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**PHYSICAL SCIENCES PAPER I**  
**GRADE 12: PRELIMINARY EXAMINATION**

**30<sup>th</sup> JULY 2024**

**Session 1**

**EXAMINER:** Mr. N. Govender

**Time:** 180 minutes

**MODERATORS:** Ms. K. Mangena, Mr M Pillay (External)

**Marks:** 200 marks

**Student Name:** \_\_\_\_\_

**Teacher:** KMA/NGO

**PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY**

1. This question paper consists of 43 pages. There are 4 page breaks and 1 page for extra working as well as a DATA SHEET of 2 pages (i–ii). Please make sure 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. Remember to write your Name in the space provided above.
4. Use the data and formulae whenever necessary.
5. Show all the necessary steps in calculations.
6. Where appropriate, give your answers to **two decimal places**.
7. It is in your interest to write legibly and to present your work neatly.

| Question number | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Total |
|-----------------|----|----|----|----|----|----|----|----|-------|
| Total Mark      | 20 | 37 | 32 | 33 | 20 | 24 | 19 | 15 | 200   |
| Student Mark    |    |    |    |    |    |    |    |    |       |

# QUESTION 1

Answer these questions on the multiple-choice answer grid below. Make a clear cross (X) in the box corresponding to the letter that you consider to be correct. Every question has only one correct answer.

|   |   |              |   |
|---|---|--------------|---|
| A | B | <del>C</del> | D |
|---|---|--------------|---|

Here the option C has been marked as an example.

|      |   |   |   |   |
|------|---|---|---|---|
| 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 A boy throws a ball vertically upwards. It rises to a maximum height, where it is momentarily at rest, and falls back to his hands.

Which of the following gives the acceleration of the ball at the various stages in its motion?

(Take vertically upwards as positive, and neglect air resistance).

(2)

|   | Rising                             | At Maximum Height                  | Falling                            |
|---|------------------------------------|------------------------------------|------------------------------------|
| A | $-9,8 \text{ m}\cdot\text{s}^{-2}$ | 0                                  | $+9,8 \text{ m}\cdot\text{s}^{-2}$ |
| B | $-9,8 \text{ m}\cdot\text{s}^{-2}$ | $-9,8 \text{ m}\cdot\text{s}^{-2}$ | $-9,8 \text{ m}\cdot\text{s}^{-2}$ |
| C | $+9,8 \text{ m}\cdot\text{s}^{-2}$ | $+9,8 \text{ m}\cdot\text{s}^{-2}$ | $+9,8 \text{ m}\cdot\text{s}^{-2}$ |
| D | $+9,8 \text{ m}\cdot\text{s}^{-2}$ | 0                                  | $-9,8 \text{ m}\cdot\text{s}^{-2}$ |

- 1.2 A ball is released from rest from a certain height above the floor and bounces off the floor a number of times. The position-time graph represents the motion of the bouncing ball from the instant it is released.

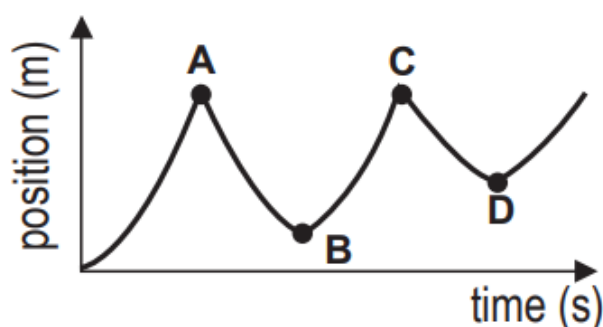


*Image generated by creative commons*

Ignoring air resistance, which point (**A**, **B**, **C** or **D**) on the graph represents the position-time coordinates of the maximum height reached by the ball after the **SECOND** bounce.

(2)

- 1.3 A block rests on a table which stands on a concrete floor. The normal force is represented by **N**, as shown in the diagram below.

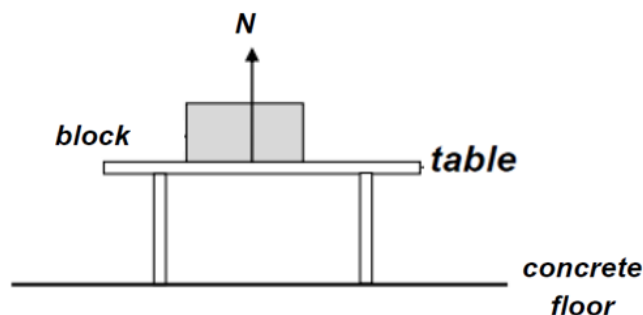


*Image generated by creative commons*

Which ONE of the following forces will form an action-reaction pair with the normal force, **N**? (2)

- A Force of the block on the Earth
- B Force of the table surface on the block
- C Force of the table on the concrete floor
- D Force of the block on the table

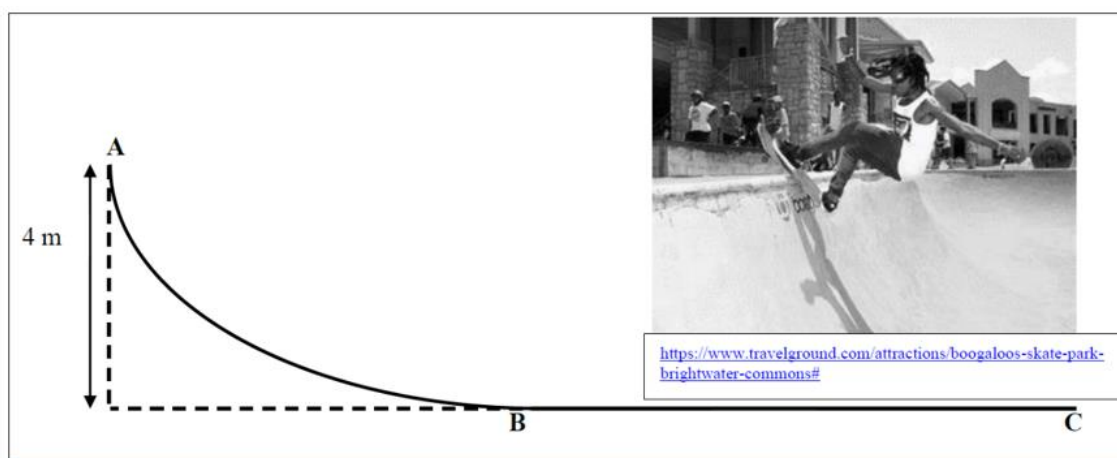
- 1.4 A ball of mass **m**, falling vertically downwards, hits the floor with a speed of **v** and bounces vertically upwards with a speed of **0,85v**.

