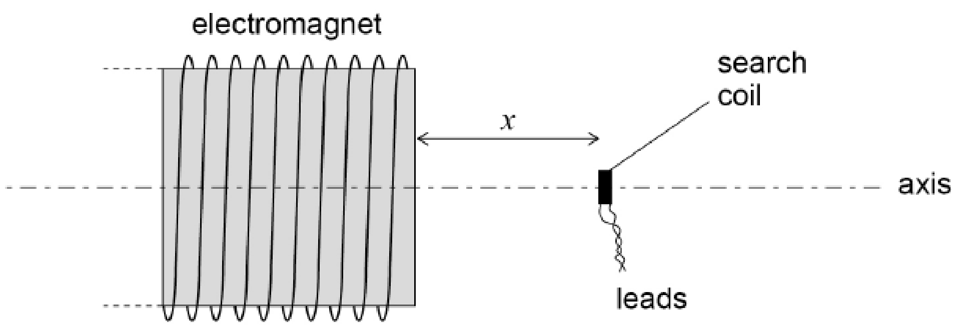
AQA – Magnetic fields – A2 Physics P2

1. June/2021/Paper_7408_2/No.04

0	4

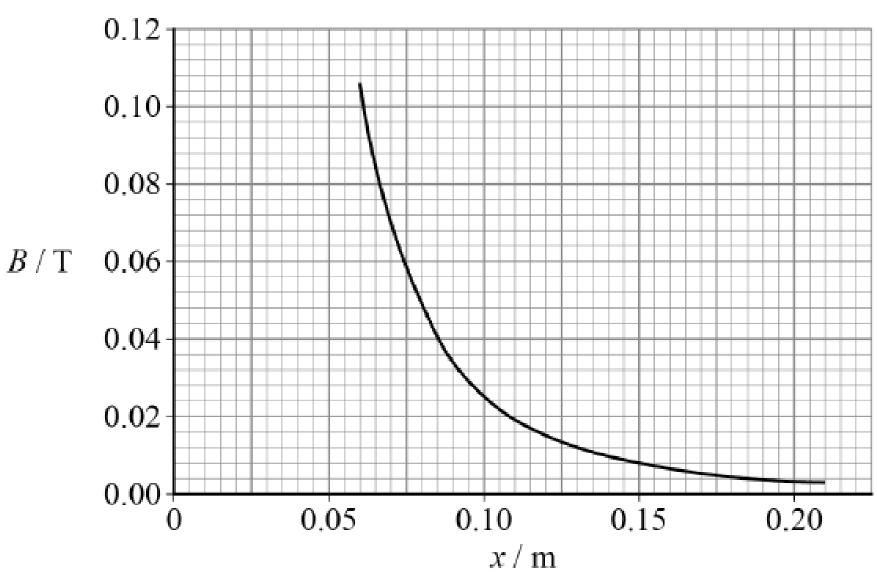
Figure 7 shows a search coil positioned on the axis of an electromagnet, with the plane of the search coil perpendicular to the axis. A magnetic field is produced by a constant current in the electromagnet.
Assume that the magnetic flux density inside the search coil is uniform.

Figure 7



The distance between the search coil and the end of the electromagnet is x.
Figure 8 shows how the magnetic flux density B of the field varies with x.

Figure 8



The search coil has 200 turns and a cross-sectional area of 3.5×10^{-5} m^2.

0 4 . 1 The search coil is placed at $x = 0.070$ m.

Show that the magnetic flux linkage through the search coil is about 5×10^{-4} Wb.

[2 marks]

The search coil is now moved at a constant speed of 0.80 m s^{-1} along the axis so that x is increasing. An emf is induced across the terminals of the search coil.

0 4 . 2 Explain what happens to the value of the emf as the search coil moves.

[2 marks]

0 4 . 3 The search coil passes through the position where $x = 0.10 \text{ m}$.

Deduce whether the emf can exceed 5 mV for values of x greater than 0.10 m.

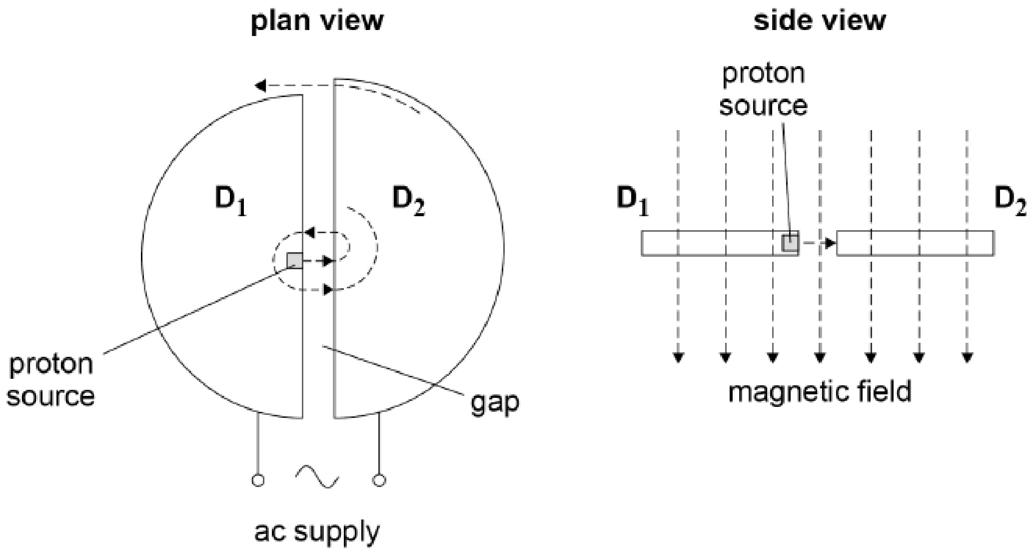
[4 marks]

