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28 AUGUST 2020

MICHAELHOUSE

PHYSICAL SCIENCES: PAPER 1 (PHYSICS)

Time: 3 hours

200 marks

Name: _____

Examiner: Mr E Jeffrey

Moderator: Mr C Sliedrecht

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
 - a question paper of 16 pages; and
 - an Answer Booklet; and
 - a Data and Formulae Sheet of 2 sides.Please make sure that your question paper is complete.
2. **Write your name on the Answer Booklet.**
3. Read the questions carefully.
4. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the Answer Grid.
The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:
Here the answer C has been marked.

A	B	C	D
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5. Use the data and formulae whenever necessary.
6. **START EACH QUESTION ON A NEW PAGE.**
7. Show your working in all calculations.
8. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
9. Where appropriate express answers to TWO decimal places, unless otherwise stated.
10. It is in your own interest to write legibly and to set your work out neatly.

The use of other IEB teacher's questions, in whole or in part, is gratefully acknowledged.

QUESTION 1

MULTIPLE CHOICE

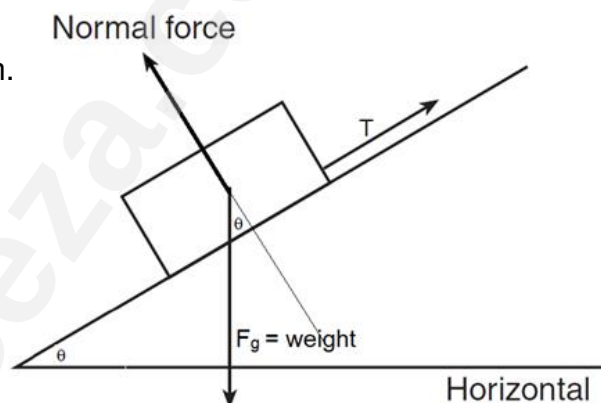
Answer these questions on the multiple-choice Answer Sheet. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

1.1 Which of the following are the base units for impulse?

- A kg.m.s^{-1}
- B kg.m.s^{-2}
- C N.m
- D N.s

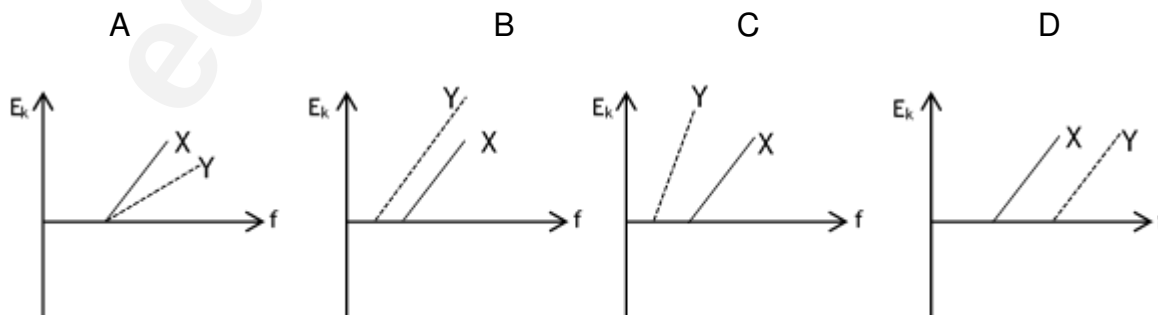
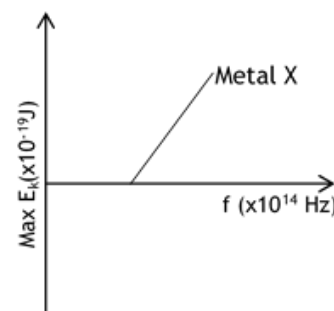
1.2 A force T is required to keep a body at rest on a frictionless inclined plane as in the sketch. The magnitude of T is given by:

- A $F_g \tan \theta$
- B $F_g \sin \theta$
- C F_g
- D $F_g \cos \theta$



1.3 Light of varying frequencies was shone onto the surface of a piece of Metal X. The graph alongside shows the maximum kinetic energy of the ejected photoelectrons for the various frequencies of light used, extrapolated back to the y-axis.

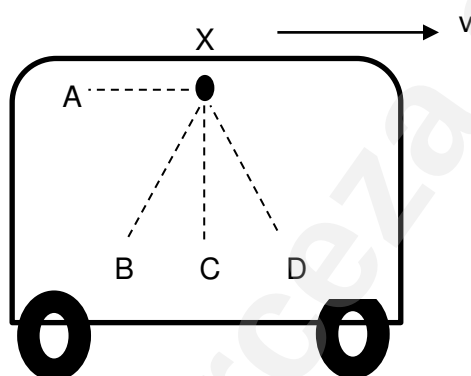
Which comparison correctly shows the extrapolated graph that would be obtained for the same experiment done with Metal Y, which has a work function that is half that of Metal X.