Which ONE of the following combinations regarding the change in momentum of the ball during the collision is CORRECT? (2)

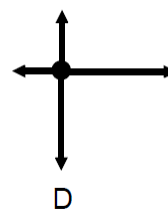
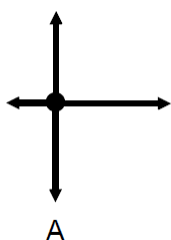
|   | Magnitude | Direction |
|---|-----------|-----------|
| A | 1,85mv    | upwards   |
| B | 1,85mv    | downwards |
| C | 0,15mv    | upwards   |
| D | 0,15mv    | downwards |

- 1.5 A skater on a skateboard is initially at rest at the top (position **A**) of a curved track skates down the slope and reaches a speed of  $7,5 \text{ m}\cdot\text{s}^{-1}$  at position **B** before coming to rest at position **C**.

**The friction cannot be ignored.**



Write down the letter that corresponds to the free body diagram of the forces acting on the skater at position **B**. (2)



- 1.6 The magnitude of acceleration due to gravity on the Earth's surface is ' $g$ '. Planet Y has **four times the mass and half the radius of the Earth**.

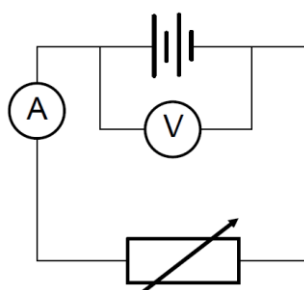
Which ONE of the following gives the correct magnitude of acceleration due to gravity on Planet Y? (2)

- A  $\frac{1}{16}g$
- B  $g$
- C  $8g$
- D  $16g$

- 1.7 In the circuit shown below, the battery has **significant internal resistance**, the ammeter and connecting wires have negligible resistance, and the voltmeter has infinite resistance.

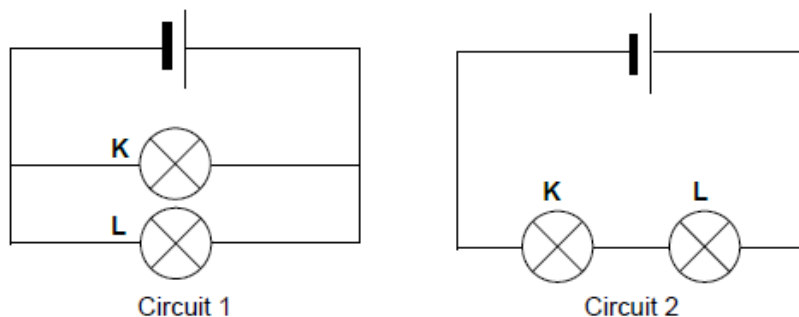
Choose the letter from the table that correctly describes the effect on the readings on the ammeter and the voltmeter when the resistance of the rheostat is INCREASED.

(2)



|   | Ammeter   | Voltmeter        |
|---|-----------|------------------|
| A | increases | decreases        |
| B | decreases | remains the same |
| C | decreases | increases        |
| D | decreases | decreases        |

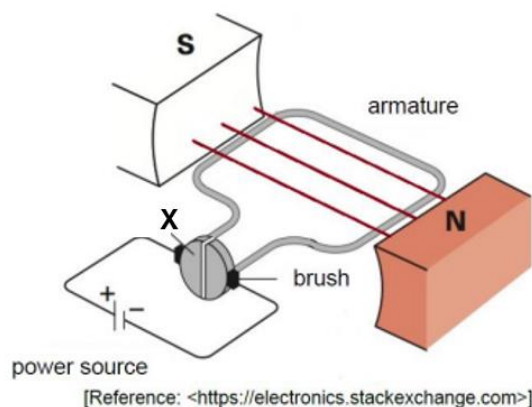
- 1.8 The same cell is connected in turn into each of the circuits shown below. Bulbs **K** and **L** have equal resistance and the cell has negligible internal resistance.



If the power in bulb **L** of circuit 1 is **P**, what is the total power in circuit 1 and circuit 2 in terms of **P** respectively? (2)

|   | Circuit 1      | Circuit 2      |
|---|----------------|----------------|
| A | $2P$           | $\frac{1}{2}P$ |
| B | $2P$           | $\frac{1}{4}P$ |
| C | $\frac{1}{2}P$ | $P$            |
| D | $\frac{1}{2}P$ | $2P$           |

- 1.9 The sketch below represents a **dc** motor. What part is represented by labelled **X** and in which direction does the armature rotate? (2)



|   | Part (Labelled X)     | Rotation direction of armature |
|---|-----------------------|--------------------------------|
| A | Split ring commutator | anticlockwise                  |
| B | Split ring commutator | clockwise                      |
| C | Slip ring             | anticlockwise                  |
| D | Slip ring             | clockwise                      |

- 1.10 The intensity of a monochromatic light source is increased. Which of the following is correct. (2)

|   | Energy of emitted photons | Number of photons emitted per second |
|---|---------------------------|--------------------------------------|
| A | increased                 | increased                            |
| B | increased                 | unchanged                            |
| C | unchanged                 | increased                            |
| D | unchanged                 | unchanged                            |

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## QUESTION 2                      KINEMATICS

A flare gun fires a flare high into the air in a situation to let other ships know that you are in distress.

A sailor accidentally lets off a flare gun from the deck of a stationary ship.

The sailor fires the flare vertically upward and the flare reaches a height of **160 m** above the deck of the ship, before it begins to fall.

The flare explodes **6** seconds after it was fired.