2. June/2021/Paper_7408_2/No.05

0 5 **Figure 9** shows a cyclotron. A proton is released from rest and is accelerated each time it reaches the gap between two horizontal 'dees' **D**$_1$ and **D**$_2$. Between these accelerations the proton moves at constant speed. A vertical magnetic field of flux density B acts over the dees so that the proton follows a semicircular path in each dee.

The dees are connected to an alternating potential difference (pd).
This pd is adjusted so that the proton is always accelerated by the peak electric field as it crosses the gap between the dees.

Figure 9



0 5 . 1 Explain why the proton travels in a semicircular path in a dee.

[2 marks]

0 5 . 2 The peak pd of the alternating supply is 10.0 kV. The proton leaves the cyclotron with kinetic energy of 14 MeV.

Determine the number of times the proton moves across the gap before it leaves the cyclotron.

[1 mark]

number of times = ____________________

The radius of the outermost semicircular path of the proton is R and the proton leaves with a maximum kinetic energy E_k.

0 5 . 3 Show that E_k is given by

$$E_k = \frac{e^2 B^2 R^2}{2m_p}$$

[3 marks]

0 5 . 4 A hospital decides to purchase a cyclotron in order to manufacture its own radioactive isotopes using high-speed protons.
The required minimum kinetic energy of the emerging protons is 11 MeV.
The cost of a cyclotron is approximately proportional to $E_k^{1.5}$.
The cost of a 10 MeV cyclotron is about £2.3 million.
Table 1 gives information for three cyclotrons **X**, **Y** and **Z**.

Table 1

Cyclotron	B / T	R / m
X	1.3	0.38
Y	1.1	0.50
Z	0.5	0.60

Deduce which cyclotron **X**, **Y** or **Z** will satisfy the energy requirement for the lowest cost.
Go on to determine the approximate cost of this cyclotron.

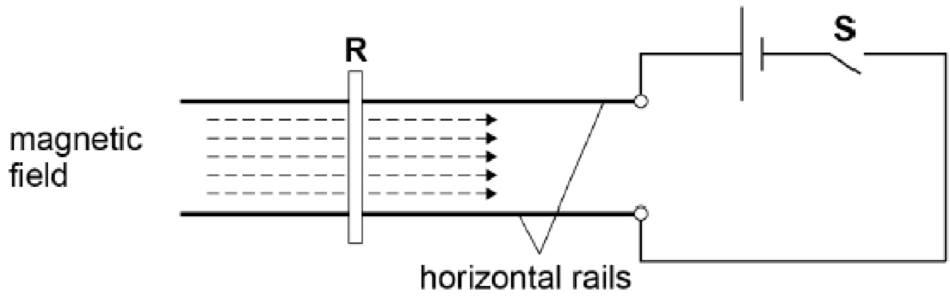
[4 marks]

cyclotron = ____________________

cost = ____________________

3. June/2021/Paper_7408_2/No.21

A short copper rod **R** is placed on a pair of thick horizontal parallel copper rails.
A horizontal magnetic field exists in the direction shown by the dashed arrows.
The diagram shows the apparatus when viewed from directly above.



When switch **S** is closed, **R** will tend to

[1 mark]

A lift upwards away from the rails. ⬭

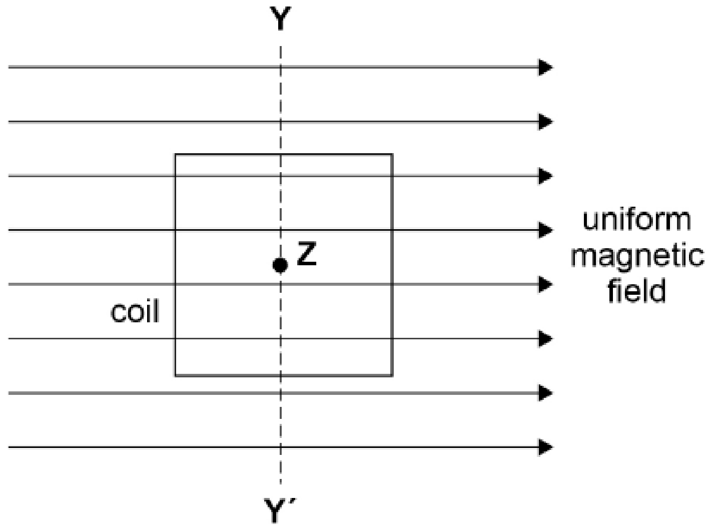
B move to the left. ⬭

C move to the right. ⬭

D be pressed downwards onto the rails. ⬭

4. June/2021/Paper_7408_2/No.22

The diagram shows a square coil with its plane parallel to a uniform magnetic field.