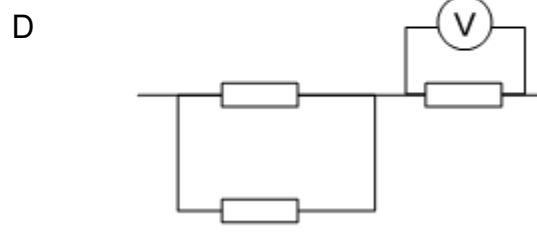
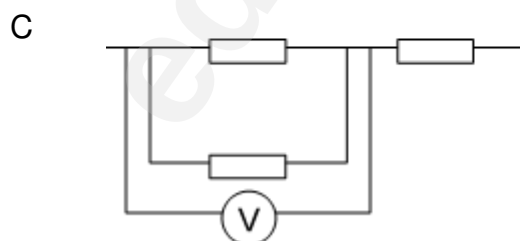
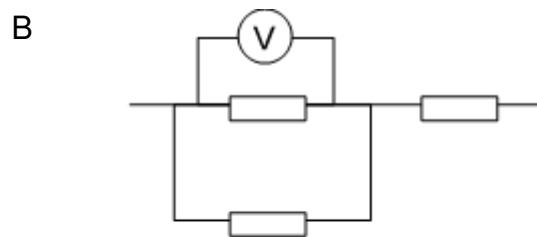
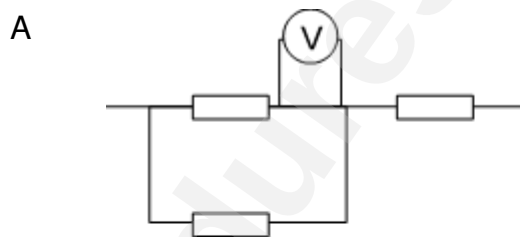
- 1.4 A Michaelhouse boy uses a flyswatter to hit a fly. Compared to the magnitude of the force that the flyswatter exerts on the fly, the magnitude of the force that the fly exerts on the flyswatter during the collision, is ...

- A zero
- B smaller but not zero
- C bigger
- D the same

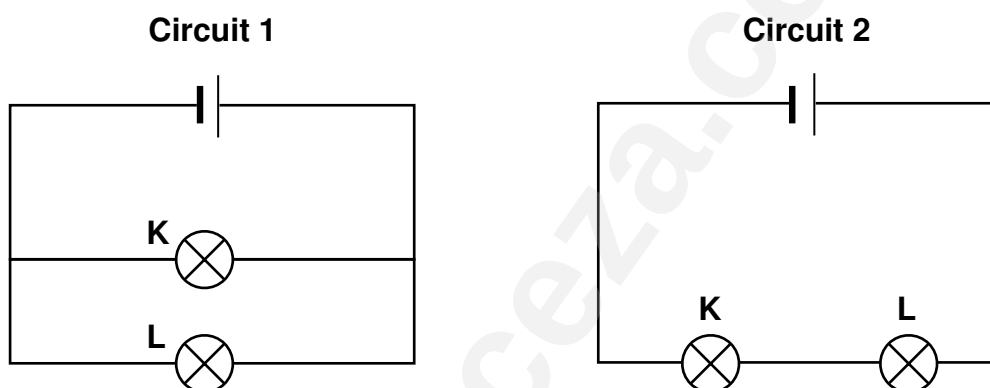
- 1.5 A ball is dropped from point X near the ceiling of a railway coach travelling at constant speed v . The ball will most probably land at point ...



- 1.6 A voltmeter is connected across different points in a network of identical resistors as shown below. The emf supplied to the network is constant. In which option is the voltmeter reading the highest?



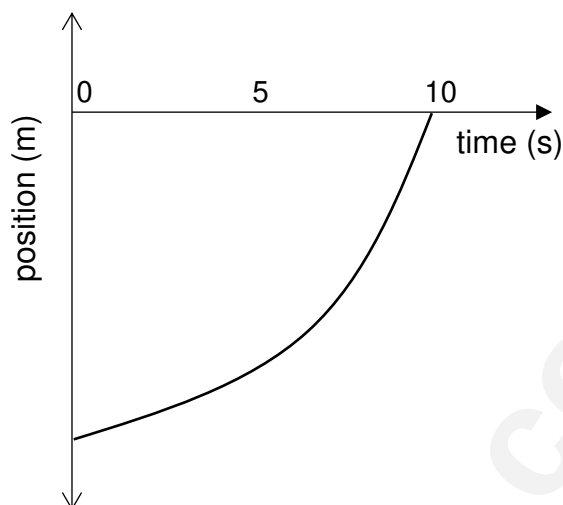
- 1.7 An athlete runs 300 m due north at $1,5 \text{ m.s}^{-1}$ and then 400 m due east at $2,0 \text{ m.s}^{-1}$. What is the average speed for her run?
- A $1,25 \text{ m.s}^{-1}$
 B $1,5 \text{ m.s}^{-1}$
 C $1,75 \text{ m.s}^{-1}$
 D $2,0 \text{ m.s}^{-1}$
- 1.8 The same cell with no internal resistance is connected in turn to each of the two circuits shown below. Bulb **K** has twice the resistance of Bulb **L**.



