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TOTAL MARKS

NATIONAL SENIOR CERTIFICATE EXAMINATION
MAY 2023

PHYSICAL SCIENCES: PAPER I

EXAMINATION NUMBER

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 28 pages and a 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 this question paper.
4. Use the data and formulae when 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 26–27) and extra graph paper (page 28) are included at the end of the paper. If you run out of space for a question, use these pages. Clearly indicate the number of your answer should you use this extra space.

FOR OFFICIAL USE ONLY: MARKER TO ENTER MARKS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	TOTAL
Mark										
Marker Initial										
Moderated Mark										
Moderator Initial										
Question Total	**20**	**19**	**20**	**27**	**30**	**17**	**28**	**21**	**18**	**200**
Re-mark										
Initial										
Code										

QUESTION 1 MULTIPLE CHOICE

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

A	B	C	D

Here the option C has been marked as an example.

1.1	**A**	**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**

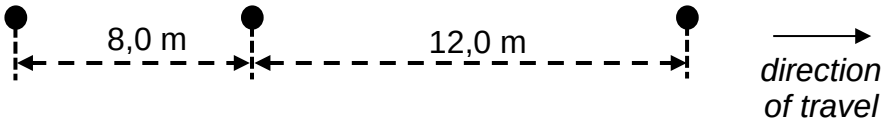
1.1 Two forces of 6 N and 10 N act simultaneously on an object. Which of these magnitudes is **not** a possible resultant force of this combination of forces?

A 4 N
B 9 N
C 16 N
D 18 N

1.2 A ball is thrown upwards by a person. Which one of the following combinations give the directions of the velocity of the ball, the acceleration of the ball and the net force that the ball experiences as it travels upwards just after leaving the person's hand?

	Velocity	**Acceleration**	**Net force**
A	Upward	Upward	Upward
B	Upward	Downward	Downward
C	Upward	Downward	Upward
D	Downward	Downward	Downward

1.3 A car moves along a straight, flat road with uniform acceleration. It drops an oil droplet every two seconds. The distances between oil droplets on the road are shown below:



The acceleration of the car is:

A $1\ m{\cdot}s^{-2}$
B $2\ m{\cdot}s^{-2}$
C $4\ m{\cdot}s^{-2}$
D $8\ m{\cdot}s^{-2}$

1.4 A light trolley is moving along a frictionless level surface at a constant speed. The top of the trolley is open. A large volume of sand is dropped into the trolley. The velocity of the trolley …

A increases.
B decreases.
C remains the same.
D immediately becomes zero.

1.5 A trolley with a mass m has momentum p. The kinetic energy of the trolley will be:

A pm
B $\frac{p}{m}$
C $\frac{p^2m}{2}$
D $\frac{p^2}{2m}$

1.6 A box rests on a desk. The Newton third law force paired with the weight of the box is …

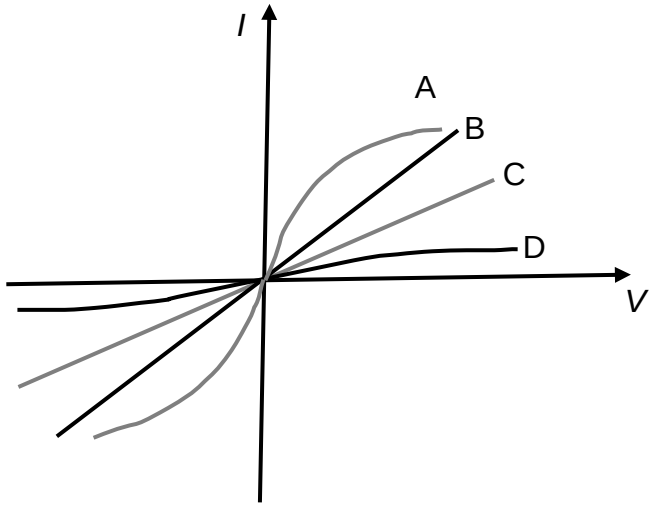
A the downward force by the Earth on the box.
B the upward force by the desk on the box.
C the downward force by the box on the desk.
D the upward force by the box on the Earth.