The coil always remains within the magnetic field.
There are four possible changes to the position of the coil:

- moving it to the left
- moving it towards **Y**
- rotating it about the axis **YY´**
- rotating it about an axis **Z** that is at its centre and perpendicular to the plane of the coil.

How many of these changes will result in an induced emf in the coil while the change occurs?

[1 mark]

A one ⬭

B two ⬭

C three ⬭

D four ⬭

5. June/2021/Paper_7408_2/No.23

Mains electricity is rated 230 V in the UK.

Which is correct?

[1 mark]

A The mean voltage is 163 V. ⬭

B The peak voltage is 230 V. ⬭

C The root mean square voltage is 325 V. ⬭

D The peak-to-peak voltage is 650 V. ⬭

6. June/2021/Paper_7408_2/No.25

The primary winding of a transformer has 200 turns and the secondary winding has 1600 turns.
A root mean square (rms) alternating voltage of 25 V is applied to the primary winding causing a primary rms current of 4.0 A. The transformer is 90% efficient.

What are the rms values of the secondary voltage and the secondary current?

[1 mark]

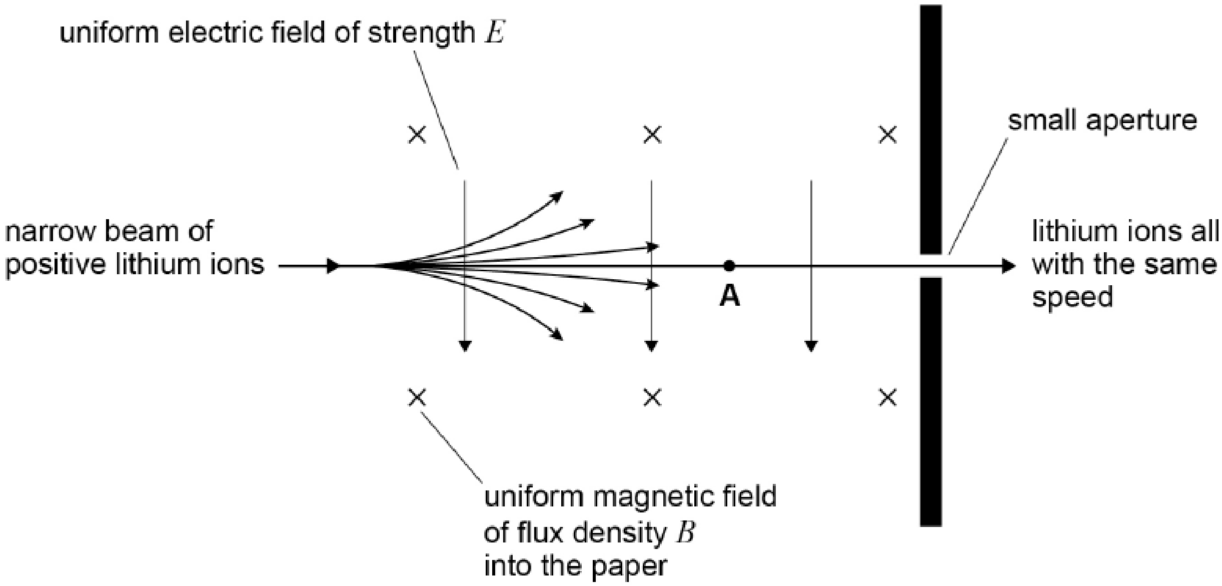
	Secondary voltage / V	Secondary current / A	
A	200	0.50	⬭
B	200	0.45	⬭
C	180	0.50	⬭
D	3.1	29.0	⬭

7. June/2020/Paper_7408_2/No.03

0 3 Mass spectrometers are used to measure the masses of ions.

Figure 3 shows one part of a mass spectrometer.

Figure 3



A narrow beam consists of positive lithium ions travelling at different speeds.
The beam enters a region where there is an electric field and a magnetic field.
The directions of the uniform electric field of strength E and the uniform magnetic field of flux density B are shown on **Figure 3**.

Most ions are deflected from their original path.
Lithium ions that travel at one particular speed are not deflected, and pass through the small aperture.

0 3 . 1 The positive lithium ion **A** in **Figure 3** moves at a speed v.

Draw **two** labelled arrows on **Figure 3** to show the directions of the electric force F_E and the magnetic force F_M acting on **A**.

[1 mark]

0 3 . 2 Lithium ions travelling at $1.5 \times 10^5\ \text{m s}^{-1}$ pass through the small aperture.

