

work done per unit positive charge ✓

- 6.11 Determine the reading on voltmeter V_1 and hence the value of the internal resistance. (4)

$$\begin{aligned} V_1 &= V_2 + V_3 \\ &= 50 + 6 \\ &= 56 \text{ V} \end{aligned}$$

$$\begin{aligned} V_{\text{lost}} &= Ir \\ (60 - 56) &= 4r \\ r &= 1 \Omega \end{aligned}$$

- 6.12 Sheldon says that the lost volts would decrease if the branch containing resistor R is removed. Do you agree with him? Explain your answer fully. (2)

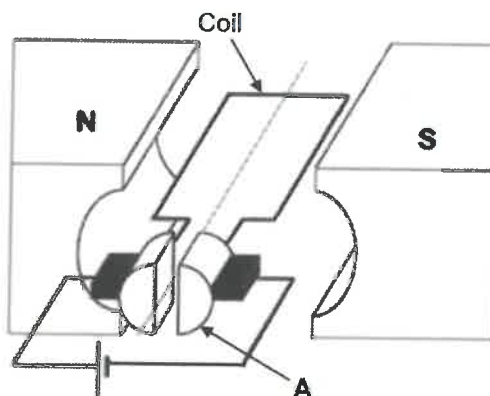
Re would increase
 $\therefore$ It would decrease
 $\therefore$ V_{lost} decreases
 $\therefore$ agree

31 MARKS

QUESTION 7

Optimus Prime has led the Autobots in the war against Megatron and the Decepticons for many years, but they have finally decided to bury their differences and open up an electronics store together.

Bumblebee is focussing on the DC motor shown below:



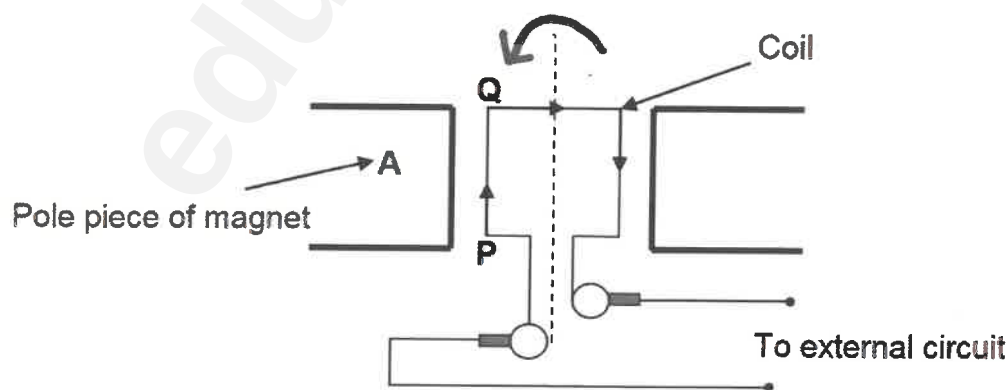
- 7.1 What is the energy conversion in a DC motor? (1)
electrical $\rightarrow$ mechanical ✓
- 7.2 What is the name of the component labelled A? (1)
split-ring commutator ✓
- 7.3 What is the function of component A? (1)
reverses the direction of the current in the loop every half rotation ✓
- 7.4 Does the armature in Bumblebee's motor rotate clockwise or anticlockwise? (1)
anti-clockwise ✓
- 7.5 Give two ways Bumblebee can make the motor more effective. (2)
- stronger magnets ✓
- stronger current ✓
- more turns on the loop

Ratchet knows that since their shop is located in Boksburg they will be subject to loadshedding, and therefore is studying the basics of an AC generator.



Ratchet
fixing
Bumblebee's
legs

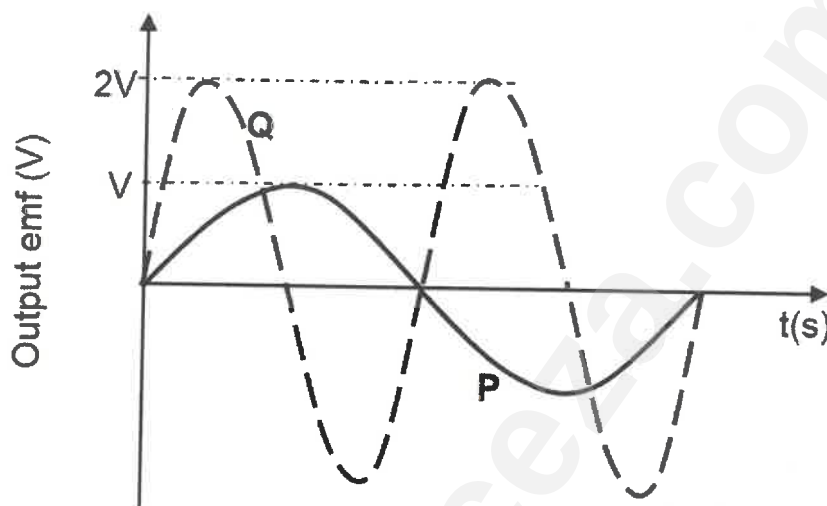
Ratchet
fixing
Bumblebee's
voice box



- 7.6 If Ratchet rotates the armature of the generator as shown in the diagram, which pole of the permanent magnet is found at position A? (1)

South ✓

He plots the output of his generator below as graph P. After making a change to the same generator, the output voltage is represented as Q.