***(Use down as the positive direction and ignore the effects of air resistance.)***

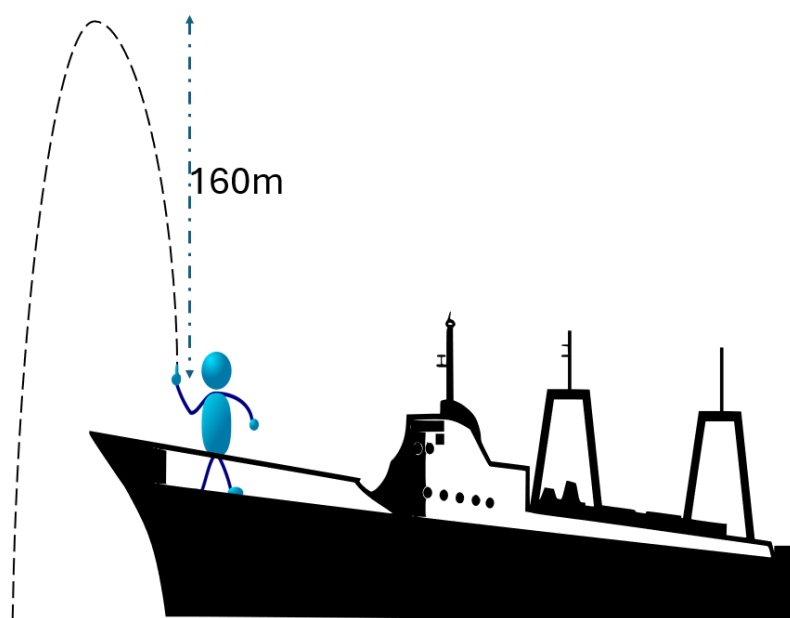


*Image created by creative commons*

2.1 Define *acceleration*. (2)

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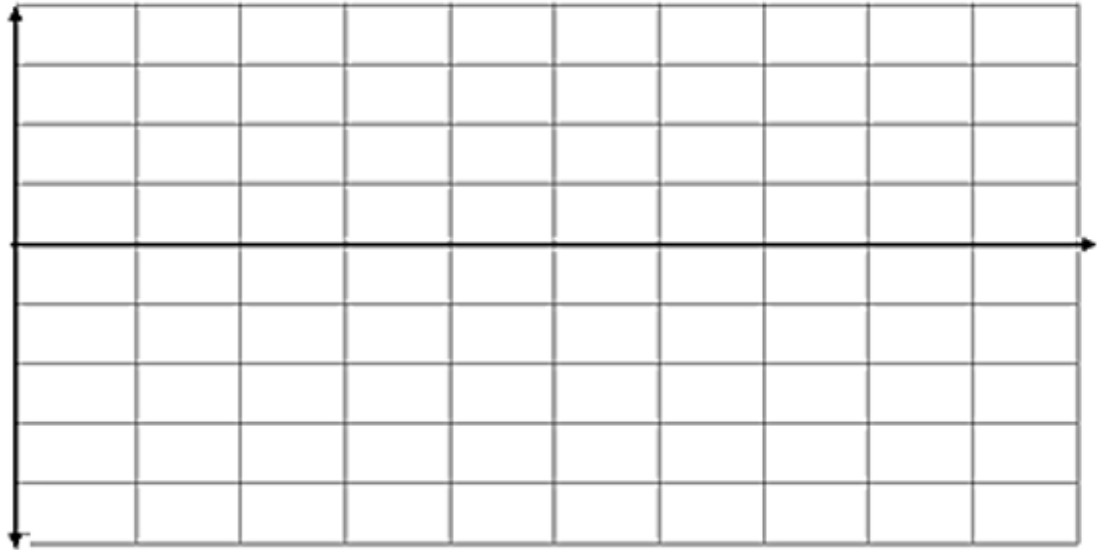
2.2 What is the acceleration of the flare after it leaves the flare gun? (2)

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2.3 Calculate the velocity at which the flare was fired upwards from the deck of the ship with? (4)

2.4 At what height above the ship's deck does the flare explode? (3)

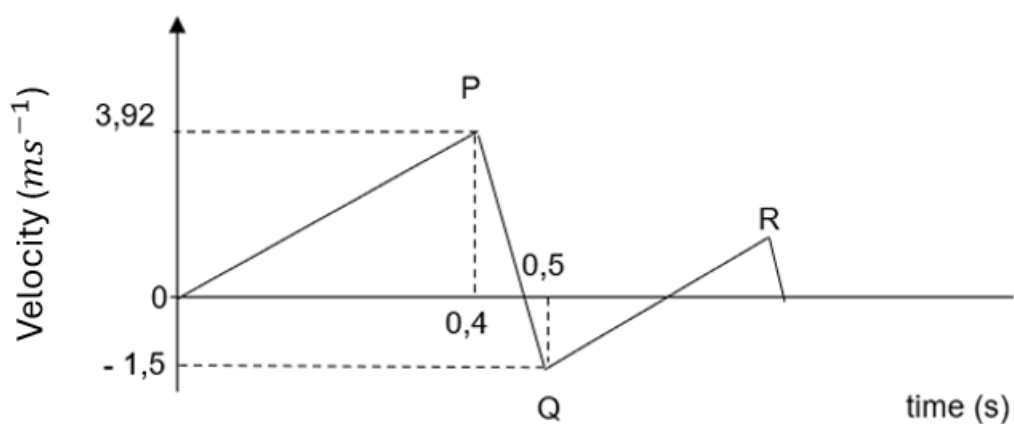
- 2.5 Draw a graph showing the velocity of the flare with time for the **6 second period** that it was in the air. (Show values on your graph that were given or calculated in previous questions. (4)



The captain gets such a fright when the sailor fires the flare gun that he drops the cannon ball that he is holding, and it falls to the deck.

The graph of the motion of the ball after he lets go of it is shown below.

(Down is taken as the positive direction)