Which statement is true regarding the brightness of Bulb **K** compared with that of Bulb **L** in each of these circuits?

- A **L** is brighter than **K** in circuit 1.
 B **K** is brighter than **L** in circuit 1.
 C **L** is brighter than **K** in circuit 2.
 D **K** is brighter than **L** in both circuits.
- 1.9 Which of the following is **true** concerning Newton's Law of Universal Gravitation?
- A The force between two masses can be attractive or repulsive
 B The magnitude of the force between two masses is directly proportional to the sum of the masses
 C The magnitude of the force between the two masses is inversely proportional to the square of the distance between the masses' centers
 D $G = 6,67 \times 10^{-11} \text{ N.m}^2.\text{kg}^{-2}$ only on Earth.

- 1.10 Refer to the following position vs. time graph for the motion of a car travelling in a straight line on a horizontal surface. North is the positive direction.



Which one of the following statements is **false**?

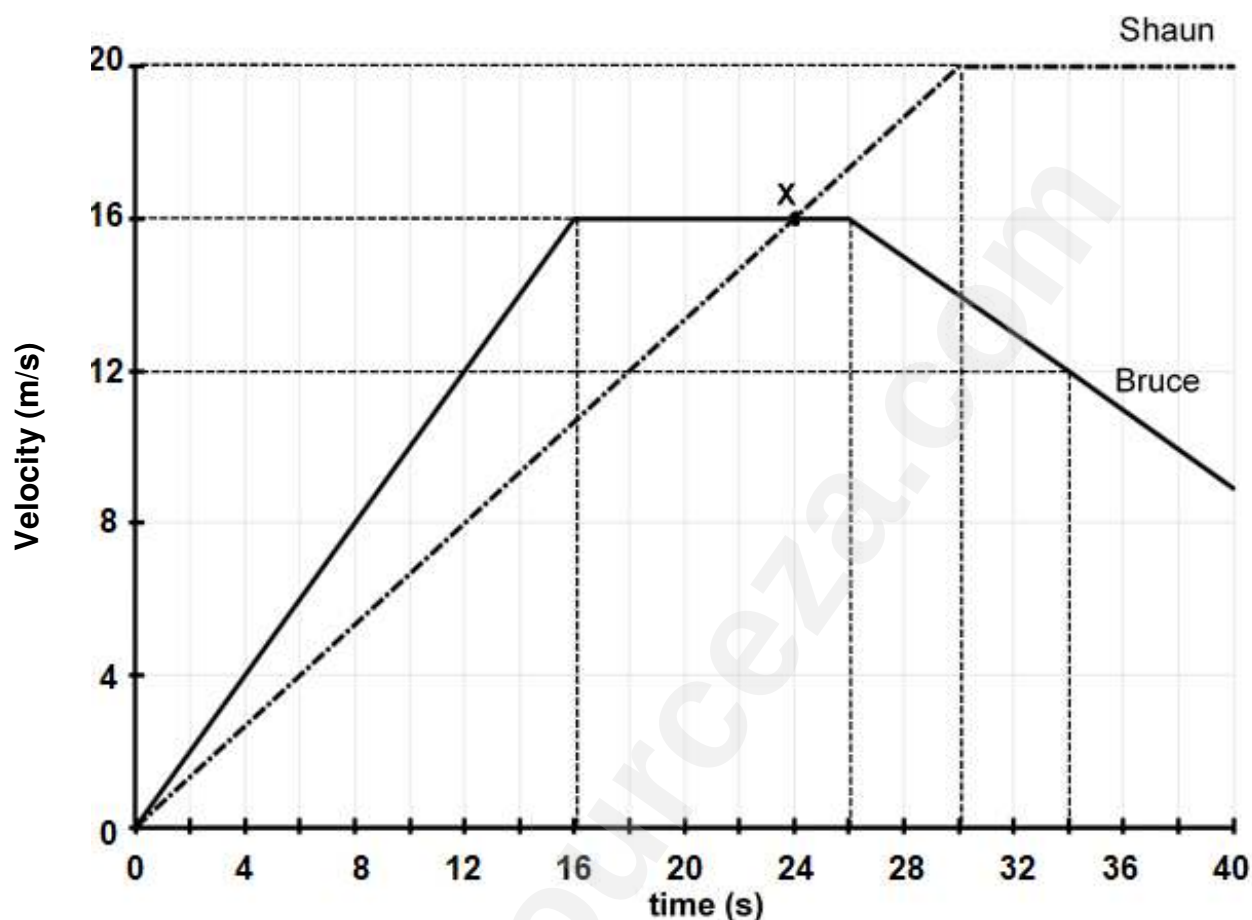
- A The average velocity of the object over the full journey is the same as the instantaneous velocity of the object at $t = 5$ s.
- B The magnitude of the average velocity and the average speed are the same.
- C The object is *travelling* south, with decreasing velocity.
- D The object is *travelling* north, with increasing velocity.

