ICLICKER QUESTION

A conducting rod slides on a conducting track in a constant B field directed into the page. What is the direction of the induced current?

a) Clockwise
b) Counterclockwise
c) No induced current
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Faraday’s Law

- A changing magnetic flux induces an emf.
- The emf induced is directly proportional the time rate of change of the magnetic flux through the circuit.

\[ \mathcal{E} = -N \frac{d\Phi_B}{dt} \quad [\text{Faraday's Law}] \]

Lenz’s Law: The induced current in a loop is in the direction that creates a magnetic field that opposed the change in magnetic flux through the area enclosed by the loop.
Induced emf and Electric Fields

\[ \oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt} \] [Faraday's Law]

• A changing magnetic field induces a nonconservative electric field.

• The electric field will exist regardless of whether there are any conductors around.

• The changing magnetic field does not need to exist at the location of the induced electric field.
A metal bar moves through a magnetic field as shown. The induced charges on the bar are

- a)  
- b)  
- c)  
- d)  
- e)  

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AC Generator

• Consider a loop of wire in a magnetic field rotated by some external means.

• If the loop rotates with angular speed $\omega$ then the magnetic flux is time-dependent:

$$\Phi_B(t) = BA \cos(\omega t)$$

• Then, the induced emf through a loop is:

$$\mathcal{E}(t) = \omega BA \sin(\omega t)$$

• And for $N$ loops:

$$\mathcal{E}(t) = \omega N BA \sin(\omega t)$$
AC Generator

• The emf varies sinusoidally, and the maximum $\varepsilon_{\text{max}}$ occurs when $\omega t = 90^\circ$ or $270^\circ$

$\varepsilon_{\text{max}} = \omega \text{NBA}$

$I_{\text{max}} = \omega \text{NBA}/R$
ICLICKER QUESTION

Which of the following choices will not cause an increase in the emf generated in the coil of an AC generator?

a) Replacing the coil wire with one of lower resistance
b) Spinning the coil faster
c) Increasing the magnetic field
d) Increasing the number of turns of wire on the coil.
e) None of the other answers (i.e. all cause an increase in emf).
ICLICKER QUESTION

If the angular speed $\omega$ of the external rotator is doubled...

a) $\mathcal{E}_{max}$ is doubled and the period is unchanged.
b) $\mathcal{E}_{max}$ is halved and the period is unchanged.
c) $\mathcal{E}_{max}$ is doubled and the period is doubled.

d) $\mathcal{E}_{max}$ is doubled and the period is halved.
e) $\mathcal{E}_{max}$ is halved and the period is halved.
Generators and Motors

- Electric generators transform mechanical energy into electrical energy.

- Motors are essentially generators operating in reverse. Instead of generating electrical current by rotating a coil, current is supplied to the coil.
Motors; Back emf

• By attaching the coil to an external device (e.g. a fan, tire, etc.) useful work can be done by the motor.

• As the coil rotates in a magnetic field, the changing magnetic flux induced an emf in the coil.

• Using Lenz’s law we can show that the induced emf (back-emf $\mathcal{E}_{\text{back}}$) always acts to reduce the current in the coil.

• $\mathcal{E}_{\text{back}}$ is zero when the motor is off and it increases as the rotational speed $\omega$ of the coil increases.

• Since the voltage available to supply current is: $\Delta V = \mathcal{E}_{\text{supply}} - \mathcal{E}_{\text{back}}$, then the current in the rotating coil is limited by the back emf.
A motor’s coil has a total resistance $R = 10.0 \, \Omega$ and it is supplied by a voltage of 120 V. When the motor is running at maximum speed, the current through the coil is 5.0 A.

A) What is the current through the coil when the motor is turned on?
B) What is the back emf when the motor is running at maximum speed?