2.6 What happens at the point **P** marked on the graph? (1)

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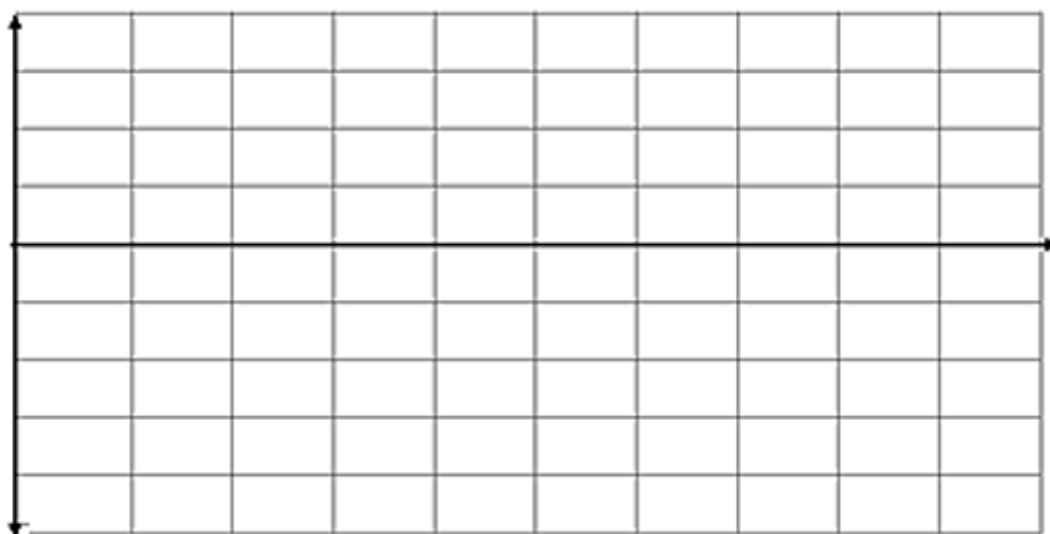
2.7 Use the graph above to calculate the height above the deck that the captain drops the canon ball from? (3)

2.8 Use the graph to calculate the acceleration of the cannon ball between **P** and **Q**.

(4)

2.9 Draw a graph of acceleration vs time for the cannon ball from **0** - **R**.

No time value is needed for **R** and no additional values need to be calculated. (4)



Having seen the flare, two ships begin to sail towards the **ship S**, they believe to be in distress, which is stationary, with its anchor down.

- Ship **A** can sail at **12 km.h<sup>-1</sup>** and is **4,5 km** to the **West** of Ship **S**.
- Ship **B** can sail at **15 km.h<sup>-1</sup>** and is **6 km** to the **East** of Ship **S**.
- There is a tide of **3 km.h<sup>-1</sup>** towards the **West**.

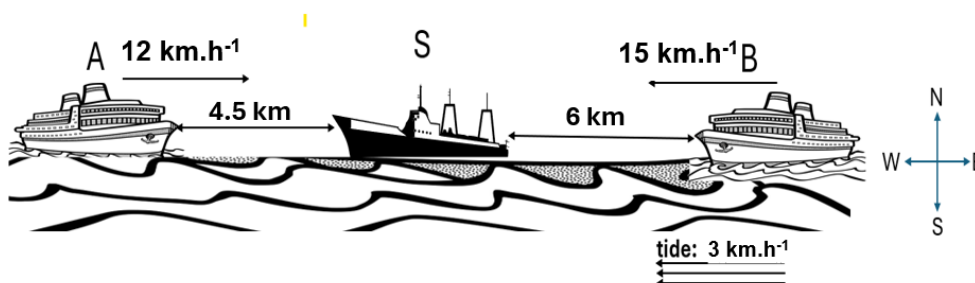


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2.10 Define *velocity*. (2)

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2.11 Determine ship **A**'s resultant velocity. (3)

2.12 By means of suitable calculations, determine which ship reaches ship **S** first.

- Assume that ship **A** and ship **B** set sail at constant velocity towards ship **S** at the same time. (5)

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## QUESTION 3                      NEWTONS LAWS

3.1 The underground mine at Gold Reef City is **70 m** deep.

Two individual cages, each with a mass of **850 kg** are connected by a cable over a frictionless pulley as depicted in a simplified diagram below.

As one cage descends (goes down), another cage ascends (goes up) at the same rate.

There is a tension  $T$  in the cable joining the two cages.

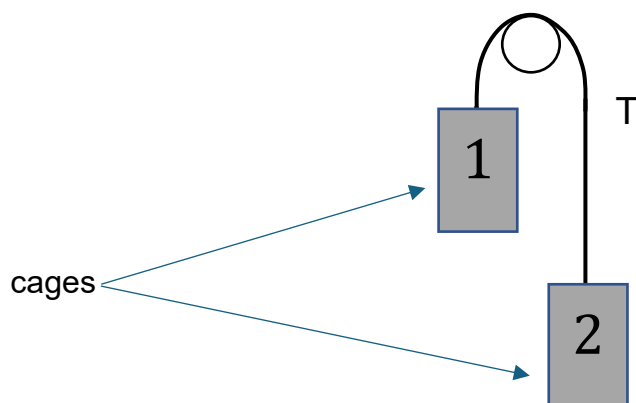


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3.1.1 State *Newton's First law*. (2)

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3.1.2 With both cages 1 and 2 empty, calculate the tension in the cable when cage 1 ascends at constant velocity. (2)

- 3.1.3 Cage 1 is now at ground level. (i.e. at the top of the mine shaft)  
Cage 1 then descends from rest containing 3 blocks of fool's gold.  
**(total mass of the cage + blocks = 925 kg).**  
Cage 2 remains empty.  
Calculate the magnitude of the acceleration of cage 1 during the descent.  
(4)

- 3.1.4 Calculate the magnitude of the velocity of **cage 1** once it has descended  
by **50 m**.  
(3)

Assume that there is a mechanism that can change the tension of the cable over the last **20 m** of the descent to decelerate the cage to a stop.

- 3.1.5 Calculate the resultant force that would have to be on cage 1 during these last **20 m**. (5)

- 3.1.6 Hence calculate what the tension would have to be in the cable during the last **20 m**. (4)

- 3.2 A **500 kg** horse is standing on a ramp leading into a horse box. When the ramp is at **40°** to the horizontal it can only just stand still without sliding backwards as depicted in the diagram below.