Calculate E.

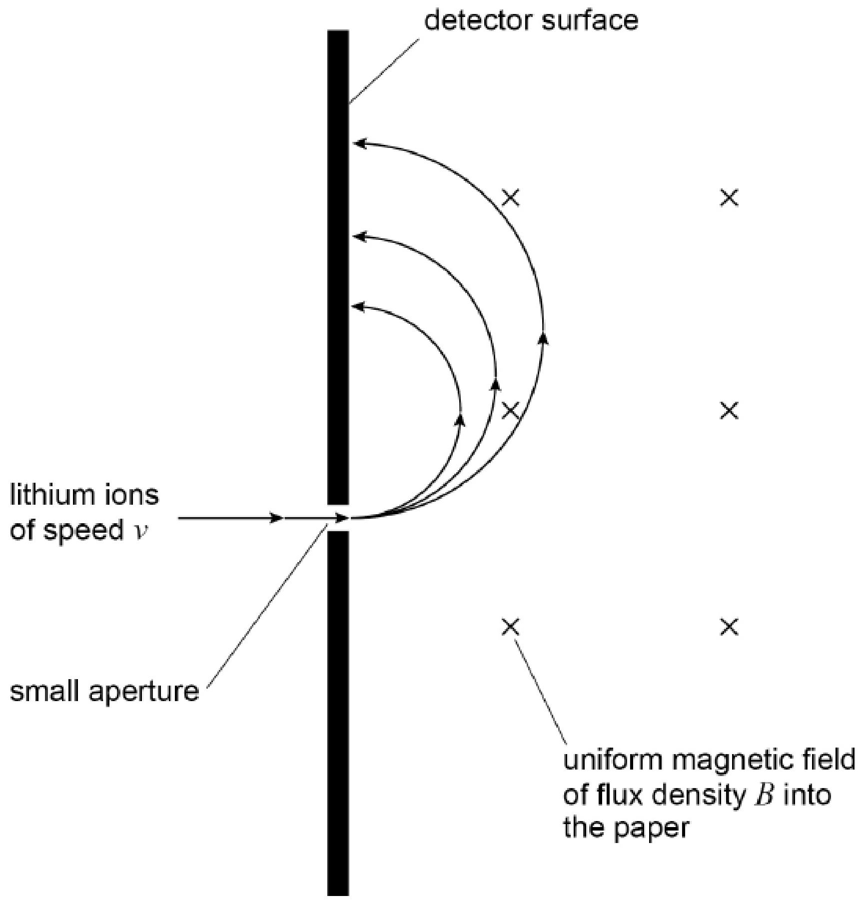
$B = 0.12\ \text{T}$

[2 marks]

$E =$ ______________________ V m^{-1}

0 3 . 3 Ions that pass through the small aperture enter a second uniform magnetic field of flux density B.
Ions of different mass are separated because they follow different paths as shown in **Figure 4**.

Figure 4



Ions of mass m and charge q travelling at speed v follow a circular path in the uniform magnetic field.

Show that the radius r of the circular path is given by

$$r = \frac{mv}{Bq}$$

[1 mark]

0 3 . 4 The ions of different mass are deflected and strike the detector surface at different distances from the small aperture as shown in **Figure 4**.

A singly-charged lithium ion ($^{6}_{3}\mathrm{Li}^{+}$) passes through the small aperture.

Calculate the distance between the small aperture and the point where this ion strikes the detector surface.

$v = 1.5 \times 10^{5}\ \mathrm{m\ s^{-1}}$

$B = 0.12\ \mathrm{T}$

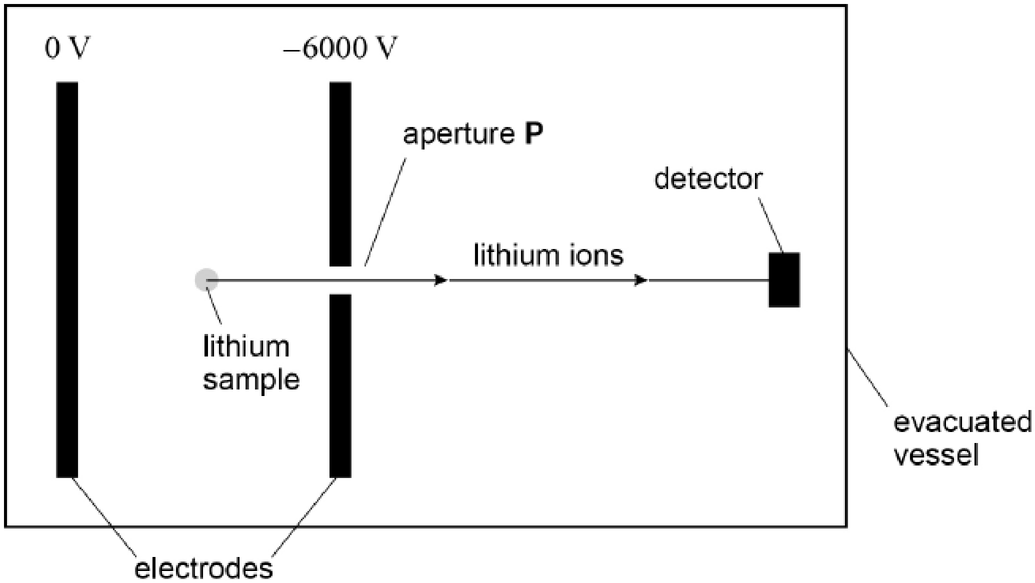
mass of $^{6}_{3}\mathrm{Li}^{+}$ ion $= 1.0 \times 10^{-26}\ \mathrm{kg}$

