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HILTON COLLEGE
GRADE 12 TRIAL EXAMINATION
2 SEPTEMBER 2024

PHYSICAL SCIENCES: PAPER 1

EXAMINATION NUMBER

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Time: 3 hours

Total: 200 marks

Examiner: Ms P. Mullan

Moderator: Mr M.J. Green

Acknowledging:

- Past papers shared by IEB Physical Sciences community;
- Department of Basic Education Past examination papers;
- Scottish Qualifications Authority Higher Physics Past Papers

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 32 pages and a separate green 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. Remember to write your examination number in the space provided above.
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. Two blank pages (pages 30 and 31) are included at the end of the paper. If you run out of space for a question, use this page. If you need another graph for Question 3.3, it is provided on page 32. Clearly indicate at the original question, if you have used the extra space on pages 30 - 32.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
Mark											
Marker's initial											
Moderated Mark											
Moderator's initial											
Question Total	20	19	32	19	17	11	24	20	21	17	200

QUESTION 1

MULTIPLE CHOICE

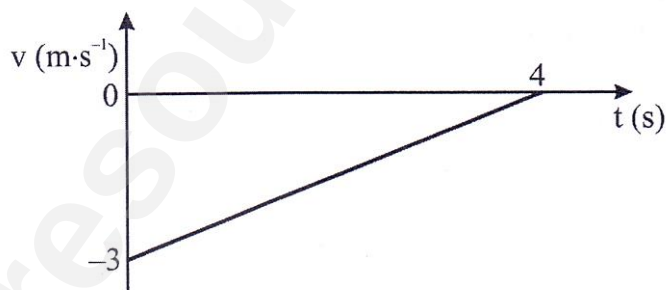
Answer these questions on the multiple-choice answer grid below. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

A	☒ B	C	D
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Here the option B 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 sketch of the velocity-time graph for a moving object is shown below.



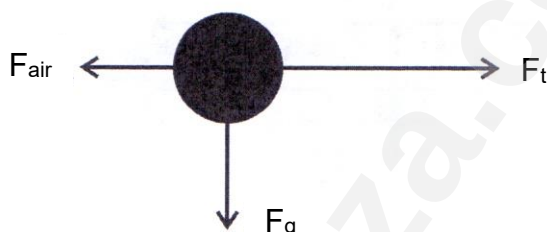
Which answer best describes the **magnitude** of the object's velocity and the sign of the acceleration?

	$v \text{ (m.s}^{-1}\text{)}$	$a \text{ (m.s}^{-2}\text{)}$
A	decreasing	+
B	decreasing	-
C	increasing	+
D	increasing	-

- 1.2 A hot air balloon is moving vertically upwards. At a height of 30 m a sandbag is dropped. The sandbag takes 3,0 s to reach the ground. The effects of air resistance can be ignored. The initial velocity of the sandbag on release is:

A 0 m.s⁻¹
 B 4,7 m.s⁻¹ upwards
 C 4,7 m.s⁻¹ downwards
 D 5,1 m.s⁻¹ downwards

- 1.3 A pupil draws the force diagram below showing the forces acting on a ball after it has been thrown. The ball is in mid-flight and is travelling horizontally to the **right**.



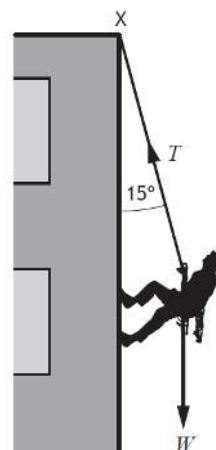
Which force, if any, is incorrect?

A F_{air} , the force due to air resistance
 B F_g , the force due to gravity
 C F_t , the force due to the throw
 D All of the forces are correct

- 1.4 A man abseils down the outside of a building using a rope. The rope makes an angle of 15° to the building.

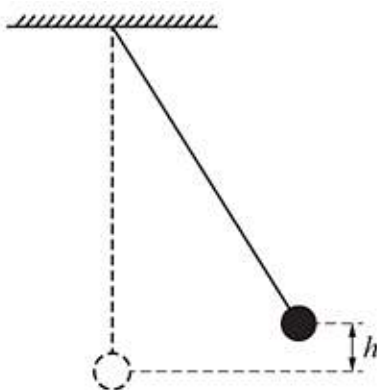
As the man abseils down the building, the angle the rope makes with the building decreases.

How will this reduction of the angle affect the tension in the rope and the horizontal force of the wall on the man?



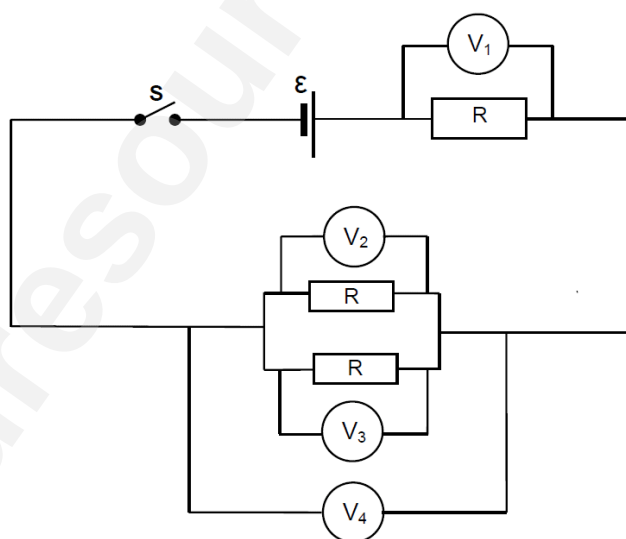
	Tension in rope	Force of the wall on the man
A	Increases	Decreases
B	Decreases	Increases
C	Decreases	Decreases
D	Remains the same	Remains the same

- 1.5 A pendulum bob of mass m is released from rest at height h . The bob reaches a speed v at the lowest point of its swing.