1.7 Two charged metal spheres exert a force ***F*** on each other. The spheres carry charges of –4 pC and +6 pC and are a distance ***r*** apart. They are brought together to touch and then separated to half their original distance apart.

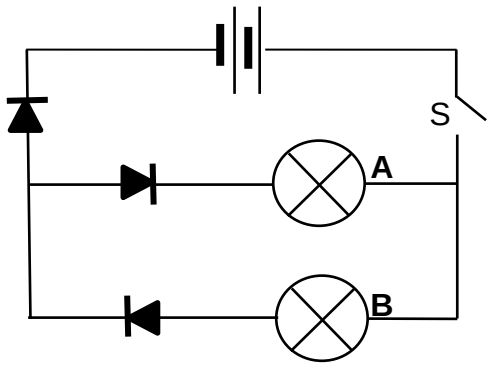
The new force between them is:

A ***F*** / 6
B ***F***
C 4***F***
D 6***F***

1.8 The graph below shows four relationships between current through a conductor and voltage across the conductor. Which graph shows the behaviour of the ohmic resistor with the highest resistance?

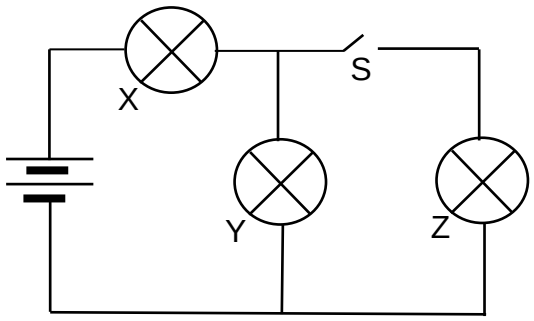


1.9 Two bulbs and three diodes are connected to a battery as shown in the circuit diagram below. Which bulb(s) will light up when switch S is closed?



A Bulb A only
B Bulb B only
C Both bulbs
D Neither of the bulbs

1.10 The bulbs in this circuit are identical. The battery has negligible internal resistance.



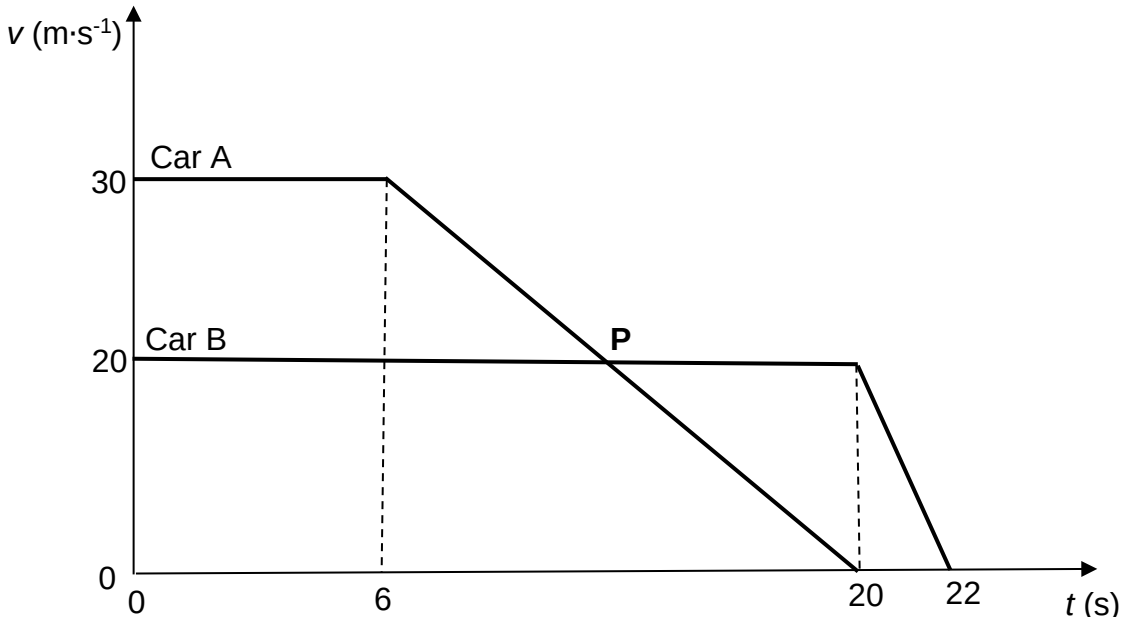
When the switch is closed:

A X and Y glow with the same brightness as before.
B X and Y glow less brightly than before.
C X glows more brightly and Y glows less brightly.
D X glows as brightly as before and Y glows less brightly.

[20]

QUESTION 2 KINEMATICS

Car A and Car B are travelling along a straight, level road. The velocity–time graph below represents the motion of the two cars.



2.1 Define *acceleration*. (2)

2.2 Which car has the greatest instantaneous acceleration? No calculations necessary. (2)

2.3 Calculate the magnitude of car A's acceleration between 6 seconds and 20 seconds. (3)

2.4 What do you know about the cars at point P, shown on the graph? (2)

After 20 seconds, car A comes to rest and the driver of car B applies the brakes. Car B takes 2 seconds to slow down to rest.

2.5 How far does car A travel over the 20 second period? (4)

2.6 If the cars come to rest next to each other, how far apart were they at time 0 seconds? (4)

2.7 Which car was leading at t = 0 seconds? (2)

[19]

QUESTION 3 KINEMATICS

3.1 A motorbike is travelling at 12 $m \cdot s^{-1}$ when it starts accelerating at 3,2 $m \cdot s^{-2}$ for 3 s.

3.1.1 Calculate the speed of the motorbike after the 3 second period of acceleration. (3)

3.1.2 How far will the motorbike travel while accelerating from 12 $m \cdot s^{-1}$ during the 3 s period of acceleration? (3)

3.2 A runner completes a 42,2 km race that starts and ends under a large banner at a sports ground. The runner's time for the race is 3 hours and 15 minutes.

3.2.1 Define *displacement*. (2)

3.2.2 Determine the runner's displacement in this race? (1)

3.2.3 Calculate the runner's average speed over the race. (4)

The start of the race is 10 km West and 14 km South of the runner's house.

3.2.4 Define a *resultant vector*. (2)

3.2.5 Determine the magnitude and direction of the runner's displacement from the house to the start of the race. (5)

[20]

QUESTION 4 STONE DROP

A stone with a mass of 300 g is dropped into a deep pool of water. Air resistance can be ignored. The stone hits the water with a velocity of 6 $m \cdot s^{-1}$ downwards. Once in the water, the stone slows down to a velocity of 0,8 $m \cdot s^{-1}$ downwards over a period of 0,2 seconds. The stone then continues to sink at this velocity.

4.1 Determine the kinetic energy of the stone just before it hits the surface of the water. (3)

4.2 Calculate the height above the surface of the water from which the stone was dropped. (3)

4.3 How long did the stone take to fall, from when it was dropped to when it hit the water? (3)

4.4 On the axes below, draw a velocity–time graph showing the velocity of the stone from the moment it was dropped to when it was sinking at constant velocity for 1,5 seconds. You must show the time values that you know. Assume a constant average acceleration for the stone after entering the water. (4)

4.5 Define *impulse*. (2)

4.6 Calculate the average net force experienced by the stone while it is slowing down in the water during the 0,2 seconds described. (5)

4.7 Draw a labelled free-body diagram of the forces acting on the stone while it is slowing down in the water, showing the relative sizes of the forces. (2)