[2 X 10 = 20]

PLEASE TURN OVER

QUESTION 2

- 2.1 Two cyclists, Bruce and Shaun, challenge each other to a race down the flat straight road, along the avenue of trees called "Warriors Walk".
The velocity - time graphs for both Bruce and Shaun cycling the race are shown below.



2.1.1 Define *acceleration*. (2)

2.1.2 Use the graph to:

- determine the magnitude of Bruce's acceleration during the first 16 s of the race. (3)
- describe Bruce's motion between 16 s and 26 s. (2)
- calculate how far Bruce cycled in 34 s. (4)

2.1.3 The two graphs intersect at point X.
What can you conclude about the cyclists at that point? (1)

- 2.2 The Michaelhouse “Bog Stream” is home to the Raucous Toad.
This toad has the ability to jump.



When this toad is startled, it crouches down and then pushes on the ground accelerating vertically up at $3,5 \text{ m.s}^{-2}$ for a distance of 7 cm while it straightens its legs. **Only** when the legs are fully straightened, the toad leaves the ground and rises into the air.

- 2.2.1 Define velocity. (2)
- 2.2.2 Identify the action-reaction pair of forces involved in the process of the toad jumping. (2)
- 2.2.3 State the name of the physics law that your answer to question 2.2.2 corresponds with? (1)
- 2.2.4 Explain why the toad accelerates upwards even though the forces in Question 2.2.2 are equal. Use one of Newton's laws to help you in your explanation. (4)

Treat the toad as a single object for the following questions.

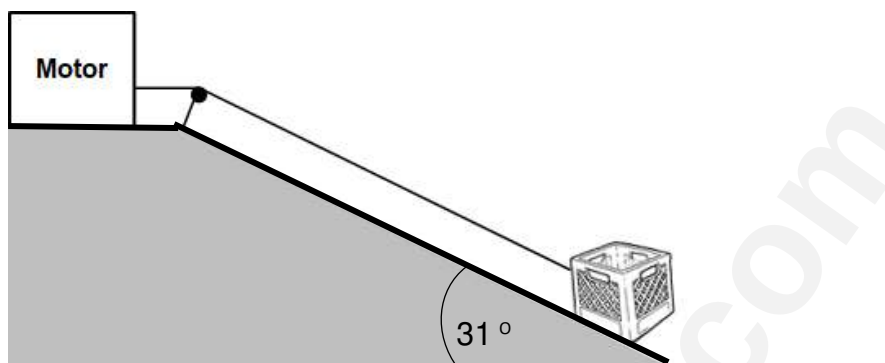
- 2.2.5 At what velocity does the toad leave the ground? (4)
- 2.2.6 Calculate the time it takes for the toad to reach the highest point of its jump. (4)
- 2.2.7 How long is the toad in the air for? (2)

[31]

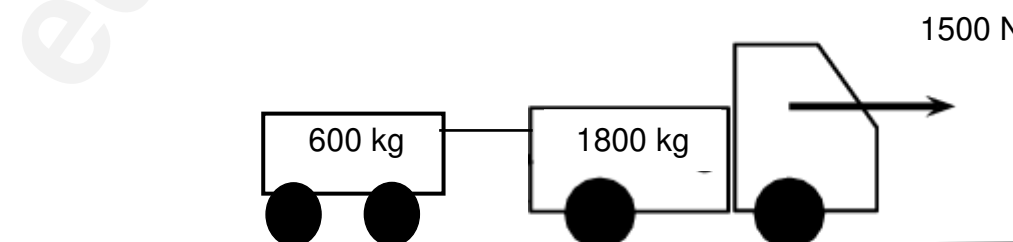
PLEASE TURN OVER

QUESTION 3

- 3.1 At the “Old Balgowan Farm” a crate is pulled up an inclined slope, moving from the bottom of the hill to the top. The crate has a mass of 15 kg and can take a maximum load of 35 kg. The motor pulls the crate with 300 N up the slope, which has a coefficient of static friction of 0,2. The crate experiences a frictional force of 10 N.



- 3.1.1 Draw a free body diagram of the crate while it moves up the slope. (3)
- 3.1.2 State Newtons Second Law. (2)
- 3.1.3 The crate accelerates at $0,81 \text{ m}\cdot\text{s}^{-2}$ when fully loaded. Prove that the angle of the incline is about 31° . (5)
- 3.1.4 Suggest **one** way in which the crate can be accelerated faster up the incline? (2)
- 3.1.5 How long is the incline if the crate reaches a maximum height of 25 m? (3)
- 3.1.6 What is the tension in the cable when the crate is **stationary**? (6)
- 3.1.7 How would the tension in the cable compare to the tension calculated in question 3.1.6 if μ was changed to 0,8? Write only; **more than**, **less than** or **equal to**. (1)
- 3.2 These crates are then loaded on to a truck and trailer and taken to market. The tow bar between a truck and its trailer is horizontal. The total mass of the truck is 1800 kg and the total mass of the trailer is 600 kg. The truck’s engine applies a forward force of 1500 N. **Ignore the effects of friction.**