Neglecting air resistance, the speed of the bob at its lowest point is doubled by:

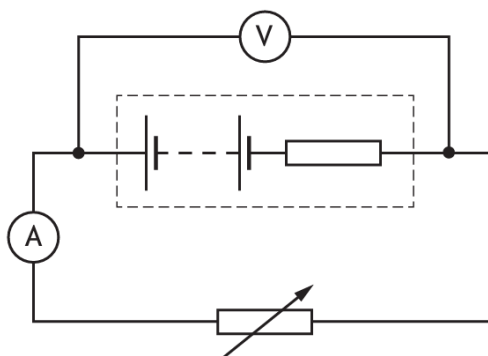
- A changing the mass of the bob to $0,5m$
 - B changing the mass of the bob to $2m$
 - C changing the height to $2h$
 - D changing the height to $4h$
- 1.6 In the circuit diagram shown below all the resistors are IDENTICAL. Ignore the internal resistance of the cell.



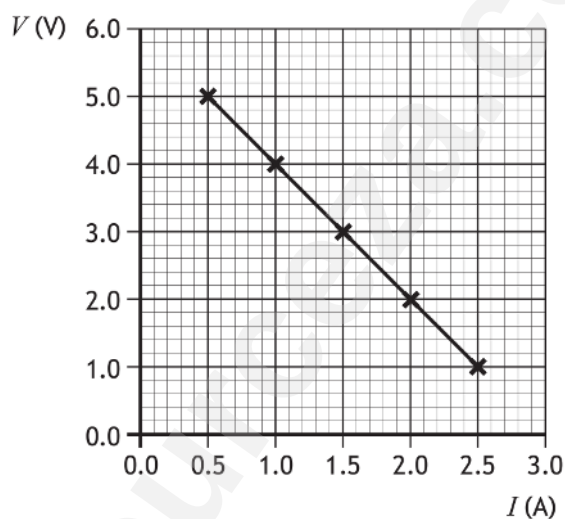
Which voltmeter will have the HIGHEST reading when switch **S** is closed?

- A V_1
- B V_2
- C V_3
- D V_4

- 1.7 A student carries out an experiment to determine the EMF and internal resistance of a battery using the circuit shown.



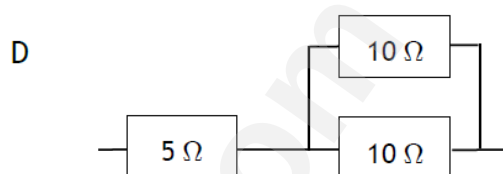
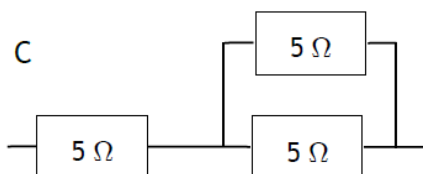
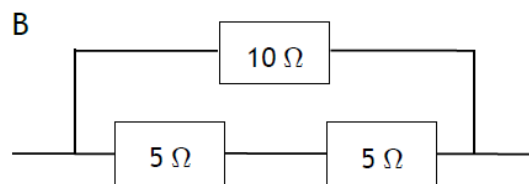
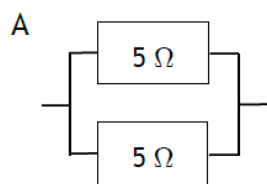
The resistance of the variable resistor is altered and readings of voltage V and current I are taken. These readings are used to produce the following graph.



Which row in the table shows the EMF and internal resistance of the battery?

	Emf (V)	Internal resistance (Ω)
A	5	0,5
B	5	2,0
C	6	0,5
D	6	2,0

- 1.8 Which one of the following combinations of resistors will have an effective resistance of $10\ \Omega$?



- 1.9 To complete some maintenance work in the house, an $800\ \text{W}$ electric drill is used. If a unit of electricity costs R1,32 what will the total charge be to use the drill for a period of 45 minutes?

- A R0,79
- B R1,41
- C R23,47
- D R28,51

- 1.10 An investigation is designed to determine the magnitude of the generated current when the strength of a magnet is varied. The magnet is dropped from a fixed height and travels through a solenoid connected to a sensitive ammeter. Which is the **dependent** variable in this investigation?

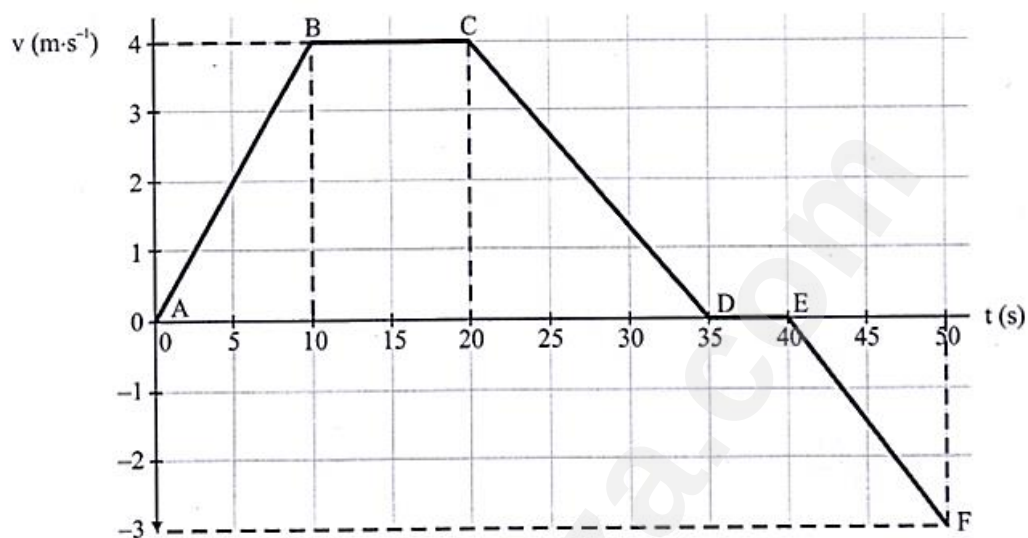
- A Speed of the magnet.
- B Strength of the magnet.
- C Magnitude of the generated current.
- D Magnitude of the magnetic flux.

[10 x 2 = 20]

QUESTION 2

KINEMATICS

- 2.1 A toy car starts from rest and initially travels east. A velocity vs time graph of the motion is shown below.



- 2.1.1 Use the graph to determine the acceleration of the car between 20 s and 35 s.