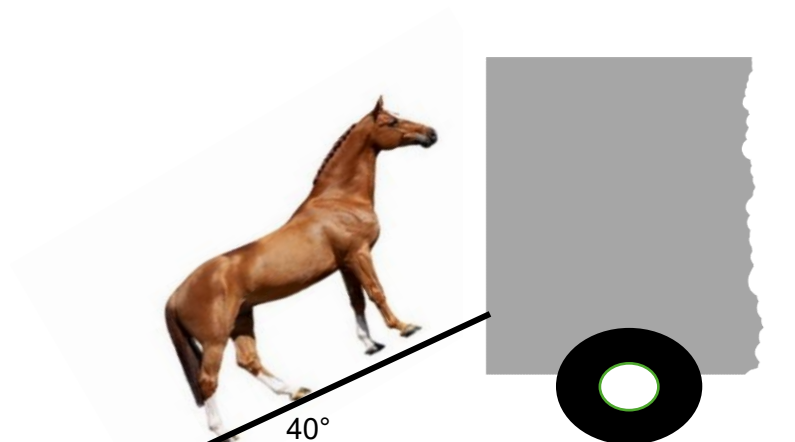


*Image generated by creative commons*

- 3.2.1 Define frictional force. (2)

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- 3.2.2 Calculate the maximum static frictional force required for this horse to remain stationary on the ramp. (3)

- 3.2.3 Calculate the coefficient of maximum static friction of the ramp. (4)

- 3.3. The horse finds it easier to stand on a ramp that is at a  $15^\circ$  angle to the horizontal as shown in the diagram below:

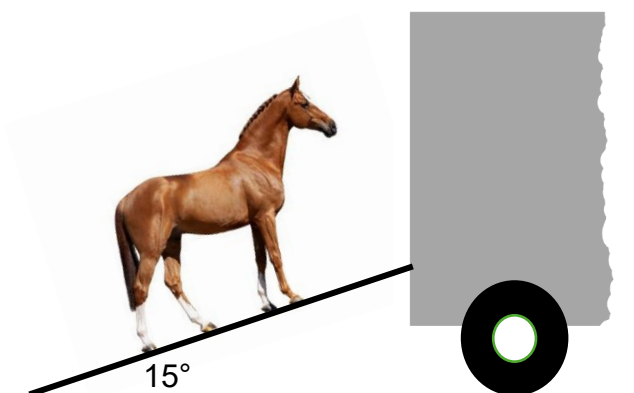


*Image generated by creative commons*

- 3.3.1 Would you expect the coefficient of static friction on this ramp to be larger, smaller or the same size as the coefficient calculated in **3.2.2**? (1)

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- 3.3.2. Explain your answer to question **3.3.1**. (2)

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## QUESTION 4

## MOMENTUM, WORK, ENERGY

- 4.1 Someone (let's call him Stan) has a plan. If it ever rains again, he is going to slide down a virtually frictionless plastic sheet on the Merriman lawn to see if he can ramp up a plank onto a bench.

We will **ignore all friction from A to C** (on the plastic sheet in the rain), but while Stan is sliding up the plank **from C to D**, he experiences a steady frictional force of **400 N**.

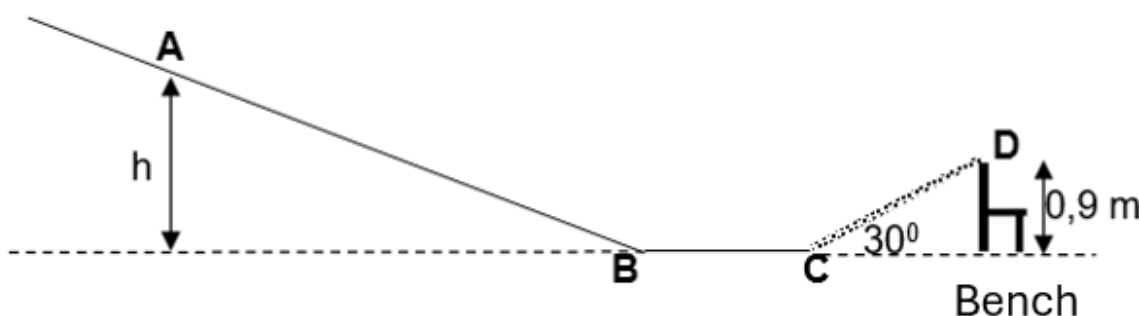


Diagram is not drawn to scale

Stan has a mass of **75 kg**.

- 4.1.1 If Stan reaches a height of **0,9 m** to make it onto the bench. How long is the plank **from C to D**? (2)

- 4.1.2 State the *work-energy theorem*. (2)

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4.1.3 What is the minimum kinetic energy that he will need to have at **point C** to just reach **D**? (4)

4.1.4 How will Stan's mechanical energy differ from point **B** to point **C**? Justify your answer. (2)

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4.1.5 **Using energy principles only**, calculate the height, **h**, that Stan will have to begin at (point **A**) to reach the bench. (3)

4.2. **Stan (mass 75 kg)** then arranges the plastic horizontally and runs and dives, sliding along the plastic at a constant velocity of  **$2,5 \text{ m}\cdot\text{s}^{-1}$  to the right**.

**Roger (mass 70 kg)** runs and dives from the other side of the plastic sheet, travelling at a constant velocity of  **$3 \text{ m}\cdot\text{s}^{-1}$  to the left** towards Stan, until they collide. Roger moves at  **$0,25 \text{ m}\cdot\text{s}^{-1}$  right** after the collision. The two boys were unharmed during the collision.

4.2.1 State the *law of conservation of linear momentum*. (2)

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4.2.2 Calculate Stan's velocity after the collision. (5)

4.2.3 Define an *inelastic collision*. (2)

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4.2.4 Show, by calculation, that the collision is inelastic. (5)

4.2.5 If the collision lasts for **0,4 s**, determine the magnitude of the force that Roger experiences during the collision. (4)

4.2.6 How will the force that Stan experiences during the collision compare to the force that Roger experiences? Name a law that you have applied to answer this question. (2)

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## QUESTION 5    FIELDS

A small, charged sphere on the end of an insulated handle carries a charge of **20 nC**. It is brought close to a piece of tissue paper of mass **0,5 g**.

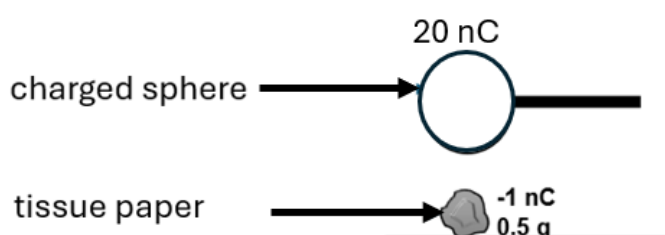


*Image generated by creative commons*

5.1 If the charge on the piece of tissue paper is **– 1 nC**.

5.1.1 State *Coulomb's law*. (2)

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5.1.2 What is the maximum distance at which the sphere will be able to pick up the piece of paper? (5)

The sphere is brought close to the tissue paper, and they touch.

- 5.2 Calculate how many electrons are transferred once the piece of paper sticks to the sphere. (4)

- 5.3 The planet Mars has a radius of  $3.5 \times 10^6 \text{ m}$  and a mass of  $6 \times 10^{23} \text{ kg}$ .