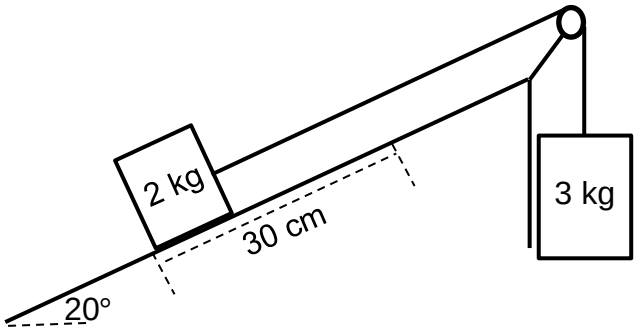
4.8 Determine the magnitude of the average upward force that the water exerts on the stone. (3)

4.9 Considering the forces acting on the stone, explain why it continues to fall at a constant 0,8 $m \cdot s^{-1}$ downwards shortly after landing in the water. (2)

[27]

QUESTION 5 ACCELERATING SYSTEM

A block of mass 3 kg is attached to a block of mass 2 kg via a light, inextensible string over a frictionless pulley as shown in the diagram. The 2 kg block is moving up the slope which is at an angle of 20° to the horizontal. The coefficient of kinetic friction between the block and the slope is 0,4.



5.1 Define *frictional force*. (2)

5.2 Draw a labelled free-body diagram of the forces acting on the 2 kg block. (4)

5.3 Determine the magnitude of the normal force acting on the 2 kg block. (3)

5.4 Calculate the magnitude of the frictional force acting on the 2 kg block as it moves up the slope. (3)

5.5 Write a mathematical expression for the forces acting on the 2 kg block parallel to the slope. (2)

5.6 Calculate the **acceleration** of the system **AND** the **tension** in the string. (4)

The 2 kg block moves 30 cm up the slope.

5.7 Define *the work done on an object by a force*. (2)

5.8 Calculate the energy lost due to the frictional force acting on the 2 kg block. (3)

5.9 How much kinetic energy is gained by the 2 kg block as it moves 30 cm up the slope? (3)

5.10 The string is cut. What will the magnitude and direction of the acceleration of the 2 kg block be? (4)

[30]

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QUESTION 6 FIELDS

6.1 A polystyrene ball carrying a charge of –5 nC rests on a surface. It has a mass of 2 g. A charged sphere is lowered towards the polystyrene ball. When the sphere is at a height of 3 mm above the polystyrene ball, the polystyrene ball is about to lift off.

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

6.1.2 Calculate the magnitude of the weight of the polystyrene ball. (2)

6.1.3 Calculate the magnitude of the charge on the charged sphere. (4)

6.2 The Hope satellite of mass 550 kg is in orbit around Mars. Mars has a mass of $6,4 \times 10^{23}$ kg and a radius of 3 400 km.

6.2.1 Define *gravitational field*. (2)

6.2.2 Calculate the magnitude of the gravitational field on the surface of Mars. (3)

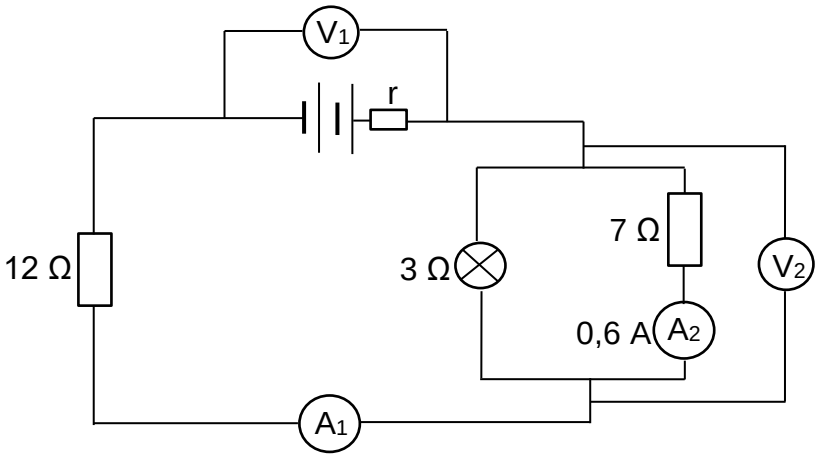
At one point in the Hope satellite's orbit, it is a distance of $31,6 \times 10^{3}$ km above the surface of Mars.