(3)

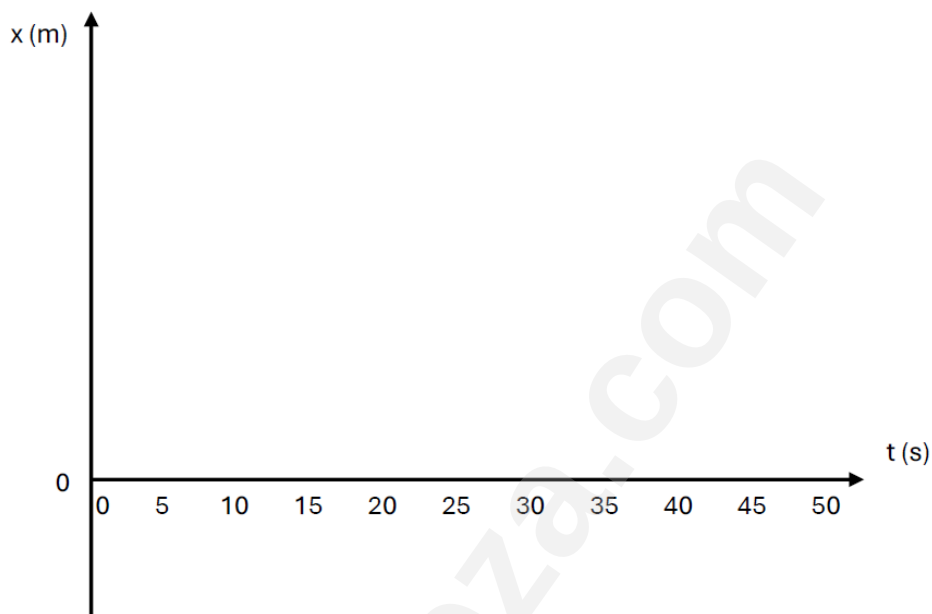
- 2.1.2 Describe the difference between *distance* and *displacement*.

(2)

- 2.1.3 Use the graph to determine the displacement of the toy car after 50 s.

(4)

- 2.1.4 Sketch a position vs time graph for the car from 0 s to 50 s. Exact values on the position axis will not be marked, however these may be helpful in sketching appropriate proportions.

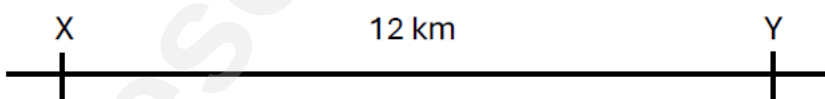


(5)

- 2.2 Speed law enforcement along stretches of the N3 highway is managed by measuring the average speed of motorists.

A camera at position X takes a photo of a car and records the time at that instant. Another camera at position Y, 12 km further along the road, takes a second photo of the car and records the time at that instant.

The speed limit along this stretch of the road is $100 \text{ km}\cdot\text{h}^{-1}$.



The motorist takes 7 minutes to travel the 12 km between X and Y.

- 2.2.1 Calculate the average speed of the car in $\text{m}\cdot\text{s}^{-1}$.

(3)

- 2.2.2 By calculation determine if the driver is exceeding the speed limit?

(2)

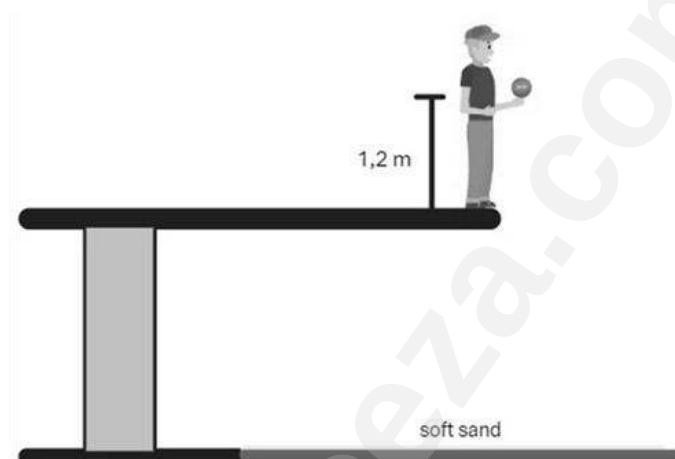
[19]

QUESTION 3

KINEMATICS

A boy wants to determine the height of a platform. He climbs to the top of the platform with several identical small metal balls. He projects each ball, vertically, over the edge of the platform. A sensor on the ground directly below records the speed of the ball at the moment before it strikes the soft sand at the foot of the platform. Before striking the sand, the balls are considered to be in free fall.

When each ball leaves his hand, his hand is 1,2 m above the surface of the platform.



The balls are projected, vertically, as follows:

- ball 1 is thrown upwards at 4 m.s^{-1}
- ball 2 is dropped
- ball 3 is thrown downwards at 3 m.s^{-1}

Take down to be the positive direction.

3.1 Name the independent variable in this investigation.

(1)