- 7.7 State Faraday's law of electromagnetic induction. (1)

the induced emf is directly proportional to the rate of change of magnetic flux ✓

- 7.8 Explain how current is produced in the coil of Ratchet's generator. (3)

- rotation of the loop produces a change in magnetic flux ✓
- a change in magnetic flux induces an emf (Faraday's law) ✓
- emf produces current ✓

7.9 What change did Ratchet make to his generator to produce graph Q ?

(1)

doubled the speed of rotation ✓

Ironhide knows that the AC current Ratchet's generator produces is very useful as it will allow the electronics store to step voltage up and down as needed.

7.10 Megatron needs a voltage of 4000 V to be produced from the 12 V ; 2 A generator Ironhide has made. Calculate the current such a transformer will produce.

(3)

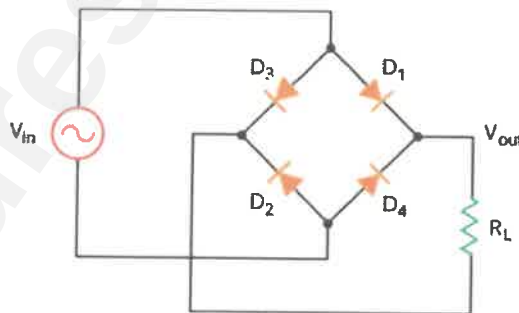
$$V_p I_p = V_s I_s \quad \checkmark$$

$$(12)(2) = 4000(I_s) \quad \checkmark$$

$$I_s = 6 \times 10^{-3} \text{ A} \quad \checkmark$$

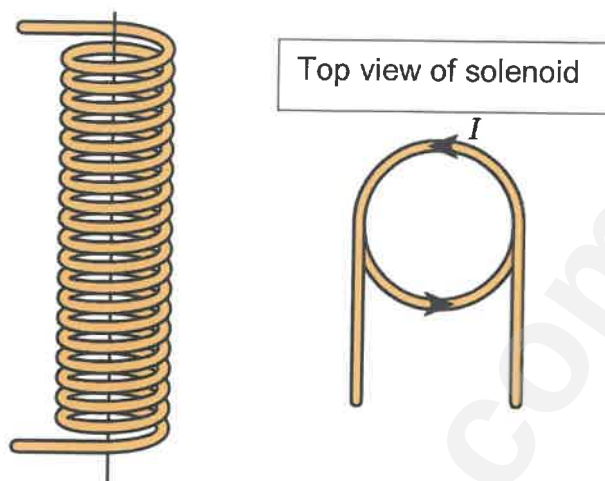
7.11 Megatron needs the current to be rectified to DC. Name the component in his circuit shown below that will allow for rectification, and explain whether he has connected it correctly or not.

(2)



- bridge rectifier (diodes) ✓
- diodes D2 and D3 should be reversed ✓

Optimus Prime is watching all of this in amusement while dropping a magnet through a coil of wire and catching it as it falls out the bottom. The top view of the solenoid is shown alongside the solenoid itself.



7.12 State Lenz's law.

(1)

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

7.13 Which pole of the magnet was Optimus dropping down towards the solenoid?

(1)

north ✓

19 MARKS

QUESTION 8

For reasons that defy all logic, Homer Simpson is employed as a safety inspector at the Springfield nuclear plant. As is par for the course, he fails to do his job properly resulting in a radiation leak, allowing x-rays to escape containment.



