**8** **(a)** Fig. 8.1 (top view) shows a metal ring of mass $m$ and radius $r$, falling from rest within a horizontal radial magnetic field.

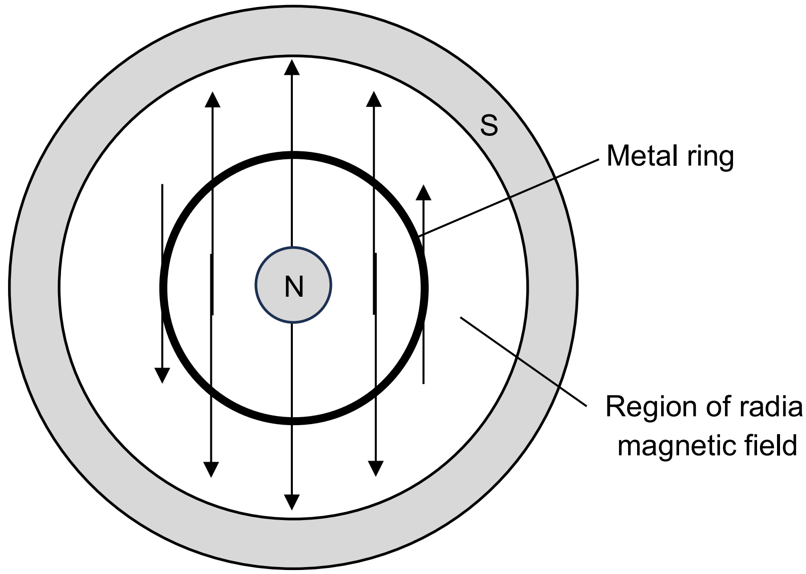


**Fig. 8.1** (top view)

The centre of the ring coincides with the centre of the radial magnetic field.

The ring has a resistance $R$ and the average magnetic flux density at the ring's position is $B$.

At time $t$, the ring has speed $v$ and acceleration $a$.

**(i)** Show that the magnetic flux cut by the ring from time $t$ to $t$+⊗$t$, where ⊗$t$ is a short time interval is given by:

$$\Delta\Phi = 2\pi rBv\Delta t$$

[1]

**(ii)** Show that the current $I$ induced in the ring is given by:

$$I = \frac{2\pi rBv}{R}$$

[2]

**(iii)** Air resistance is negligible. Show that the acceleration $a$ of the ring is given by:

$$a = g - \frac{(2\pi rB)^2 v}{mR}$$

where $g$ is the acceleration of free fall.

[2]

**(iii)** The average magnetic flux density $B$ at the ring's position is 0.800 T. The ring has a resistance $R = 2.30 \times 10^{-4}$ ∧, radius $r = 3.00$ cm and mass $m = 0.0235$ kg.

Determine the maximum speed of the ring.

maximum speed = ……………… m $s^{-1}$ [3]

**(iv)** On Fig. 8.2a and Fig 8.2b below, sketch the variation with time $t$ of

**1.** the velocity $v$ of the ring. [2]
**2.** the acceleration $a$ of the ring. [1]


**Fig. 8.2a**


**Fig. 8.2b**

**(b)** Fig. 8.3 shows the ring in **(a)**, with one quadrant removed and placed in a uniform magnetic field of flux density 0.500 T.

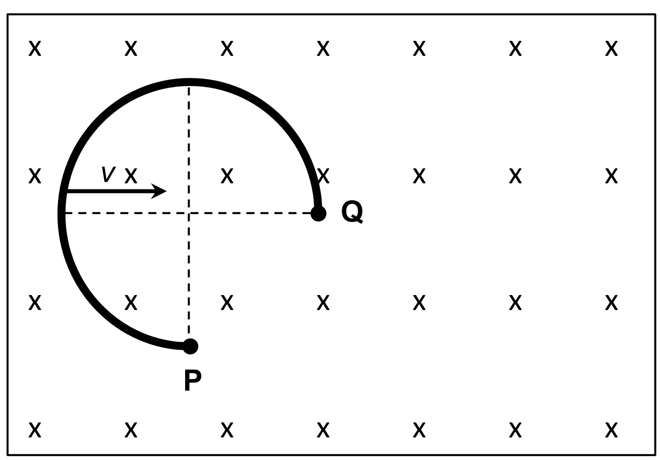

**Fig. 8.3**

The three-quarter ring is moved at a constant speed of 3.00 cm $s^{-1}$ towards the right.