6.2.3 Calculate the force on the Hope satellite at this point in the satellite's orbit. (4)

[17]

QUESTION 7 ELECTRIC CIRCUITS

In the circuit represented below, the battery has an emf of 30 V and an unknown internal resistance. Ammeter A_2 reads 0,6 A. The ammeters have zero resistance and the voltmeters have infinite resistance.



7.1 State *Ohm's law*. (2)

7.2 Calculate the reading on V_2. (3)

7.3 What is the effective resistance of the bulb and resistor connected in parallel? (2)

7.4 Define *current*. (2)

7.5 Calculate the current reading on ammeter A_1. (4)

7.6 Calculate the power of the 12 Ω resistor. (3)

7.7 Determine the internal resistance of the battery. (4)

7.8 Calculate the amount of energy emitted by the 3 Ω bulb in 3 minutes. (4)

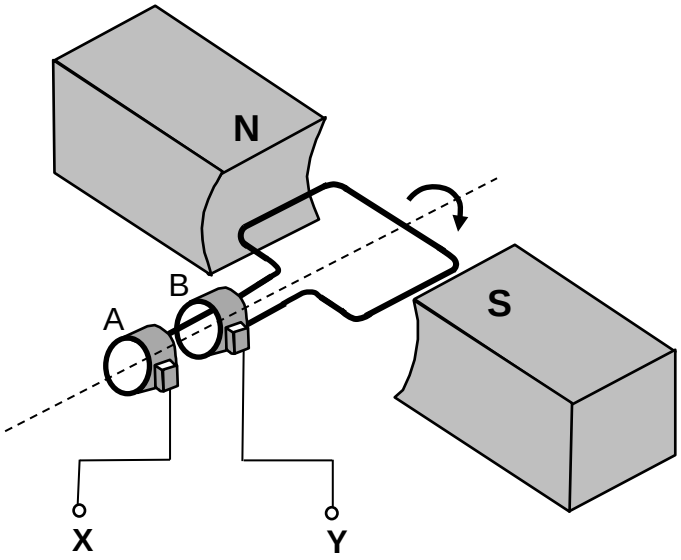
7.9 If the voltmeter V_2 is replaced by a conducting wire, what would happen to the reading on V_1? (1)

7.10 Explain your answer to Question 7.9. Use an appropriate equation to aid you in your explanation. (3)

[28]

QUESTION 8 ELECTRODYNAMICS

The diagram below shows a simple generator with a coil that is rotated clockwise in the magnetic field.