3.2 In the table,

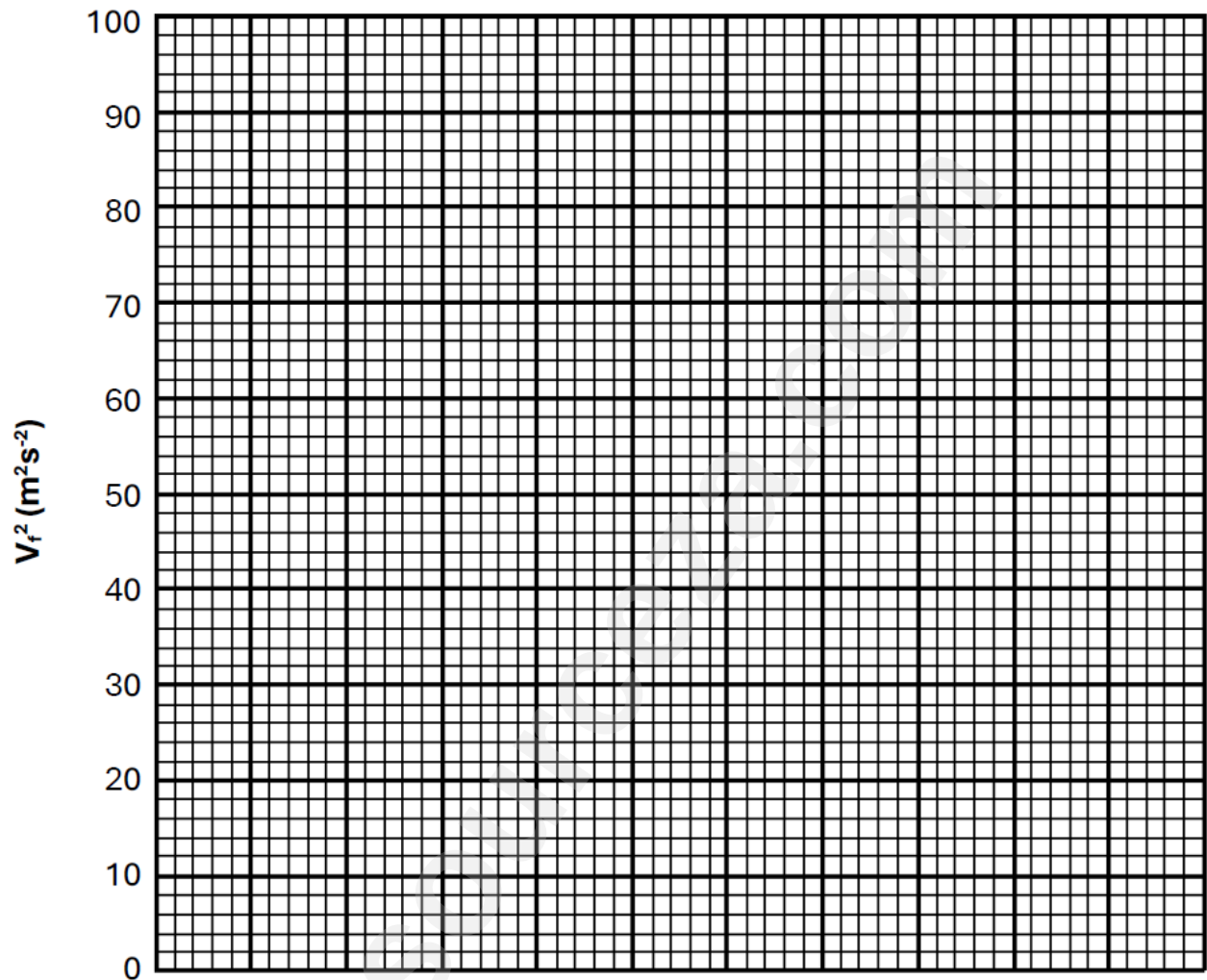
- record values for the initial velocity (v_i) of the ball
- calculate the values of v_f^2 and record them in the table

Ball	$v_i (\text{m.s}^{-1})$	$v_i^2 (\text{m}^2.\text{s}^{-2})$	$v_f^2 (\text{m}^2.\text{s}^{-2})$
1			79
2			63
3			72

(4)

3.3 Use the graph paper on the next page to plot a graph of v_f^2 versus v_i^2 .

(6)



- 3.4 Use an appropriate equation of motion and relate it to the y-intercept from your graph to determine the height of the platform.

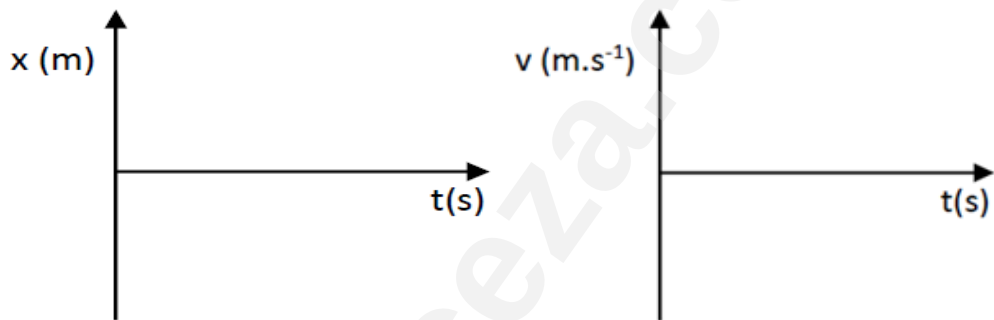
(5)

3.5 For ball 1:

3.5.1 Calculate the time taken for **ball 1** to reach the ground.

(4)

3.5.2 Sketch a position vs time and a velocity vs time graph for **ball 1** from the time that it leaves the boy's hand until it reaches the ground. Take the thrower's hand as the reference point.



(4)

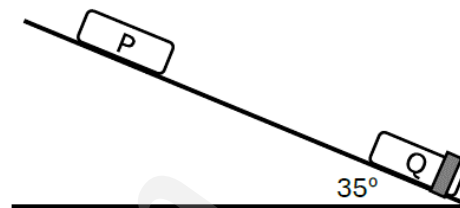
3.6 Each ball has a mass of 50 g. **Ball 1** sinks to a depth of 20 cm in the soft sand. Calculate the force exerted by the sand to stop the ball.

(8)

[32]

QUESTION 4 FORCES

Two magnets, **P** and **Q**, are placed on a rough slope inclined at 35° to the horizontal. Magnet **Q** is clamped in place on the surface and their **north poles are facing each other**. The mass of each magnet is **500 g** and there is a magnetic force of **2 N** between them.



Magnet **P** is **just about to begin sliding** down the slope.

4.1 Name and state the law that explains magnet **P**'s state of motion.

(3)

4.2 Draw a free-body diagram showing all the forces acting on magnet **P**, which are parallel to the slope.

(3)

4.3 Hence, determine the magnitude of the maximum static friction acting on **P**.

(5)

4.4 Calculate the coefficient of static friction between **P** and the surface.

4.5 The slope and magnets are lowered and now lies horizontally. The magnets remain the same distance apart. Magnet **Q** is replaced with a new magnet, **R**. Magnet **P** is about to begin sliding towards **R**.



In what two ways does magnet **R** differ from magnet **Q**? **Explain** your answer fully.