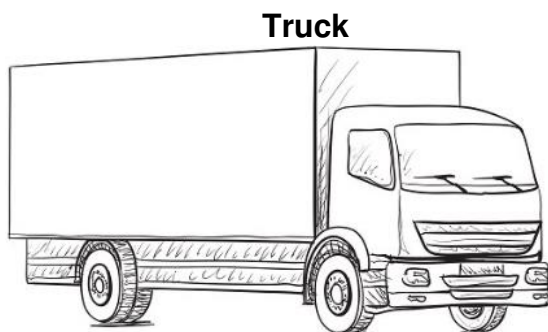


Calculate the **acceleration** of the truck and the **tension** in the tow bar, T , between the truck and the trailer.

(5)
[27]

QUESTION 4

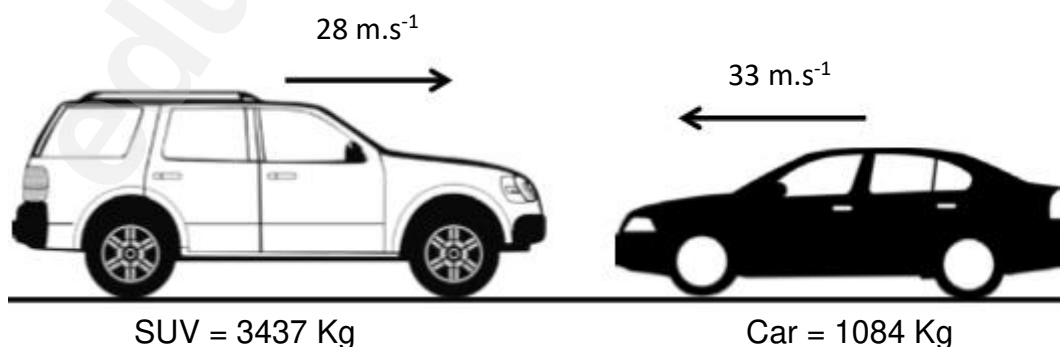
- 4.1 A truck of mass 3 500 kg was driving from Nottingham Road to Howick at 20 m.s^{-1} . At the Tweedie T-Junction, the driver crashed straight into the roadside barrier. The truck was stopped by the barrier within a distance of 0,8 m.



Barrier after being crashed into

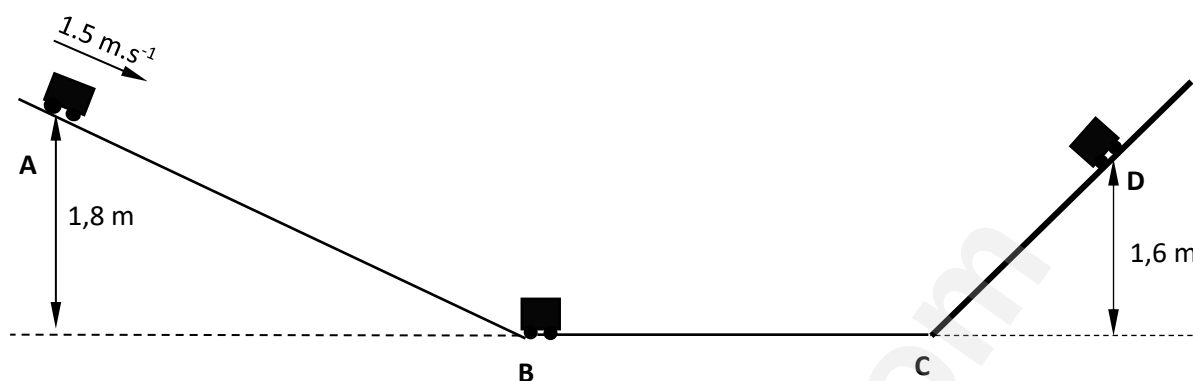


- 4.1.1 Calculate the **magnitude** of the change in momentum of the truck during the accident. (3)
- 4.1.2 State the work-energy theorem. (2)
- 4.1.3 Use the **work-energy theorem** to calculate the average resultant force that brought the truck to rest. (4)
- 4.1.4 Use your answers from Questions 4.1.1 and 4.1.3 to calculate how long it took the truck to come to rest. (3)
- 4.1.5 Fortunately the driver (who was wearing a seatbelt) was not injured during the accident. Explain why the driver would have been more seriously hurt if the same truck had stopped almost instantly. Use a relevant formula to help you in your explanation. (3)
- 4.2 A small car of mass 1 084 kg was travelling West at a speed of 33 m.s^{-1} . A large SUV of mass 3 437 kg was travelling East at a speed of 28 m.s^{-1} . The two vehicles collided head on with each other. Immediately after the collision, the small car was moving East at 16 m.s^{-1} .