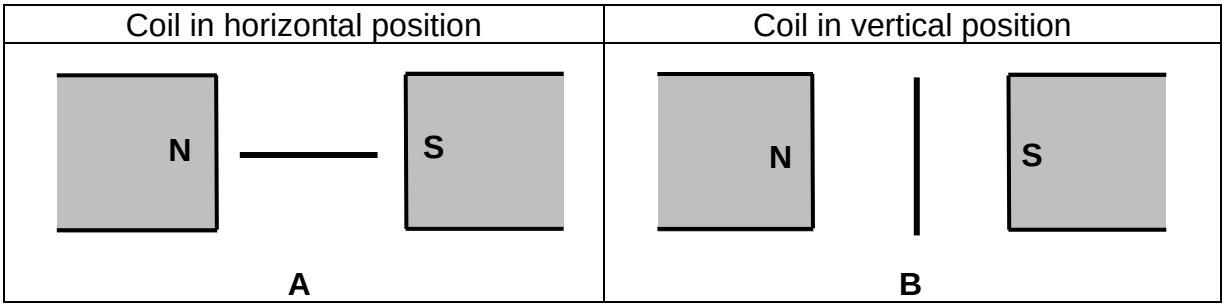


8.1 Name the components that are labelled A and B on the diagram. (1)

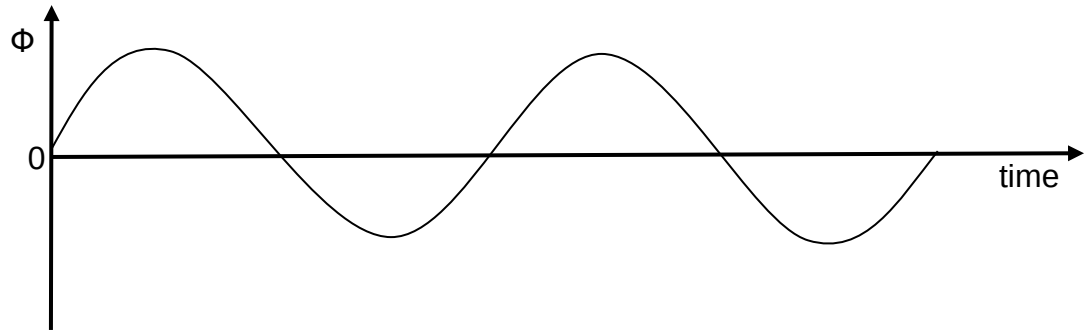
8.2 Explain why current flows in the coil when it is rotated through the magnetic field. (3)

8.3 In which direction will the current flow in an external circuit connected to X and Y? Write only **X to Y** or **Y to X**. (2)

8.4 Two positions of the coil as seen from the axis of rotation are shown below:



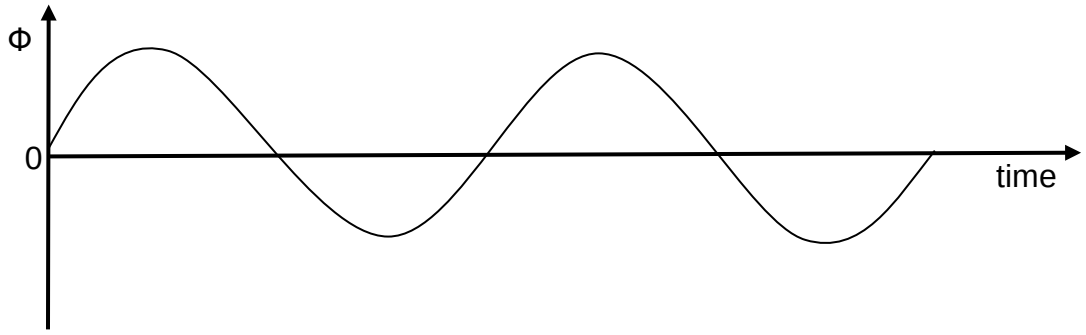
The graph below shows the magnetic flux experienced by the coil as it is rotated against time.



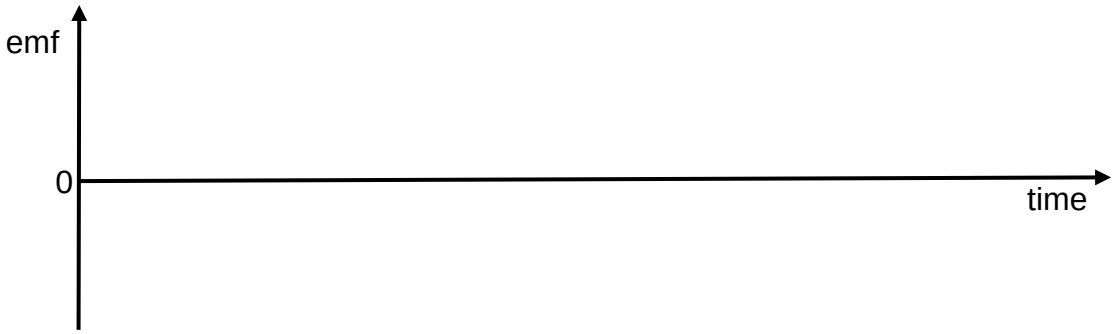
8.4.1 Will the coil be in the horizontal position or the vertical position at time = 0 as shown on this graph? (2)