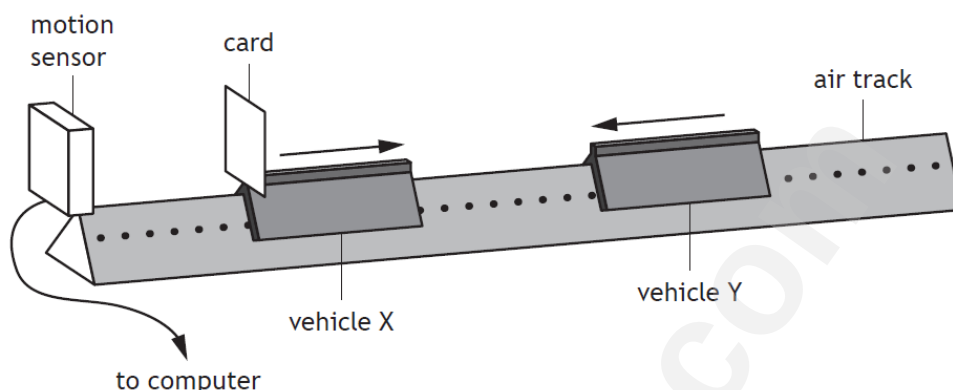
(4)

(4)

[19]

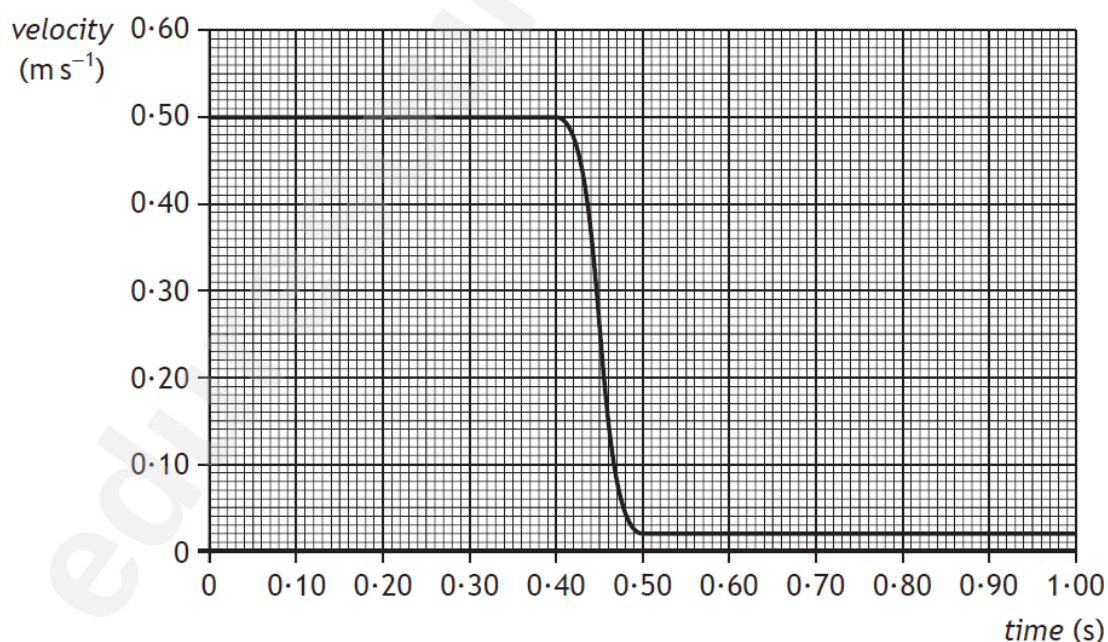
QUESTION 5 MOMENTUM

A student sets up an experiment to investigate a collision between two vehicles on a frictionless air track.



Vehicle **X** of mass 0,75 kg is travelling to the **right** along the track. Vehicle **Y** of mass 0,50 kg is travelling to the **left** along the track with a speed of $0,30 \text{ m}\cdot\text{s}^{-1}$. The vehicles collide and move off separately. A computer displays a graph showing the velocity of vehicle **X** from just before the collision to just after the collision.

A graph showing the change in the velocity of vehicle X as a result of a collision with vehicle Y



5.1 State the *Law of Conservation of Linear Momentum*.

(2)

5.2 Show that the velocity of vehicle Y after the collision is $0,42 \text{ m.s}^{-1}$.

(3)

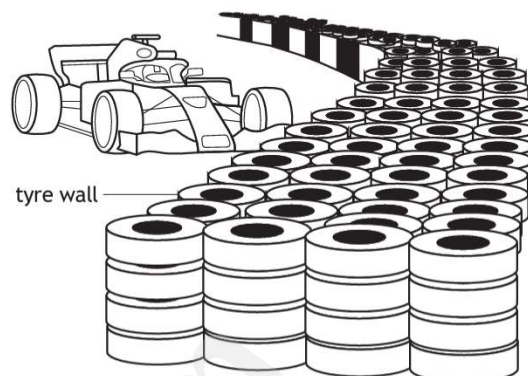
5.3 Determine the impulse on vehicle Y during the collision.

(5)

5.4 Is the collision elastic or inelastic? Justify your answer by calculation.

(4)

Extremely high speeds in Formula One motor racing make it a dangerous sport. Tyre walls are safety features used at certain high-risk parts of the track.



- 5.5 Demonstrate your understanding of impulse by explaining how a tyre wall may save the life of a driver in the event of a high-speed collision.

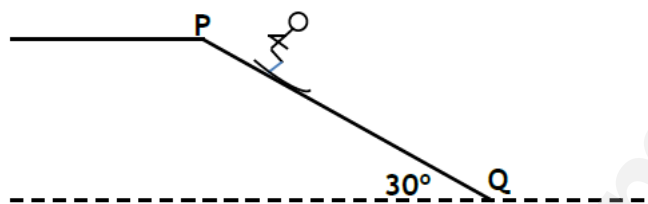
(3)

[17]

QUESTION 6

WORK, ENERGY & POWER

A skier of mass 70 kg starts from **rest** at **P** and skis down a hill, of slope 30° to the horizontal, with an average net force of 224 N down the slope. The distance **PQ** is 100 m.