- 5.3.1 Define *gravitational field*. (2)

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5.3.2 Calculate the gravitational field strength on the surface of Mars. (4)

5.3.3 Deduce and explain whether the distance calculated in **5.1.2.** would be *the same, greater* or *less* if the charged sphere was used to pick up the tissue paper on Mars. (3)

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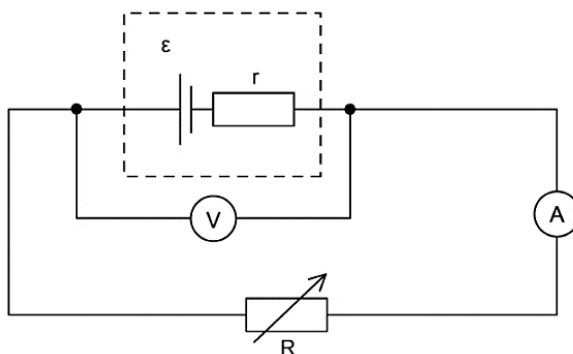
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**[20]**

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## QUESTION 6: ELECTRIC CIRCUITS

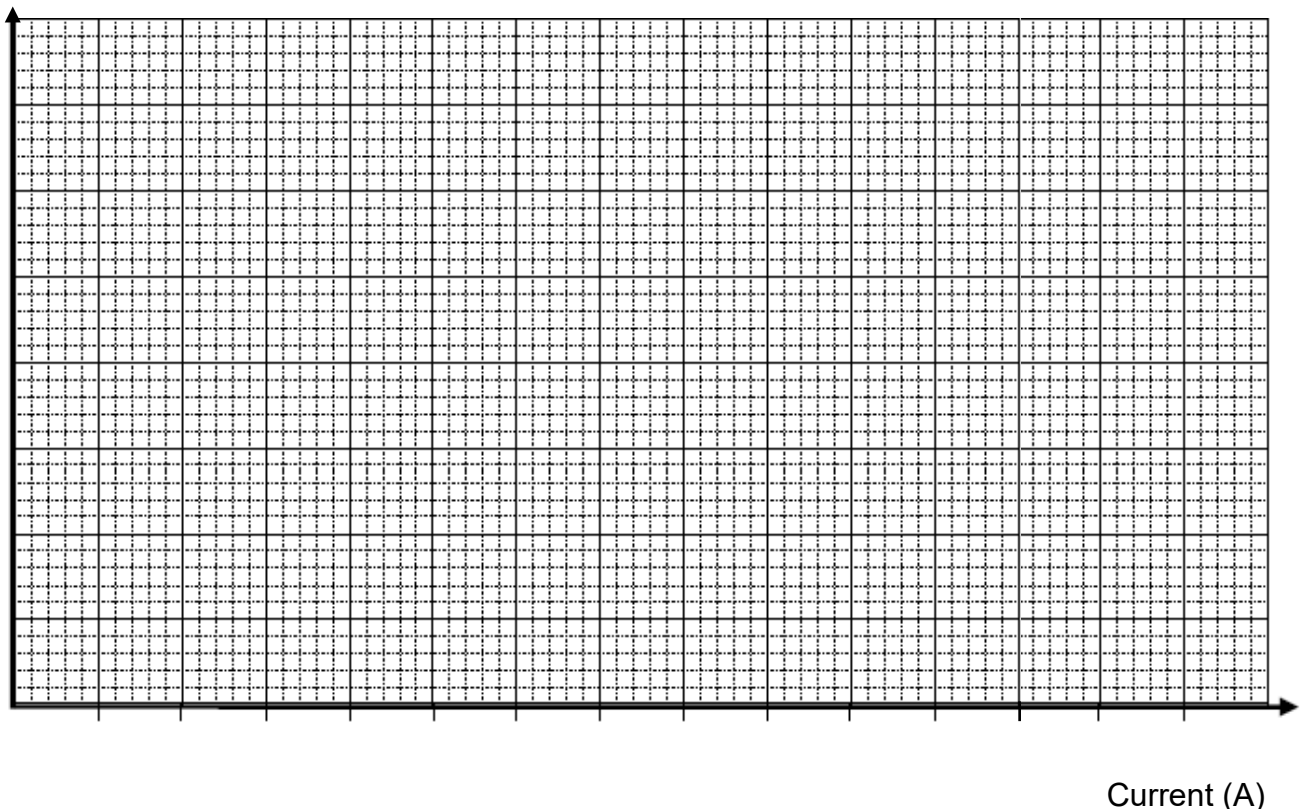
- 6.1 The diagram below shows a circuit having a cell of emf  $\mathcal{E}$ , with an internal resistance  $r$ , that is connected to a variable resistor  $R$ . The current through the cell and the external voltage ( $V_{\text{ext}}$ ) of the cell are measured as  $R$  is decreased.



The data is recorded in the table below

| $V_{\text{ext}}$ (V) | Current (A) |
|----------------------|-------------|
| 3,4                  | 0,6         |
| 3,0                  | 1,4         |
| 2,1                  | 3,0         |
| 1,5                  | 4,0         |
| 0,5                  | 5,8         |

- 6.1.1 Draw a graph on the graph paper below of this data (a heading is not required).  
(5)



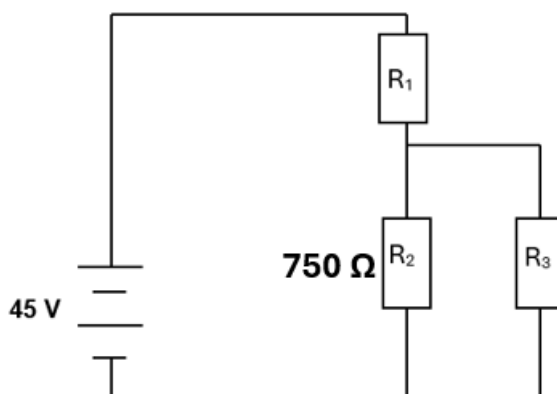
6.1.2 The equation for the graph is:  $\text{emf} = V_{\text{ext}} + Ir$

- a) Change this equation into  $y = mx + c$  format. (2)

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- b) Use this equation and your graph to find the emf,  $\mathcal{E}$ . (1)

- c) Use your graph to calculate the internal resistance,  $r$ , of the cell. (4)

- 6.2 The battery of the following circuit has negligible internal resistance and a voltage of **45 V**. Resistor **R<sub>2</sub>** has a resistance of **750 Ω**. The total current in the circuit is **0.03 A** and the current flowing through **R<sub>3</sub> = 0,01 A**.