8.4.2 Give a reason for your answer to Question 8.4.1. (2)

The graph of magnetic flux against time from the previous page is repeated here for convenience:



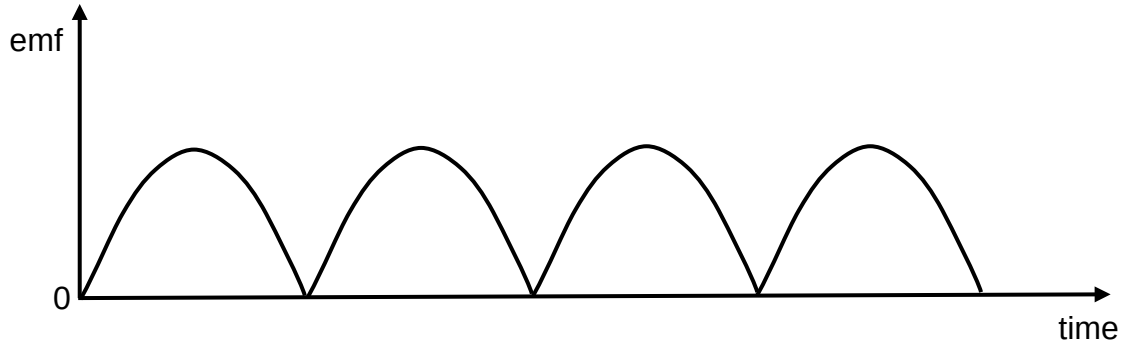
8.4.3 Draw a sketch graph on the axes given below showing the emf against time for the coil, corresponding to the magnetic flux against time graph shown above. (2)



8.5 A transformer has 20 turns on the primary coil. The potential difference across the primary coil is 8 V. How many turns must be on the secondary coil of the transformer to step the voltage up to 240 V? (3)

8.6 Explain why a transformer operates with an alternating current input, but not with a direct current input. (2)

8.7 The graph below represents the fully rectified output of an AC generator. On the same set of axes, draw a graph showing the *emf* against time when the coil is rotated at half the rate. Label this line **slower**. (2)