6.1 Show that the potential energy of the skier at **P** is 34300 J.

(3)

6.2 State the *work-energy theorem*.

(2)

6.3 Use the work-energy theorem to calculate the kinetic energy of the skier at **Q**.

(3)

- 6.4 **Hence**, determine the magnitude of the average frictional force encountered by the skier.

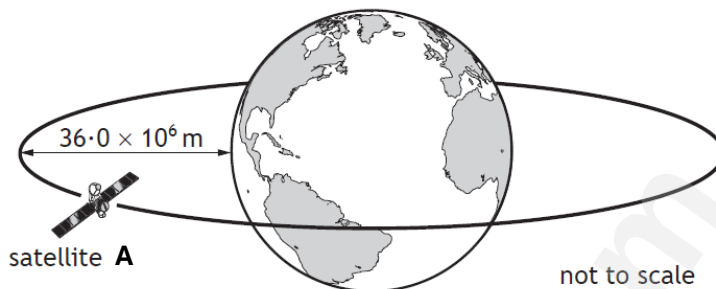
(3)

[11]

QUESTION 7

FIELDS

- 7.1 A communications satellite, **A**, orbits the Earth at a height of $36,0 \times 10^6$ m above the surface of the Earth.



The mass of the Earth is $6,0 \times 10^{24}$ kg and the radius of the Earth is $6,4 \times 10^6$ m.

- 7.1.1 State Newton's Law of Universal Gravitation.

(3)

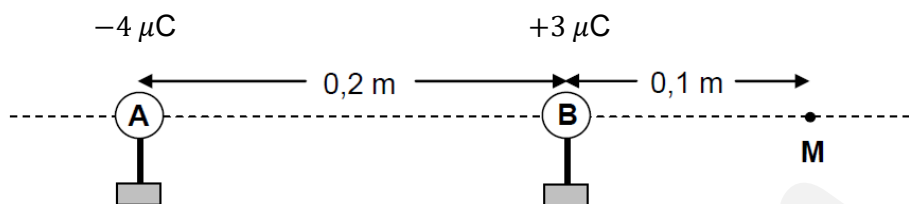
- 7.1.2 The gravitational force of attraction between the Earth and the satellite is 57 N. Calculate the mass of the satellite.

(4)

- 7.1.3 An identical satellite, **B**, orbits another planet, **β**, that is **twice** the **mass** of Earth at **half** the **distance** from its centre. By what factor will satellite **B**'s weight compare with satellite **A**'s weight in their respective positions.

(3)

- 7.2 Two small, charged spheres, **A** and **B**, are placed on insulated stands, 0,2 m apart, as shown in the diagram below.
They carry charges of $-4\ \mu\text{C}$ and $+3\ \mu\text{C}$ respectively.



M is a point that is a distance of 0,1 m to the right of sphere **B**.

- 7.2.1 Calculate the number of excess electrons on sphere **A**.

(3)

- 7.2.2 Describe the term *electric field*, including reference to the direction of the electric field.

(2)

- 7.2.3 Determine the net electric field at point **M**.

(5)

- 7.2.4 Calculate the force experienced by an electron at point **M**.

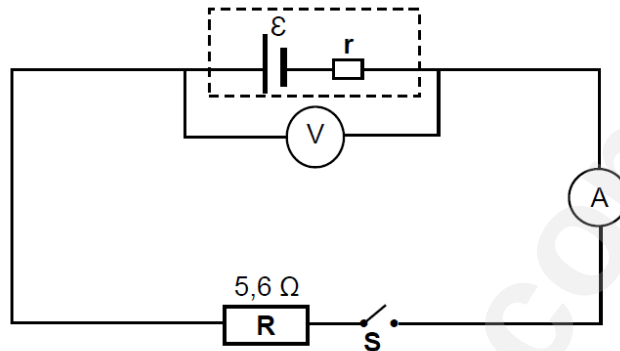
(4)

[24]

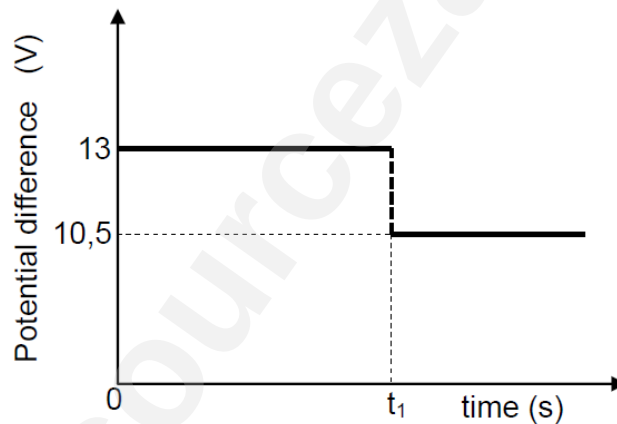
QUESTION 8

ELECTRIC CIRCUITS

In the circuit diagram below, resistor **R**, with a resistance of $5,6 \, \Omega$, is connected with a switch, an ammeter and a high-resistance voltmeter, to a battery with an unknown internal resistance, **r**. The resistance of the connecting wires and the ammeter may be ignored.



The graph below shows the potential difference across the terminals of the battery as a function of time. At time t_1 , switch **S** is closed.



8.1 Define the term *emf*.

(2)

8.2 Write down the value of the emf of the battery.

(1)

8.3 When switch **S** is CLOSED, calculate the:

8.3.1 current through resistor **R**.

(3)

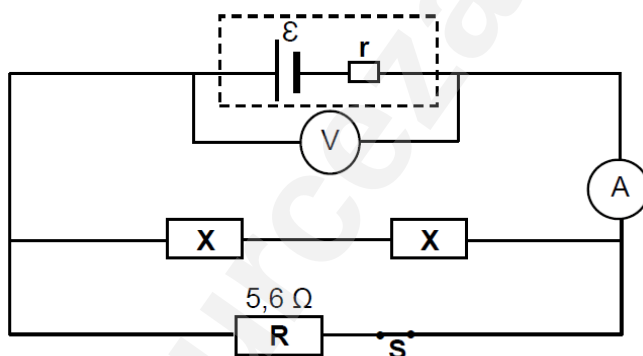
8.3.2 power dissipated in resistor **R**.