- 4.2.1 Name the law you would use to calculate the velocity of the SUV immediately after the collision. (2)
- 4.2.2 Determine the velocity of the SUV, immediately after the collision. (4)

- 4.3 A toy car with a mass of 635 g is freewheeling down a frictionless inclined plane **AB**. It passes point **A** with a speed of $1,5 \text{ m.s}^{-1}$ as shown in the diagram below.



4.3.1 Define *mechanical energy*. (2)

4.3.2 If point **A** is 1,8 m above the ground, calculate the **speed** of the toy car at point **B**. (4)

The toy car now moves along the frictionless horizontal plane BC.

4.3.3 While the toy car is moving up **CD**, it experiences a frictional force of 1,2 N. Use the **law of conservation of energy** to calculate the length of the inclined plane **CD**. (6)

[33]

QUESTION 5



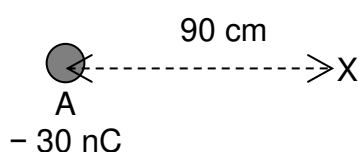
MARS  ONE

- 5.1 An astronaut that is a part of the **Human Settlement on Mars Project** has a mass of 87 kg on earth. When he goes on a space mission to Mars, he will weigh 324 N. The mass of Mars is $6,4 \times 10^{23}$ kg.

5.1.1 Calculate the gravitational acceleration, g , on Mars. (3)

5.1.2 Use ' g ' determined in 5.1.1 to calculate the radius of Mars. (4)

- 5.2 In the diagram below, point charge **A** has a charge of - 30 nC. This charged sphere, is held fixed in position on a horizontal, insulated surface .

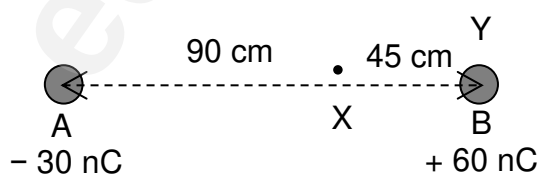


5.2.1 How many electrons were lost or gained for point charge **A** to have this charge? (Show your answer to 3 decimal places) (2)

5.2.2 Draw the electric field pattern produced by point charge **A**. (2)

5.2.3 Calculate the magnitude and direction of the **electric field strength** at position X, 90 cm away from point charge **A**. (4)

- 5.3 A second point charge **B** holding a charge of + 60 nC, is placed at position Y, 45 cm to the right of X, on the horizontal, insulated surface and is free to move.



5.3.1 State Coulomb's Law. (2)

5.3.2 Calculate the electrostatic force that B will experience due to A. (4)

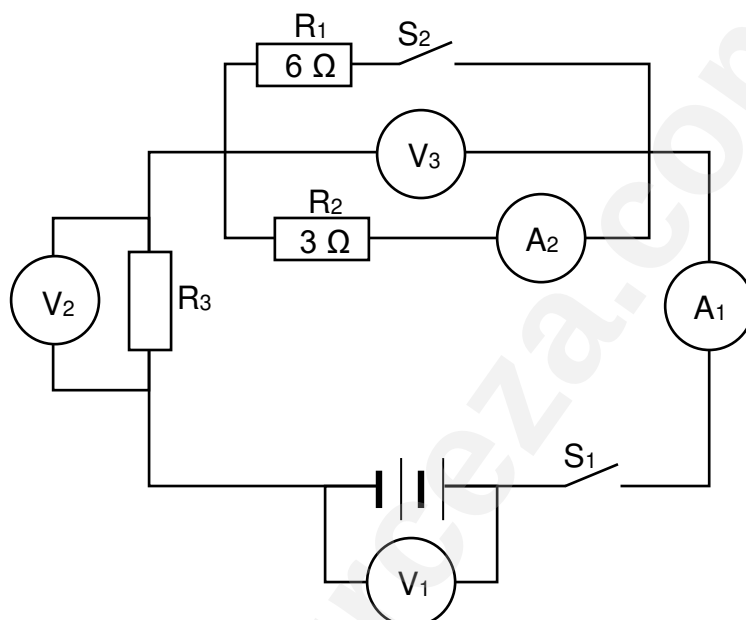
[21]

QUESTION 6

A circuit consists of a battery with an emf of 36 V and an unknown but significant internal resistance, three resistors, two ammeters and three voltmeters. The circuit is connected as shown below.

When both switches (S_1 and S_2) are closed,

- Voltmeter (V_1) measures a potential difference of 30 V.
- Ammeter (A_2) measures a current of 3 A.



- 6.1 Define *potential difference*. (2)
- 6.2 Calculate the reading on V_2 . (4)
- 6.3 Calculate the reading on ammeter A_1 . (4)
- 6.4 Calculate the quantity of charge that passes through the battery in 2 minutes. (3)
- 6.5 Calculate the internal resistance of the battery. (3)
- 6.6 Determine the power output of resistor R_3 when the circuit is connected for 1 minute. (3)

Switch S_2 is now opened.