[2 marks]

distance = ______________________ m

0 3 . 5 **Figure 5** shows a different type of mass spectrometer working with lithium ions.

Figure 5



A stationary $^{7}_{3}\mathrm{Li}^{+}$ ion in the lithium sample is at the mid-point between the parallel electrodes. The $^{7}_{3}\mathrm{Li}^{+}$ ion accelerates towards aperture **P**.

Determine the speed of the ion when it emerges through aperture **P**.

mass of $^{7}_{3}\mathrm{Li}^{+}$ ion $= 1.2 \times 10^{-26}$ kg

[3 marks

speed = ____________________ $\mathrm{m\,s^{-1}}$

0 3 . 6 $^{6}_{3}\mathrm{Li}^{+}$ and $^{7}_{3}\mathrm{Li}^{+}$ ions are produced in the sample simultaneously and travel a distance L from aperture **P** to the detector.
For each type of ion, the time interval between production and detection is measured.

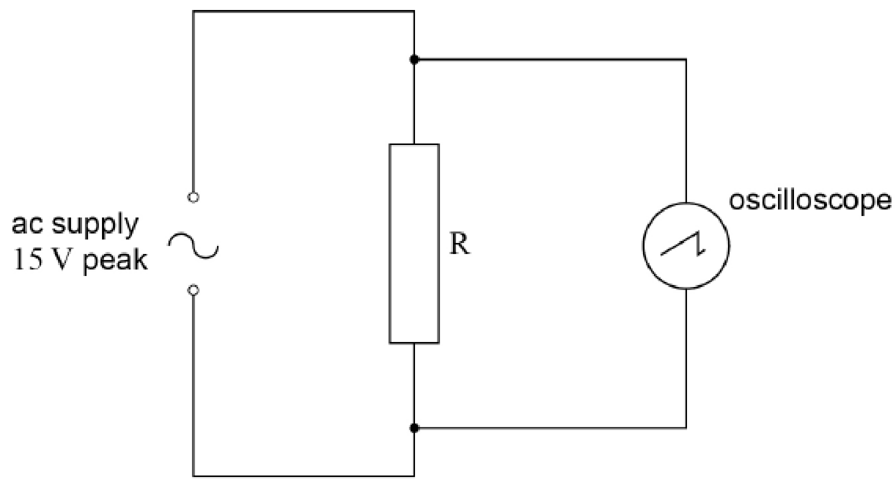
Discuss how the masses of the ions can be deduced from the measurement of these time intervals.

[2 marks]

8. June/2020/Paper_7408_2/No.4

0 4 **Figure 6** shows an oscilloscope connected across resistor R which is in series with an ac supply. The supply provides a sinusoidal output of peak voltage 15 V.

Figure 6



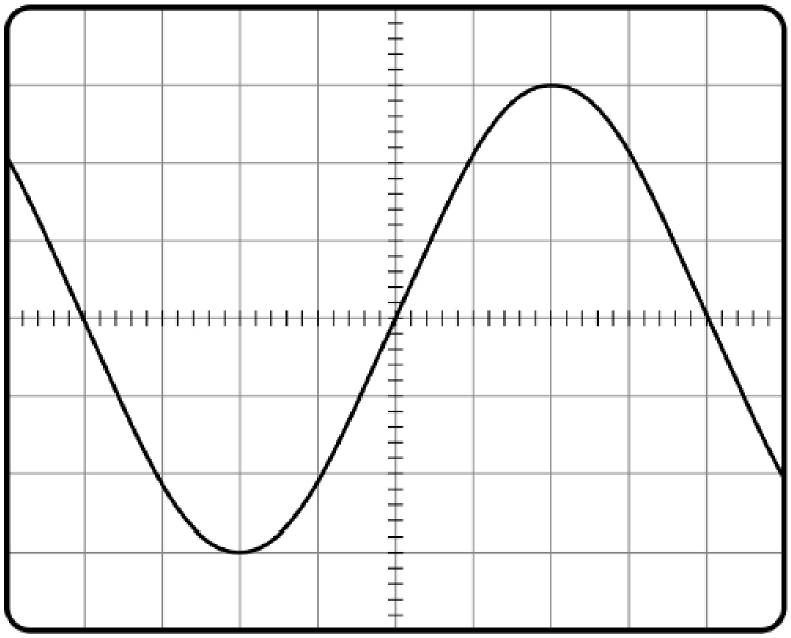
0 4 . 1 Calculate the rms voltage of the supply.