(3)

8.3.3 internal resistance, **r**, of the battery.

(3)

8.4 Two IDENTICAL resistors, each with resistance **X**, are now connected in the same circuit with switch **S** closed, as shown below.



The ammeter reading now increases to 4 A.

8.4.1 How would the voltmeter reading change? Choose from INCREASES, DECREASES or REMAINS THE SAME. Give a reason for your answer.

(3)

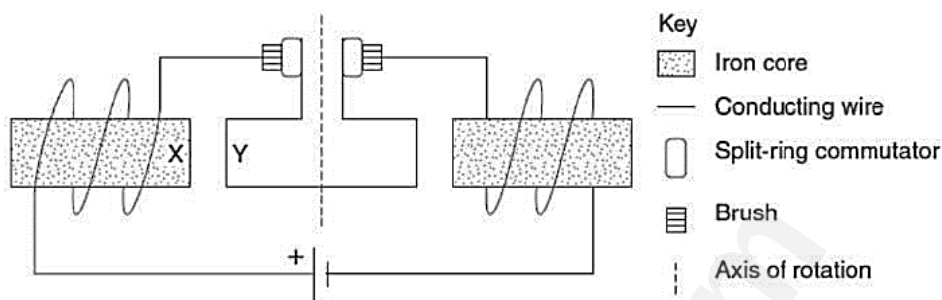
8.4.2 Calculate resistance **X**.

(5)

[20]

QUESTION 9 ELECTRODYNAMICS

9.1 The diagram below represents a DC motor.



9.1.1 What is the polarity of the electromagnet at X?
(Answer: NORTH or SOUTH)

(1)

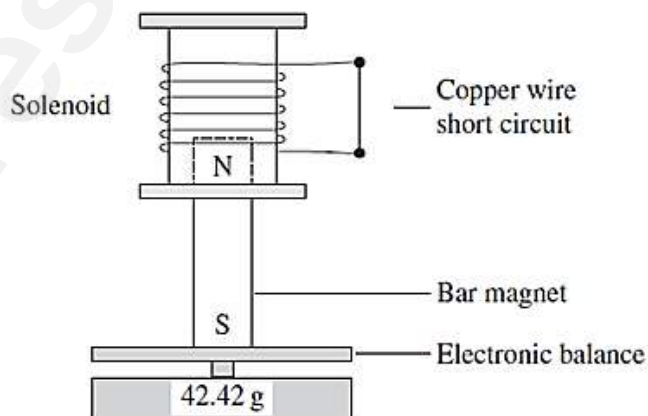
9.1.2 In what direction will the portion of the coil labelled Y rotate?
(Answer: INTO THE PAGE or OUT OF THE PAGE)

(1)

9.1.3 What is the function of the split-ring commutator?

(2)

9.2 A bar magnet is placed on a sensitive electronic balance as shown in the diagram. A hollow solenoid is held stationary, such that the magnet is partly within the solenoid.



The solenoid is then lifted straight up, from its original position, without touching the magnet. The reading on the balance is observed to change briefly.

9.2.1 How does the reading on the balance change?
(Answer: INCREASE or DECREASE)

(1)

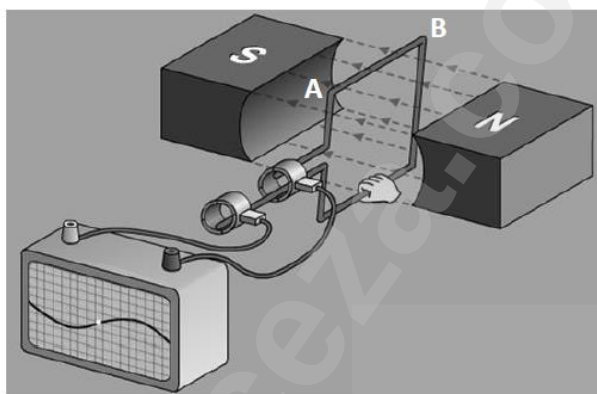
9.2.2 Name the law that was applied in answering 9.2.1.

(1)

9.2.3 Explain why the reading on the electronic balance changes as the solenoid is lifted.

(2)

9.3 The diagram below shows an alternating current dynamo connected to an oscilloscope.



9.3.1 State the energy conversion that takes place in an alternating current dynamo.

(2)

9.3.2 In the position shown, the oscilloscope indicates that the emf in the external circuit equals 0 V. Explain this value.

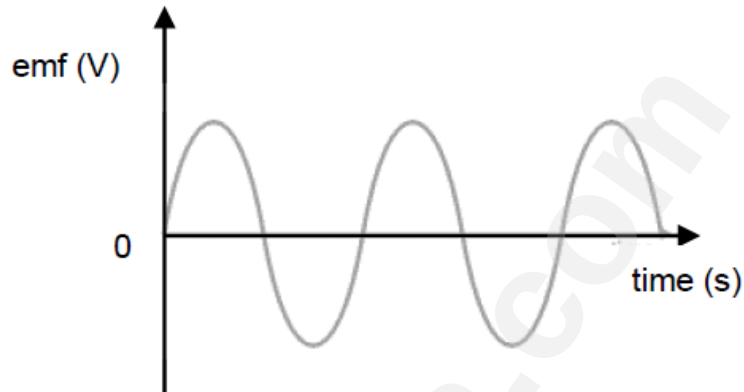
(2)

9.3.3 The coil is rotated in an anti-clockwise direction. In the next instant, what will be the direction of the induced current in the section of the conductor labelled **A B**? (Answer: A to B OR B to A)

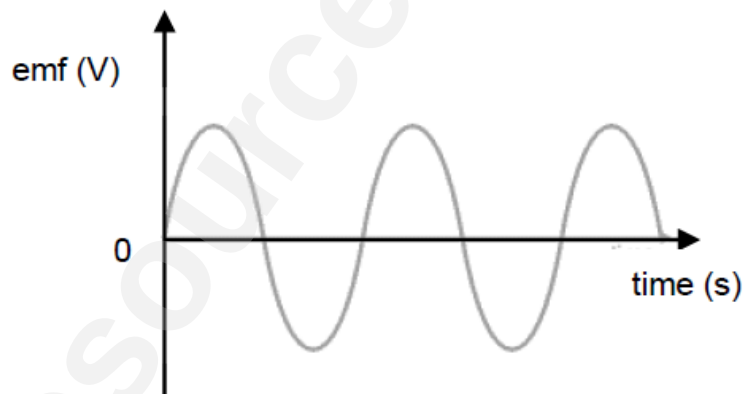
(1)

9.3.4 The trace from the oscilloscope screen has been redrawn below. On the given axes, sketch the image which would be shown on the screen if:

i) the coil is rotated at twice the original speed



ii) a single diode is connected in the forward biased direction to the external circuit with the coil rotated at the original speed.