- 6.7 How will the reading on A_1 change?
Write **increase**, **decrease** or **stay the same**. Explain your answer. (3)
- 6.8 How will the reading on V_1 change?
Write **increase**, **decrease** or **stay the same**. Explain your answer. (2)

[24]

QUESTION 7

7.1 Faraday's and Lenz's laws of electromagnetic induction state that:

$$\text{emf} = -\frac{N\Delta\Phi}{\Delta t}$$

7.1.1 State the meaning of the term $N\Delta\Phi$ and give its unit. (2)

7.1.2 Describe the significance of the negative sign. (1)

7.2 A student connects a lamp and a power supply to a transformer as shown in Diagram 1.

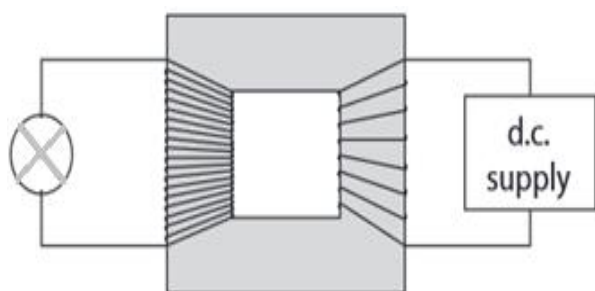


Diagram 1

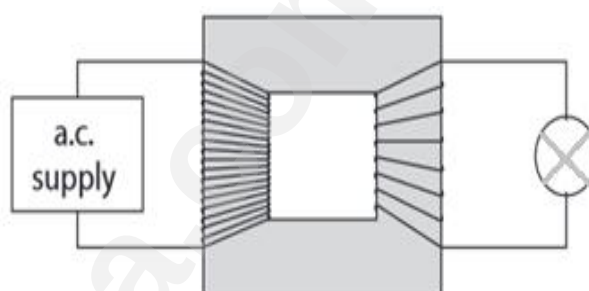


Diagram 2

The lamp does not glow.

He then connects the same lamp to the other side of the transformer and uses a different power supply, as in Diagram 2. Now the lamp glows.

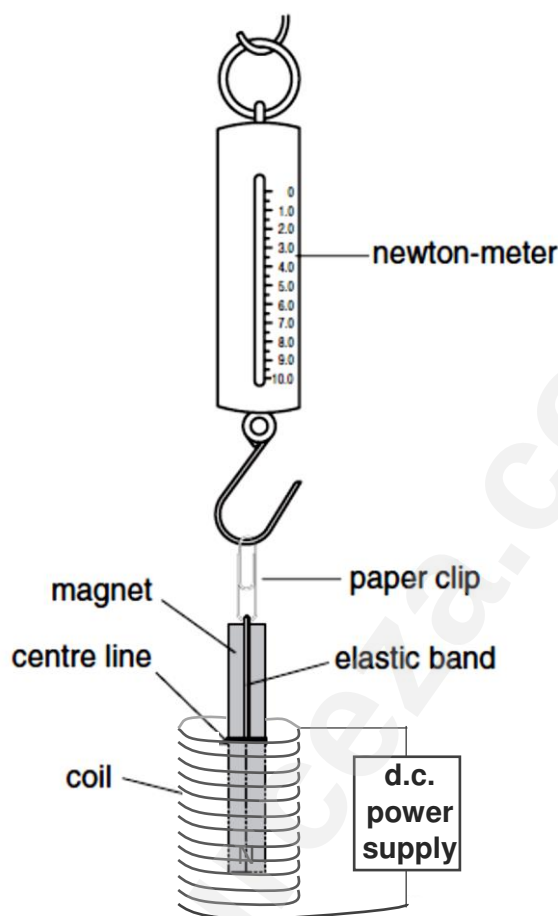
State why the lamp glows when connected as shown in Diagram 2 but does not glow when connected as shown in Diagram 1. (1)

7.3 A step-down transformer has 20 turns on one coil and 500 turns on the other. One end of the transformer is connected to a power supply and the other end to an appliance which needs 12 V.

Calculate the voltage of the power supply. (3)

PLEASE TURN OVER

- 7.4 A student carries out an investigation to find out how the force acting on a bar magnet suspended in a current carrying coil is related to the magnitude of the current in the coil.



A magnet was suspended from a newton-meter as shown. The position of the magnet was adjusted to ensure that the magnet was hanging inside the coil and the line at the centre of the magnet coincided with the top of the coil as shown alongside.

The coil was connected to a d.c supply and the current in the coil was adjusted to ensure values between 0 A and 3 A.

