

Question No. 7 Electromagnetic Induction

(1) Underlying concept -

When a metallic rod of length 'l' is rotated with angular velocity ω in a plane perpendicular to the direction of magnetic field about one of its ends then, the induced emf across its end is given by

$$e = \frac{B\omega l^2}{2}$$

where B = magnetic field

l = length of the metallic rod.

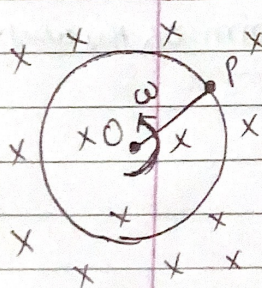
ω = angular velocity

if N (rpm) then $\omega = \frac{2\pi N}{60}$ rad/sec

(2) Reference with NCERT

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(3) Answer & Explanation:-



Induced emf across one spoke $(e) = \frac{B\omega l^2}{2}$

$$\omega = \frac{2\pi N}{60}$$

$$= \frac{2\pi \times 120}{60} = 4\pi \text{ rad/s}$$

$$e = \frac{0.4 \times 10^{-4} \times 4\pi \times 1^2}{2}$$

$$= 2.51 \times 10^{-4} \text{ Volt}$$

All spokes are identical so induced emf between the axle & rim will be 2.51×10^{-4} Volt.

④ fate of other options

- If the magnetic field ~~$B=0.04T$~~ then option (1) is correct
- If the magnetic field $B=0.04T$ then option (3) is correct.

✗

⑤ Other possible cases.

(1). If the ~~plane~~ ^{plane} of ~~rotation~~ ^{rotation} of wheel & the direction of magnetic field is having angle ' θ ' then induced emf between axle of wheel & rim can be asked.

(2). If the wheel is pure rolling and the magnetic field is perpendicular to the plane of the wheel then induced emf between the centre ~~of the~~ & rim of the wheel can be asked.

⑥ Possible expected questions:-

① A wheel with 20 metallic spokes each 1m long is rotated in X-Y plane with a speed of 120 rpm. ~~in~~ of the magnetic field $\vec{B} = (3\hat{i} + 4\hat{j} + 5\hat{k})T$. ~~then~~ find out the emf between the axle ~~of~~ & rim of the wheel?

(1). $20\pi V$

(2). $10\pi V$

(3). $6\pi V$

(4). $8\pi V$

② A wheel is rolling on a horizontal ground ~~with~~ ~~an~~ ~~angular~~ ~~velocity~~ ~~of~~ ~~120~~ rpm with a speed of 120 rpm without slipping. ~~of~~ the magnetic field is perpendicular to the plane of rolling.

Q2 A wheel is rolling on a horizontal ground ~~with~~ at a speed of 120 rpm without slipping. If the magnetic field $B = 0.4 \text{ T}$, is perpendicular to the plane of rolling. Find the induced emf b/w ~~any~~ any of the two points on the circumference of the wheel? (Take radius of wheel = 1m)

(1) $2.51 \times 10^{-4} \text{ V}$

(2) $2.51 \times 10^5 \text{ V}$

(3) Zero.

(4) $4.0 \times 10^5 \text{ V}$