8.8 Give one example of how the output of the generator could be fully rectified. (2)

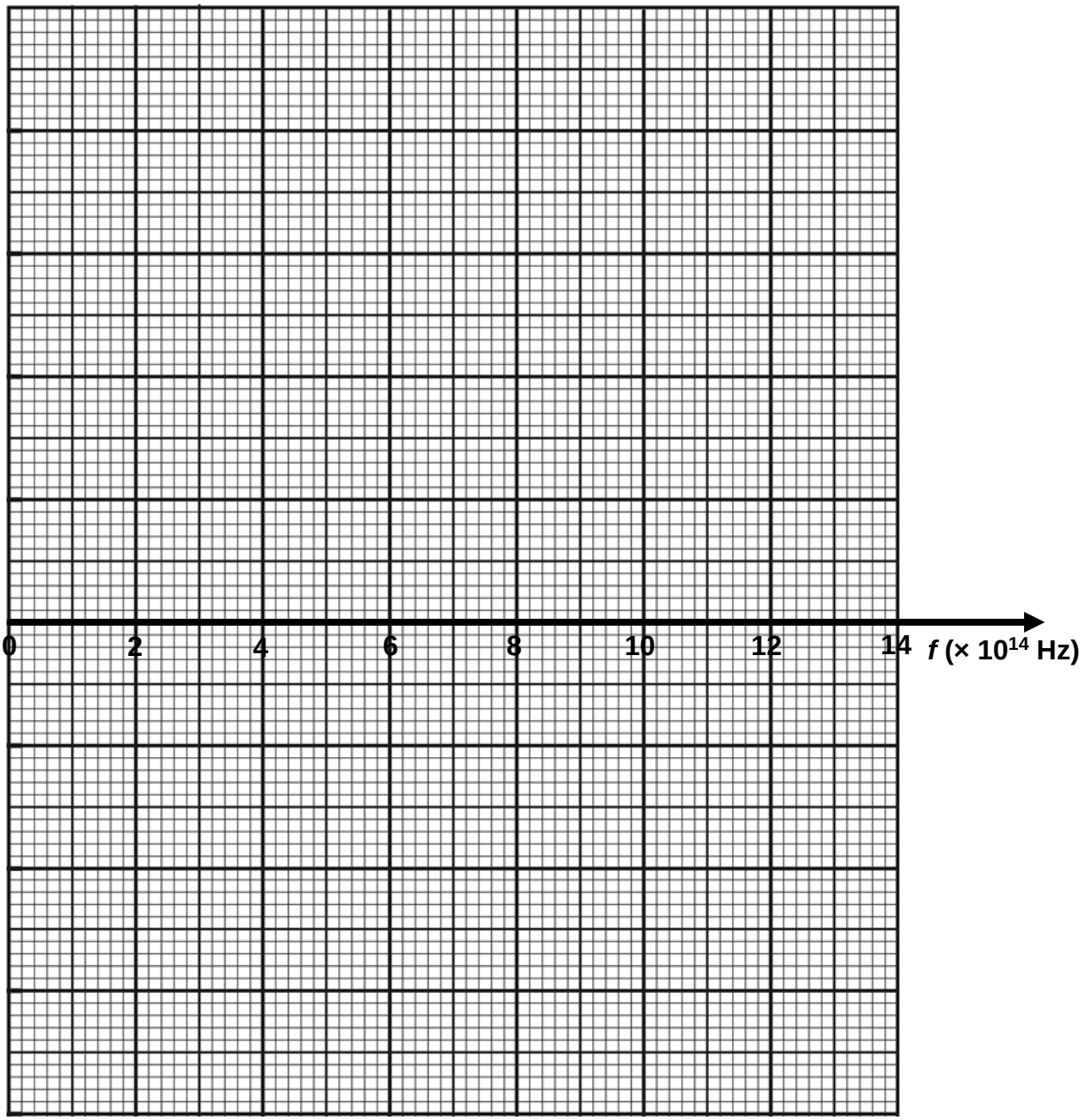
[21]

QUESTION 9 PHOTONS AND ELECTRONS

Light of increasing frequency is shone onto a caesium surface and the maximum kinetic energy of the electrons ejected from the surface is recorded in the table below.

f (× 10^{14} Hz)	$E_{K(max)}$ (× 10^{-19} J)
5,6	0,3
6,2	0,8
7,8	1,7
8,4	2,3
10,0	3,4
11,4	4,2

9.1 Plot a graph of the maximum kinetic energy of the ejected electrons (on *y*-axis) vs the frequency of incident light (on *x*-axis) on the graph paper below. (6)



9.2 Define *threshold frequency*. (2)

9.3 Determine the threshold frequency of caesium using the graph drawn in Question 9.1. (2)

9.4 Determine the gradient of the graph that you plotted in Question 9.1. Include a unit with your gradient. (4)

9.5 Use the photoelectric effect equation and your answer to Question 9.4 to calculate Planck's constant. (2)

9.6 State what quantity can be determined from the y-intercept of the graph plotted in Question 9.1.

(2)

[18]

Total: 200 marks

ADDITIONAL SPACE (ALL questions)

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

QUESTION 9.1 EXTRA GRAPH PAPER