8.1 Define a photon.

(1)

discrete packet of light energy ✓

8.2 Calculate the wavelength of an x-ray photon with a frequency of 2×10^{16} Hz.

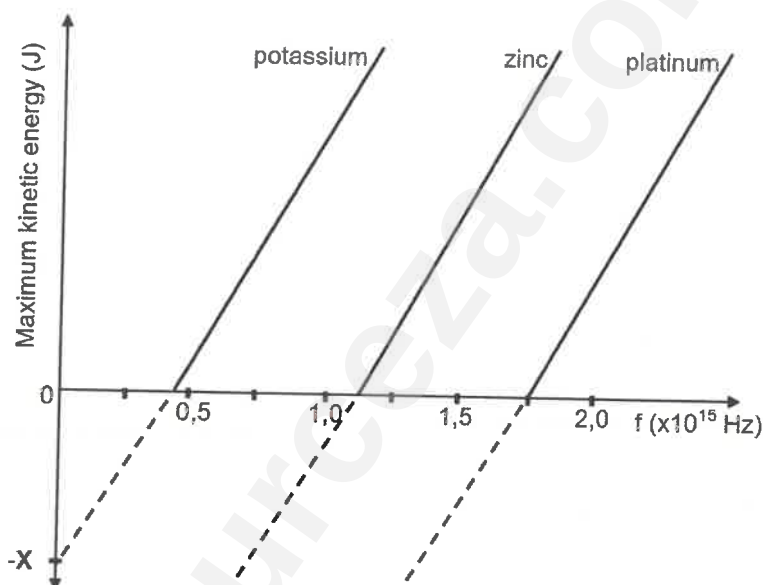
(3)

$$c = f\lambda$$

$$3 \times 10^8 = (2 \times 10^{16})\lambda$$

$$\lambda = 1,5 \times 10^{-8} \text{ m}$$

The graph below shows the kinetic energy vs frequency of three metals, namely potassium, zinc and platinum.



8.3 Define work function.

(1)

minimum amount of energy needed to emit an electron from the surface of a metal ✓

8.4 Calculate the work function of platinum.

(3)

$$W_0 = hf_0$$

$$= (6,6 \times 10^{-34}) (1,75 \times 10^{15})$$

$$= 1,16 \times 10^{-18} \text{ J}$$

- 8.5 Calculate the velocity of ejected electrons if the x-rays were shone onto **platinum** metal.

(6)

$$E = W_0 + E_{k \max}$$

$$(6,6 \times 10^{-34})(2 \times 10^{16}) = 1,16 \times 10^{-18} + E_{k \max}$$

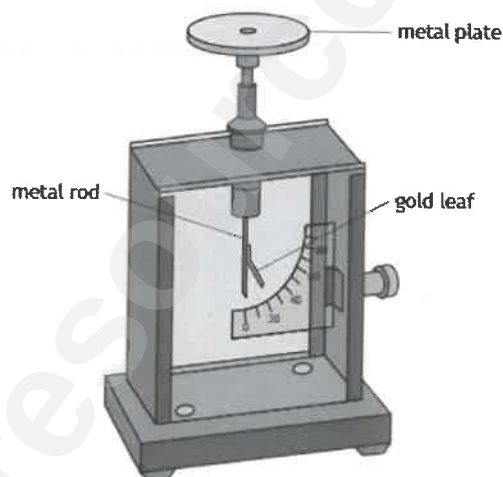
$$E_{k \max} = 1,20 \times 10^{-17} \text{ J}$$

$$E_{k \max} = \frac{1}{2}mv^2$$

$$1,2 \times 10^{-17} = \frac{1}{2}(9,1 \times 10^{-31})v^2$$

$$v = 5,14 \times 10^6 \text{ m.s}^{-1}$$

Homer somehow manages to direct the x-rays to the cap of a nearby **charged** electroscope and he watches as the leaf **rises**.



- 8.6 What charge was the electroscope originally? Explain your answer fully.

(2)

- positive
- when e^- are ejected the electroscope becomes more positively charged

- 8.7 All of this leaking radiation causes the red warning light to start flashing in the control room. When this red light with a wavelength of 800 nm reaches a piece of metal on Homer's desk it causes the metal to emit photoelectrons with a certain kinetic energy. The warning light suddenly switches off and is replaced with an emergency green light which has a wavelength of 500 nm. This green light causes the kinetic energy of the photoelectrons to double.

Calculate the work function of the metal.

(5)

$$E_1 = hc / 800 \times 10^{-9} = 2,48 \times 10^{-19} \text{ J}$$

$$E_2 = hc / 500 \times 10^{-9} = 3,96 \times 10^{-19} \text{ J}$$

$$E = W_0 + E_k$$

$$2,48 \times 10^{-19} = W_0 + E_k \quad \text{--- (1)}$$

$$3,96 \times 10^{-19} = W_0 + 2E_k \quad \text{--- (2)}$$

$$3,96 \times 10^{-19} = W_0 + 2(2,48 \times 10^{-19} - W_0)$$

$$\therefore W_0 = 1 \times 10^{-19} \text{ J} \\ (9,9 \times 10^{-20})$$

- 8.8 What effect would x-rays with the same intensity as the green light reaching the metal have on

8.8.1 the number of photoelectrons emitted from the piece of metal?

(1)

no effect

8.8.2 the speed at which the electrons are ejected from the piece of metal?

(1)

increases

23 MARKS