**(i)** Determine the e.m.f. induced across the two free ends P and Q.

e.m.f. = ………………… V [2]

**(ii)** State which end (P or Q) is at a higher potential.

higher potential at ………… [1]

**(c)** Fig. 8.4 shows three long straight current-carrying conductors placed parallel to one another.

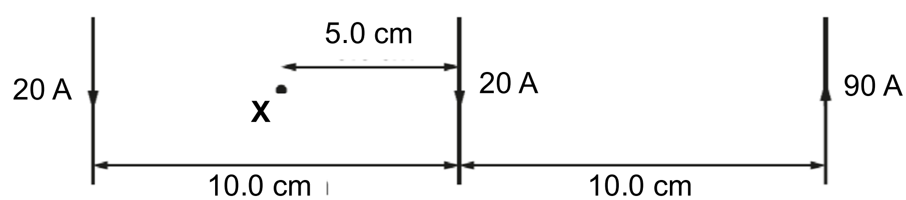


**Fig. 8.4**

**(i)** Determine the resultant magnetic flux density at X.

Flux density at X = ………………………………….……. T [2]

Direction = …………………………………… [1]

**(ii)** The distance measured from the left-most conductor is *d*.

Curve A in Fig. 8.5 shows the variation with *d* of the magnetic flux density *B* due to the left-most conductor for the range 2.0 cm δ *d* δ 8.0 cm.

Curve C shows the magnetic flux density due to the current in the right-most conductor.

Positive values of *B* represent magnetic flux density pointing out of the page.

On the same figure, sketch the variation with *d* of

**1**. the magnetic flux density due to the current in the middle conductor.

Label the curve B and

**2**. the resultant magnetic flux density due to the current in all three conductors. Label the curve R.

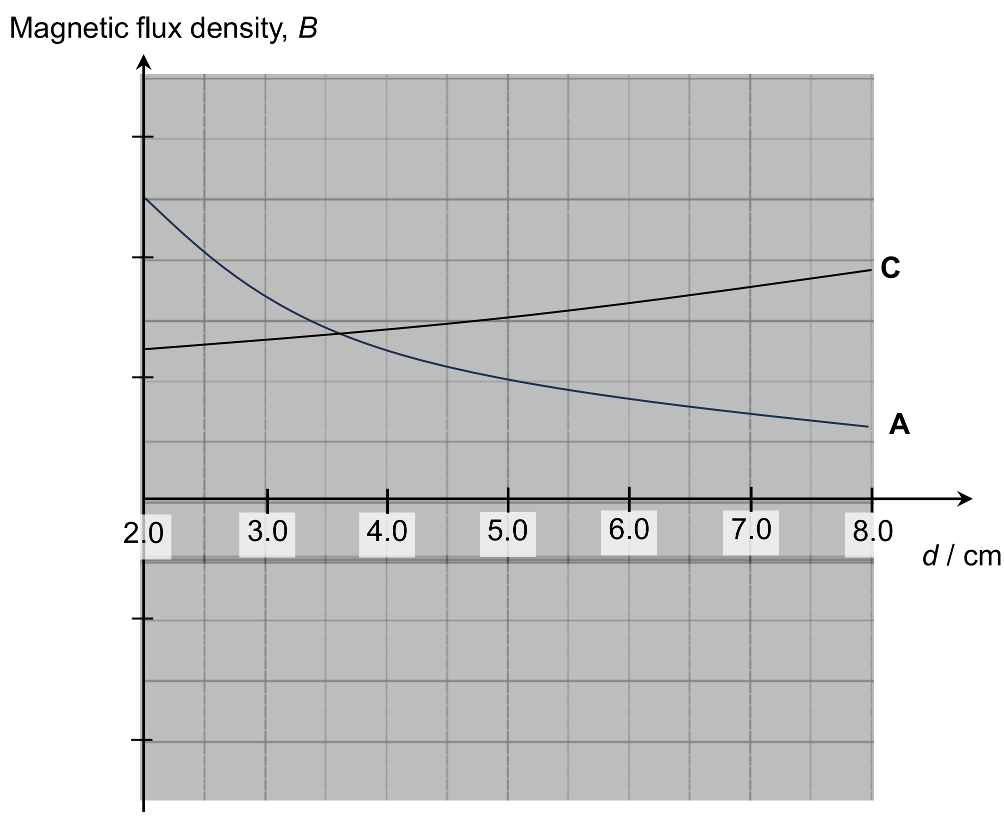

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**Fig. 8.5**

[3]

[Total: 20]