[1 mark]

rms voltage = ______________________ V

Figure 7 shows the trace of the waveform displayed on the oscilloscope.

Figure 7



0 4 . 2 Determine the y-voltage gain of the oscilloscope used for **Figure 7**.

[1 mark]

y-voltage gain = ____________________ $V\ div^{-1}$

0 4 . 3 A dc supply gives the same rate of energy dissipation in R as the ac supply in **Figure 6**.

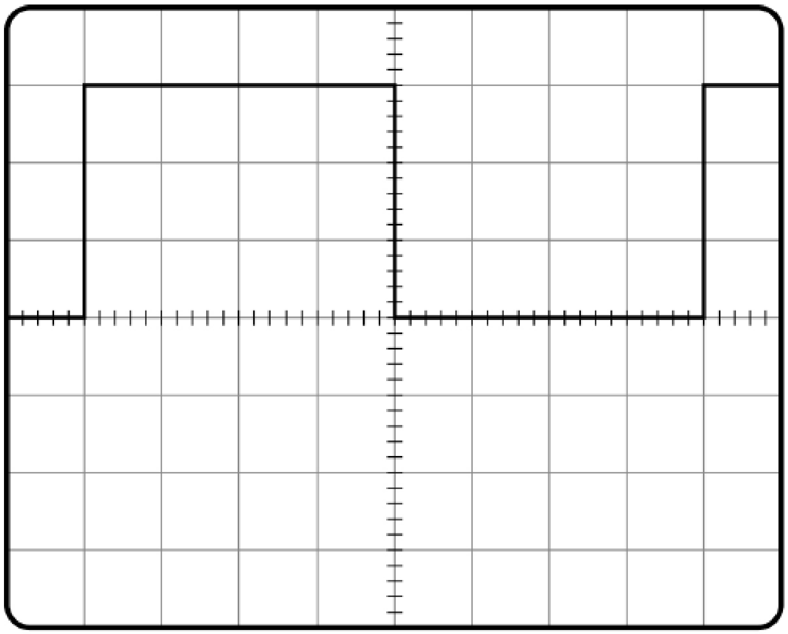
Draw the trace of the output of the dc supply on **Figure 7**.
The oscilloscope settings remain the same.

[1 mark]

0 4 . 4 The ac supply shown in **Figure 6** is replaced with a square-wave generator operating between 0 and +15 V.

Figure 8 shows the trace of the new waveform displayed on the oscilloscope. The time-base is set to 5.0×10^{-4} s div^{-1}.

Figure 8



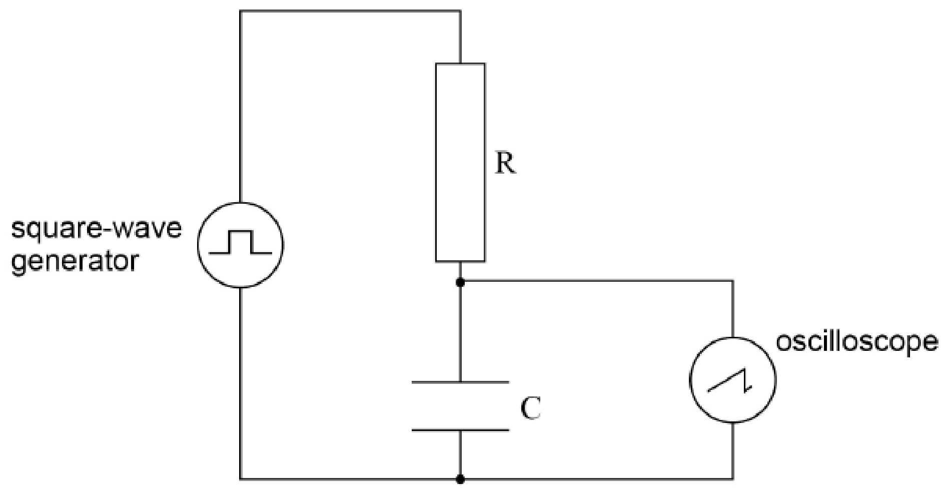
Calculate the frequency of the square waves.

[1 mark]

frequency = ____________________________ Hz

0 4 . 5 **Figure 9** shows the arrangement with the square-wave generator connected to an RC circuit.
A capacitor C is placed in series with the resistor R.
The oscilloscope is connected across the capacitor C.

