# PhysicsTutor

Induction

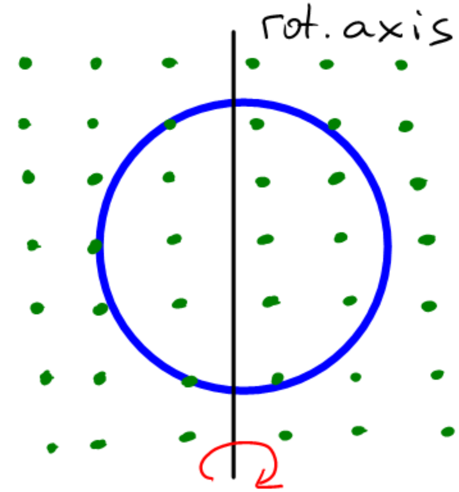
# Problem:

- A wire loop with radius 3.4 cm is placed in a uniform magnetic field of strength 0.88 T with the plane of the coil perpendicular to the field. The loop is rotated by 180° about the shown axis in 0.22 s. What is the average induced EMF in the coil?

$\vec{B}$

(out of page)

$B = 0.88\ T$



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- The orientation of the loop with respect to the flux lines changes under rotation. The **B** field is constant, and the area is fixed.
- EMF at all times obtainable using uniform rotation; the average can be found from the flux difference for initial and final orientations.

# Equations associated with ideas:

$$|\mathcal{E}| = \frac{\Delta \phi_M}{\Delta t}$$

$$\phi_M = \vec{B} \cdot \vec{A} = B\,A\,\cos(\measuredangle\,\vec{B}, \vec{A})$$

$$= B A \cos \alpha$$

@ $t = 0$ : $\alpha = 0$ ; @ $t = \Delta t$ : $\alpha = \pi$

$\cos \alpha = -1$

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- What is the flux after rotation by 180° ?

$$\Phi_M^{(2)} = B\,A\,\cos(\pi) = -B\,\pi\,R^2$$

# Strategy

- Calculate the magnetic flux for the initial orientation.
- What is the flux after rotation by 180° ?
- It has the same magnitude, but opposite sign.
- This change occurs in a known time, i.e., the average flux change can be calculated.

$$\frac{\phi_M^{(2)} - \phi_M^{(1)}}{\Delta t}$$

# Solution

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- $\Phi_M^{(1)} = B \pi R^2 = 0.88 \cdot 3.14 \cdot (3.4 \times 10^{-2})^2 \; Tm^2$ 

  $\overset{\text{Wb}}{\shortparallel}$

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- $|\Delta\Phi_M| = 6.39 \times 10^{-3}\ \text{Tm}^2$ ; $\frac{|\Delta\Phi_M|}{\Delta t} = 29.\ \text{mV}$
- $\mathcal{E} = 29\ \text{mV}$

This doesn't seem like much, but given a small resistance (thick copper) a substantial current flows! ($R$ can be $\sim m\Omega$)

This EMF source has no beginning or end, it is very different from a battery EMF with +, − terminals

There is no place of high vs low potential on the ring.