(3)

9.4 An AC generator is used to supply energy to a transformer at a rate of 5 kW at 100 V. The current supplied to the secondary coil is 2,5 A.

9.4.1 Calculate the current in the primary circuit.

(3)

9.4.2 Assuming that the transformer is 100% efficient, determine the ratio of coils in the primary circuit to coils in the secondary circuit.

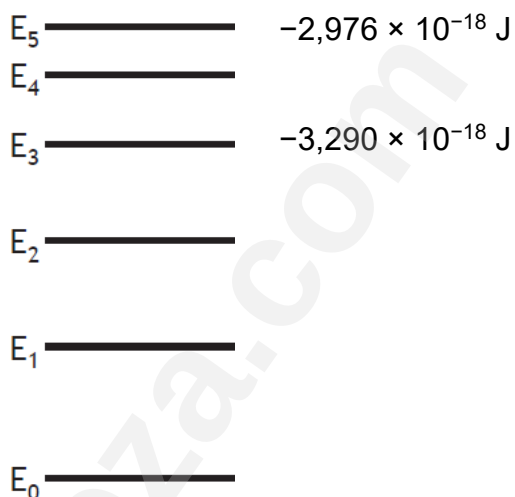
(2)

[21]

QUESTION 10

PHOTONS AND ELECTRONS

- 10.1 A laser emits light when electrons transition between energy levels. In one particular laser, a photon is produced by the electron transition between E_3 and E_5 . The diagram indicates the energy of an electron at E_3 and E_5 .



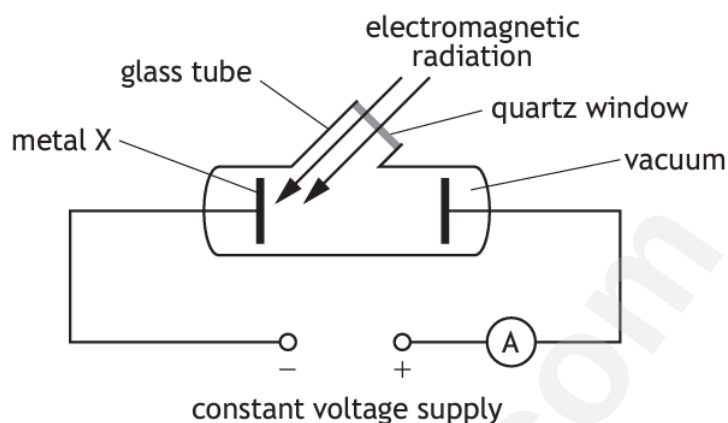
- 10.1.1 For light to be emitted by the laser, does the electron transition from E_3 to E_5 OR from E_5 to E_3 ?

(1)

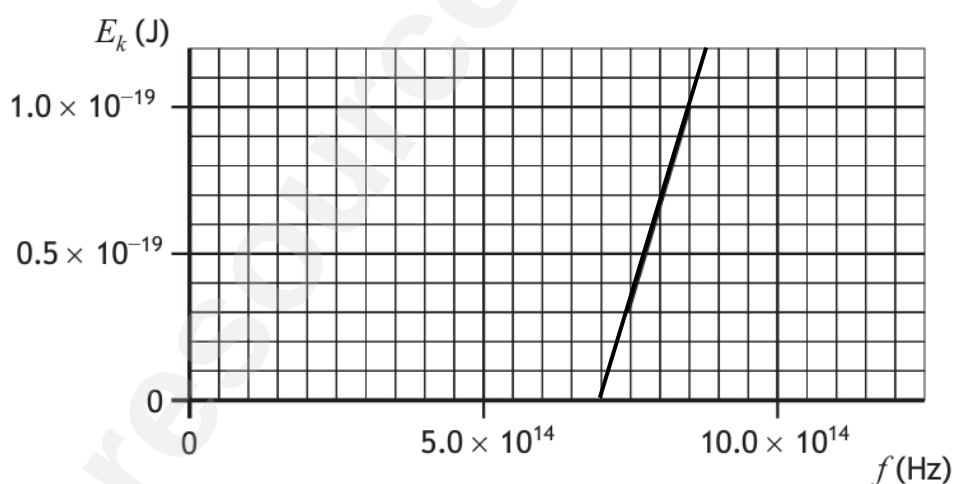
- 10.1.2 Calculate the wavelength of the photon emitted.

(4)

- 10.2 The apparatus shown is used to investigate photoemission. Electromagnetic radiation is incident on metal **X**.



The frequency of the electromagnetic radiation is varied. The maximum kinetic energy of the photoelectrons emitted from metal **X** is determined for a range of frequencies. The graph shows how the maximum kinetic energy, E_k , of the photoelectrons varies with frequency f .



- 10.2.1 Define *threshold frequency*.

(2)

- 10.2.2 Using the graph, determine the threshold frequency, f_0 , of metal **X**.

(1)

10.2.3 The work function of different metals is shown in the table.

Metal	Work function (eV)
Potassium	2,24
Calcium	2,90
Zinc	3,58
Gold	5,38

Identify which of these metals is most likely to be metal **X**. Justify your answer by calculation.

(4)

10.2.4 Use the graph to calculate Planck's constant.

(2)

10.2.5 The graph on the previous page is produced from a range of frequencies. If the intensity of the light source is increased across the same range, how will the graph be affected? Explain your answer.

(3)

[17]

ADDITIONAL SPACE (ALL QUESTIONS)

**REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE
ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.**

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QUESTION 3.3 SPARE GRAPH PAPER