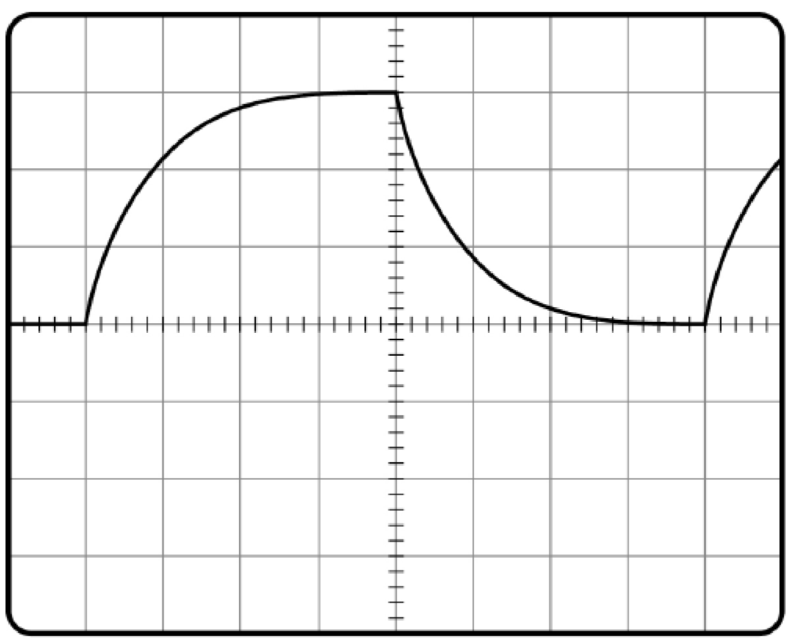
Figure 9



The capacitor charges and discharges.

Figure 10 shows the trace of the waveform displayed on the oscilloscope.
The settings of the oscilloscope remain the same as in Question **04.4**.

Figure 10



Deduce the time constant for the RC circuit, explaining each step of your method.

[3 marks]

time constant = ______________________ s

____

____

____

____

____

____

0 4 . 6 State and explain a change to **one** control setting on the oscilloscope that would reduce the uncertainty in the value of the time constant.

[2 marks]

____

____

____

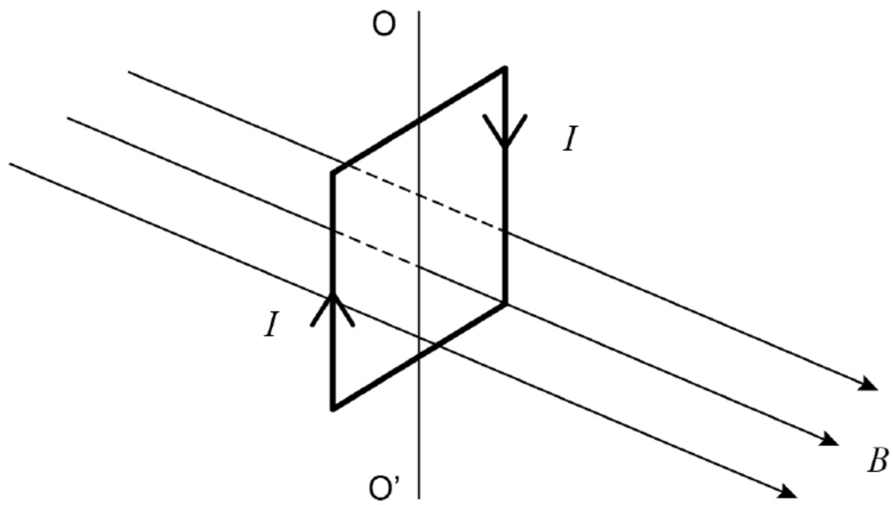
____

____

____

9. June/2020/Paper_7408_2/No.23

The diagram shows a current I in a vertical square coil.
The coil can rotate about an axis OO'.
The plane of the coil is at right angles to a uniform horizontal magnetic field of flux density B.



Which statement is correct?

[1 mark]

A The forces on the vertical sides of the coil are equal in magnitude and opposite in direction. ⬭

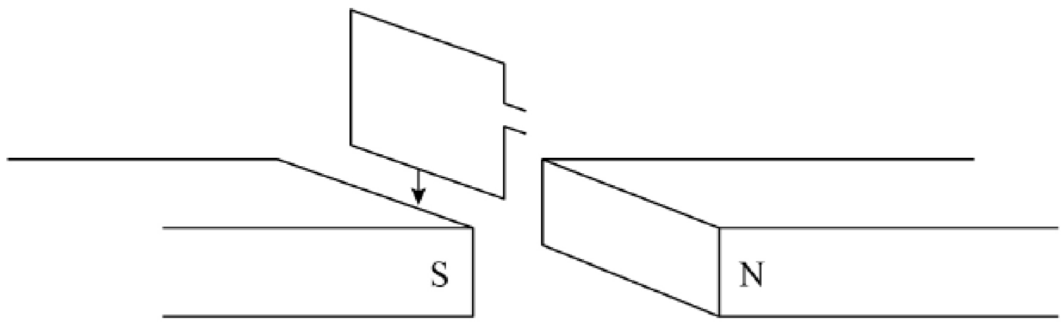
B A non-zero couple acts on the coil. ⬭

C No forces act on the horizontal sides of the coil. ⬭

D The forces on all sides of the coil act toward the centre of the coil. ⬭

10. June/2020/Paper_7408_2/No.24

The diagram shows a small rectangular coil falling between two magnetic poles.