- 6.2.1 Define *Resistance*. (2)

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- 6.2.2 Calculate total resistance of the circuit. (3)

6.2.3 Calculate the resistance of resistor  $R_3$ . (4)

6.2.4 Calculate the resistance of resistor  $R_1$ . (3)

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## QUESTION 7                      ELECTRODYNAMICS

7.1. The diagram below shows a vertical wire, held in position between fixed points at **P** and **Q**.

A short section of the wire is positioned between the pole pieces of a permanent magnet, which applies a uniform horizontal magnetic field at right angles to the wire.

An external circuit, with a **DC** power supply, allows an electric current to pass through the wire in the direction **P** to **Q** as shown in the diagram.

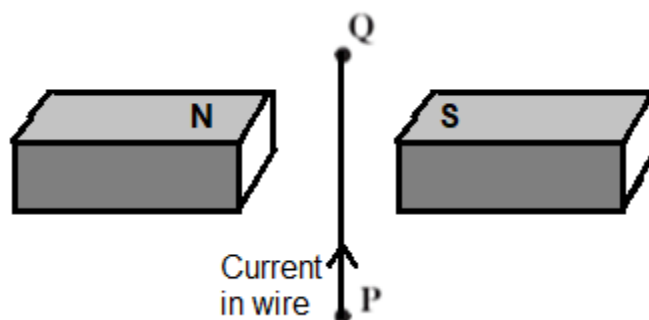


*Image generated by creative commons*

7.1.1 If there is a direct current flowing from **P** to **Q**, as shown in the figure above, state the direction of

a) the magnetic field due to the permanent magnets. (Choose from **left to right** or **right to left**.) (1)

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b) the magnetic field due to the current in the wire. (Choose from **clockwise** or **anti clockwise**.) (1)

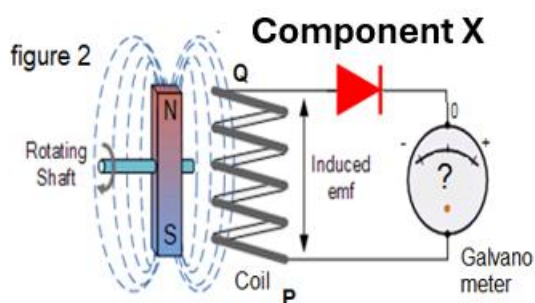
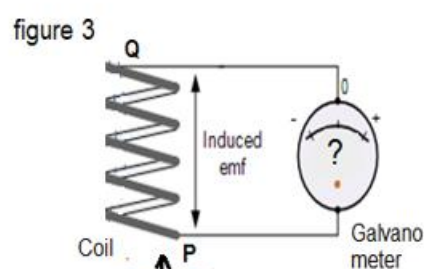
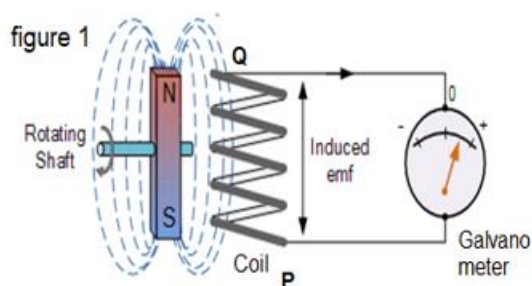
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c) the force on the wire. (Choose from **into page** or **out of page**.) (1)

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7.2 A bar magnet is rotated near a coil of copper wire that is connected to a galvanometer as shown in **figure 1** below.

- The motion of the bar magnet has induced an emf in the copper coil.
- A galvanometer is a device that will indicate the direction of the induced emf.
- A qualitative assessment of the magnitude of the induced emf can be determined by the displacement of the needle from the zero position.



<https://www.electronics-tutorials.ws/wp-content/uploads/2018/05/electromagnetism-mag25.gif>

7.2.1 State Faraday's law of Electromagnetic Induction. (2)

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- 7.2.2 Describe the motion of the needle on the galvanometer that will be observed during one rotation of the magnet in **figure 1**. (2)

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The circuit is adapted by the addition of **component X** as shown in **figure 2** above.

- 7.2.3 Name component **X**. (1)

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- 7.2.4 Describe the changes of the needle's motion during one rotation of the magnet, if any. Explain your answer. (2)

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The rotating magnet is replaced by a stationary magnet that is now moved towards point **P** of the coil as shown in **figure 3**.

- 7.2.5 Name the Law that describes the direction of the induced current in the copper coil. (1)

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- 7.2.6 Give the polarity of the induced magnetic field on the coil's end at **P**. (1)

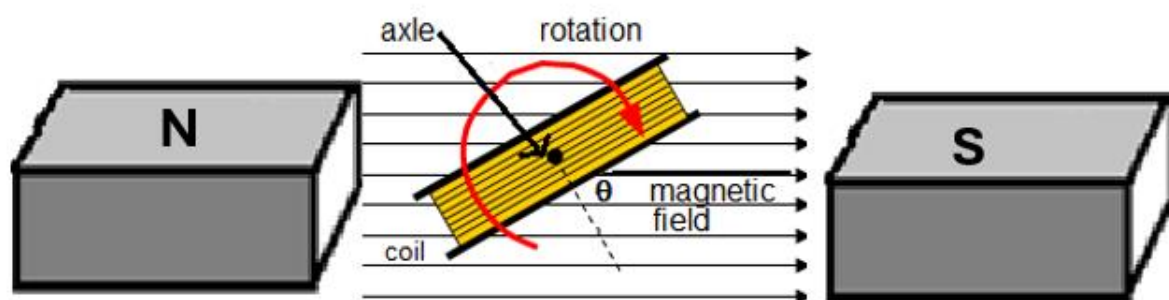
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- 7.2.7 State the direction of the induced current **in the coil**.  
**Write only P to Q or Q to P.** (1)