- 7.4.1 Consider the north side of the magnet to be inside the coil. When viewed from the top of the coil, **briefly explain** whether the current needs to flow **clockwise** or **anticlockwise** to ensure that the reading on the newton-meter increases. (3)

The following results were obtained by a student:

Current (A)	Force (N)
0,5	4,65
1,0	7,59
1,5	11,17
2,0	13,96
2,5	17,39

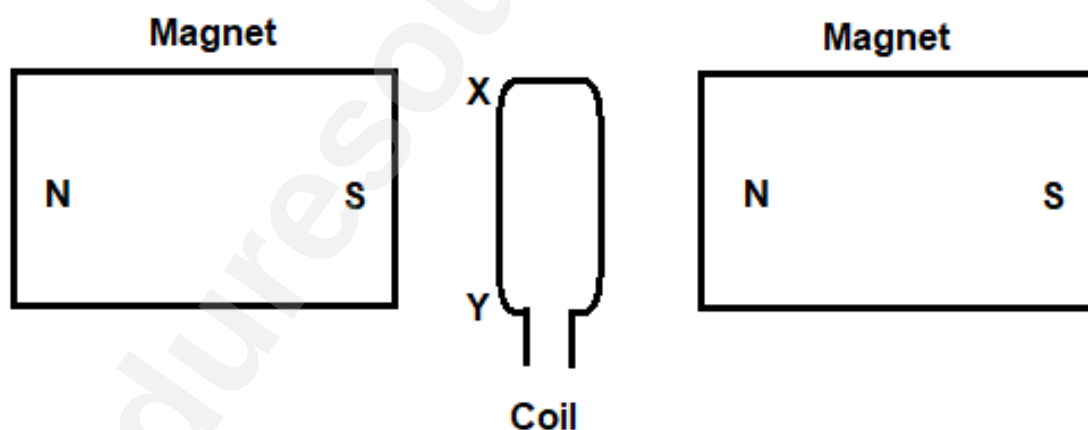
7.4.2 Plot a graph of the data in the table on the graph paper provided **on the answer sheet**. Include a line of best fit. The heading of the graph has been provided. (6)

7.4.3 A student suggests that there is a directly proportional relationship between the variables. Does your graph support this suggestion? Justify your answer. (2)

7.4.4 State what the y-intercept represents physically in this experiment. (1)

7.4.5 Another student did not manage to take measurements for this experiment as an a.c. supply was used instead of the specified d.c supply. State what you would expect the student to observe while trying to take force readings and explain the observation. (3)

7.5 The coil and magnets illustrated in the diagram below are part of a motor.



7.5.1 The current direction is from X to Y in the coil.

- In which direction would side XY experience a force? (2)
- How would you change **two** factors in order to increase the magnitude of the force exerted on side XY?

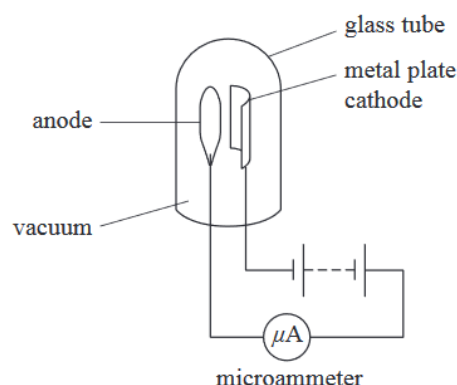
7.5.2 Compare the motor and generator in terms of energy conversion. (2)
[28]

QUESTION 8

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PHOTONS & ELECTRONS

The diagram below shows a phototube. One use of a phototube is in light meters to measure the intensity of light.



8.1 When light is incident on the cathode, electrons may be emitted and the microammeter shows a current. The following observations are made when varying the frequency and intensity of light incident on the phototube.

- There is only a current if the frequency of the incident light is greater than a certain value.
- The size of the current increases as the intensity of the incident light increases.

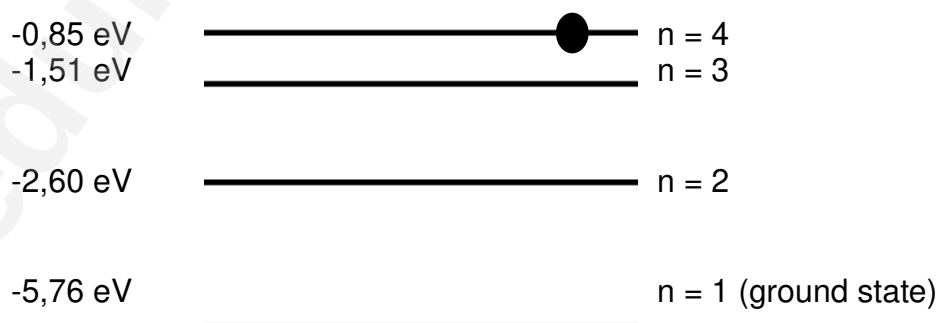
Explain these observations. (4)

8.2 Define *work function*. (2)

8.3 For a particular phototube the minimum frequency required for a current to be produced is 6.34×10^{14} Hz. The phototube is illuminated with light of frequency 7.52×10^{14} Hz.

Calculate the maximum kinetic energy of the released electrons in eV. (4)

8.4 The energy levels for a helium atom are represented on the diagram below. An excited electron is in the fourth level as indicated.



The Helium gas in a discharge tube emits light of wavelength 707 nm.

8.4.1 Calculate the energy (in eV) that corresponds to this wavelength of light. (4)

8.4.2 Between which two levels did this transition take place that will result in a wavelength of 707 nm. (2)

[16]