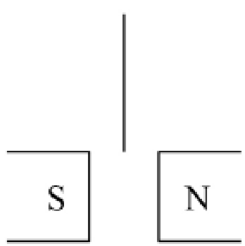


The coil is shown at four instants as it passes through the magnetic field.

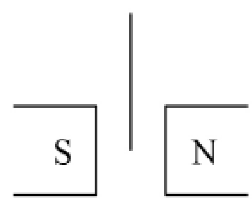
At which instant will the induced emf be a maximum?

[1 mark]

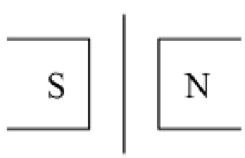
A



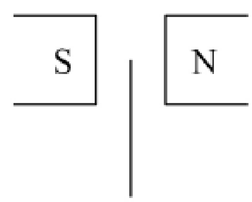
B



C



D



A ○

B ○

C ○

D ○

11. June/2020/Paper_7408_2/No.25

An alternating emf is induced in a coil rotating in a magnetic field.

What is the phase difference between the magnetic flux linkage through the coil and the emf?

[1 mark]

A 0 ○

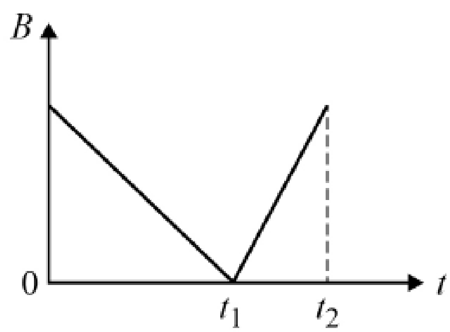
B $\frac{\pi}{3}$ rad ○

C $\frac{\pi}{2}$ rad ○

D π rad ○

12. June/2020/Paper_7408_2/No.26

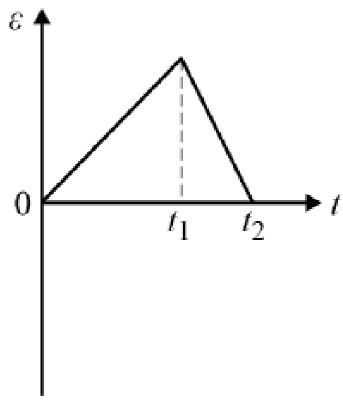
The diagram shows the variation with time t of the magnetic flux density B of the field linking a coil.



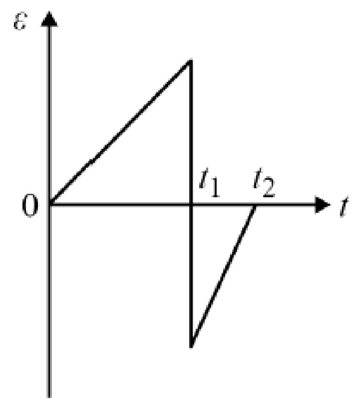
Which graph shows the variation of induced emf ε in the coil during this time interval?

[1 mark]

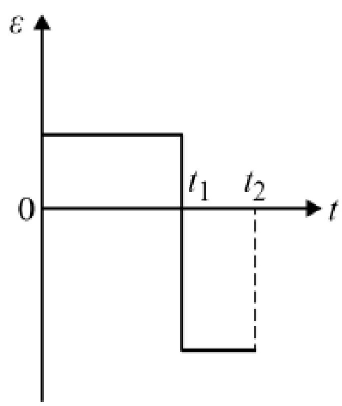
A



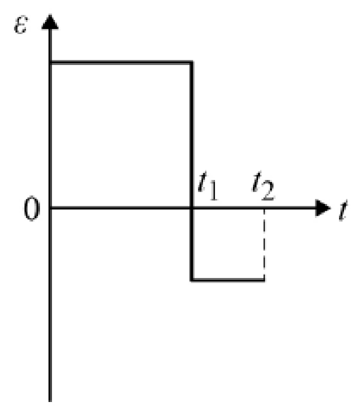
B



C



D



A ⬭

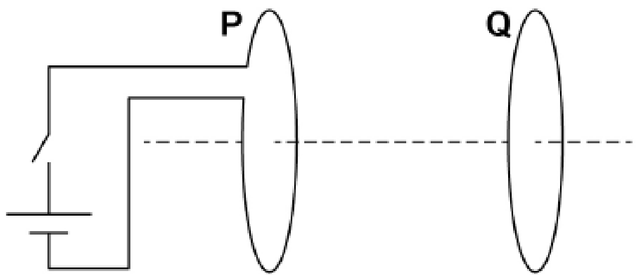
B ⬭

C ⬭

D ⬭

13. June/2020/Paper_7408_2/No.27

A coil **P** is connected to a cell and a switch.
A closed coil **Q** is parallel to **P** and is arranged on the same axis.



Which describes the force acting on **Q** after the switch is closed?

[1 mark]

A steady and directed to the left ⬭

B steady and directed to the right ⬭

C short-lived and directed to the left ⬭

D short-lived and directed to the right ⬭