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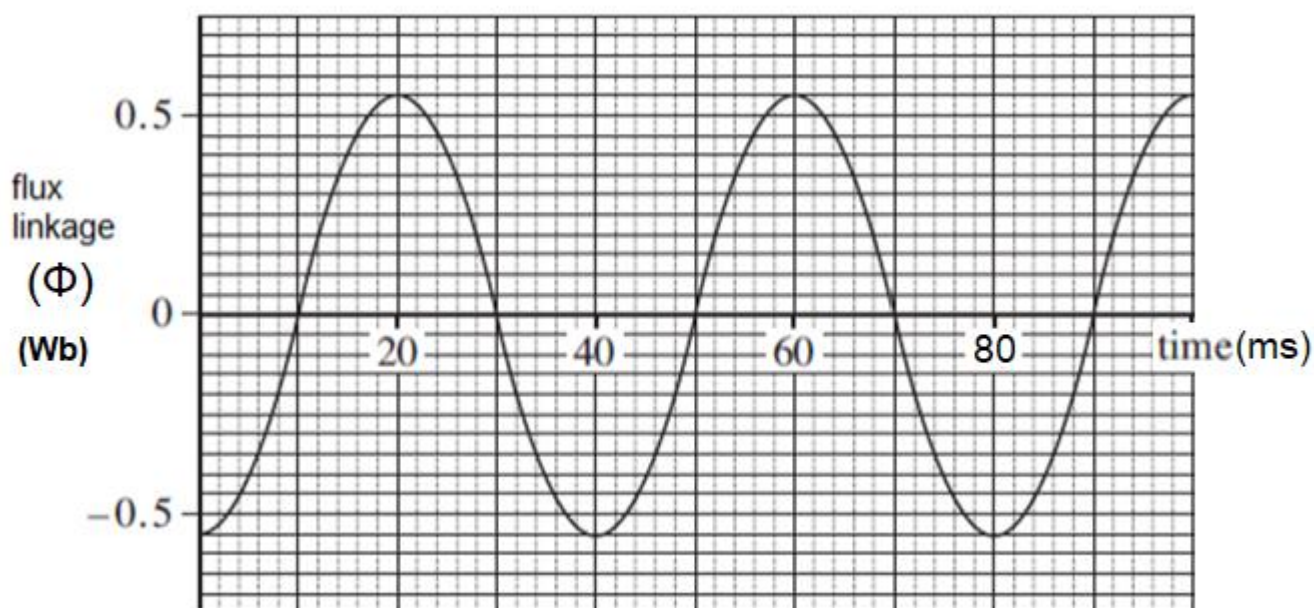
- 7.3 A rectangular coil is rotating clockwise at constant angular speed with its axle at right angles to a uniform magnetic field.

As the coil rotates within the magnetic field, the flux linkage ( $\Phi$ ) varies in the different positions.



[http://www.schoolphysics.co.uk/age16-19/Electricity and magnetism/Electromagnetic induction/text/Induced\\_emf\\_in\\_a\\_rotating\\_coil/images/1.png](http://www.schoolphysics.co.uk/age16-19/Electricity and magnetism/Electromagnetic induction/text/Induced_emf_in_a_rotating_coil/images/1.png)

A graph representing how the flux linkage through the coil varies with time is given below.



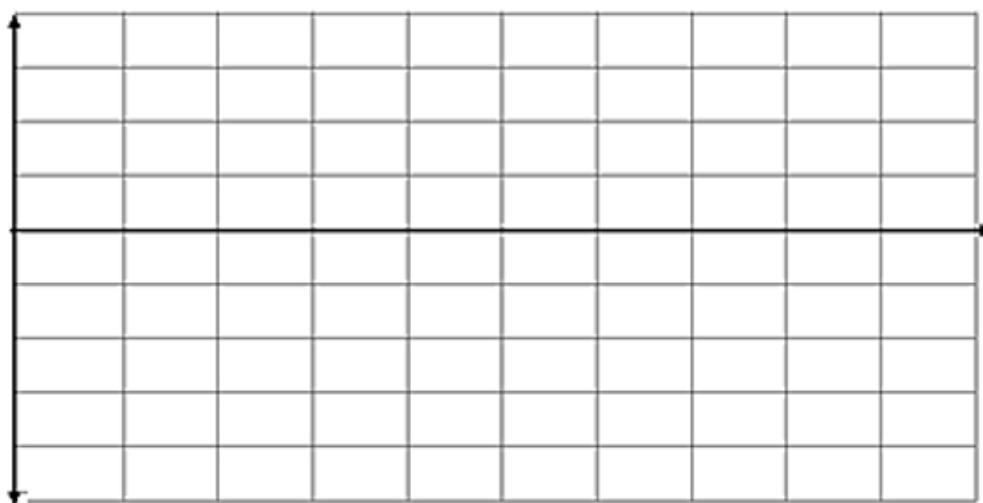
7.3.1 State the position of the coil (**vertical or horizontal**), relative to the horizontal magnetic field of the permanent magnets, at the following time intervals:

a) 20 ms (1)

b) 50 ms (1)

7.3.2 What physical quantity is represented by the gradient of the graph shown above? (1)

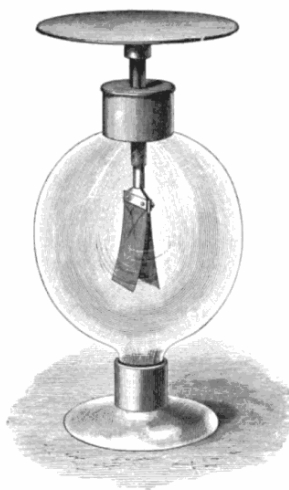
7.3.3 Sketch an emf vs time graph on your **answer sheet** for the time interval **0 - 40 ms**. Values of emf do not need to be included. (3)



[19]

## QUESTION 8    PHOTONS AND ELECTRONS

The device pictured below is used to investigate the strange phenomenon whereby light causes the emission of electrons from the surface of metal.



Light of **340 nm** is shone onto the photosensitive metal plate. A minimum energy of **3,1 eV** is needed to remove one electron from the metal surface.

8.1 What is the name given to the “strange phenomenon” whereby light causes the emission of electrons from the surface of a metal? (1)

8.2 Name the device pictured above. (1)

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8.3 Define the term *threshold frequency*. (2)

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8.4 Calculate the threshold frequency of this metal? (3)

8.5 With the aid of a suitable calculation, explain why photoelectrons are emitted from the surface of the metal. (3)

8.6 Calculate the speed of the emitted photoelectrons. (5)

**[15]**

**Total: 200 marks**

Extra working out page