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Rec 20: Oct 29, 2007

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\[ I = I_0 e^{-bt} \] decreases with time
Thus \( B \) at the coil decreases with time
Hence induced current will produce \( B_{ind} \) out of page \( \Rightarrow I_{ind} \) is ccw.

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\[ \vec{B} \]

\[ a) \ \vec{F}_B = q \vec{v} \times \vec{B} \; \vec{v} \perp \vec{B} \]

For positive charged \( \vec{F}_B = q \vec{v} \vec{B} \) toward \( \vec{B} \)
must be balanced by electric force
\[ \vec{F}_E = q \vec{E} \text{ along rod toward } \vec{E} \]
\[ q \vec{E} = q \frac{\vec{v} \vec{B}}{L} \]
\[ \vec{E} = \frac{\vec{v}_B}{L} \Rightarrow \vec{E} = \frac{\vec{v}_B}{L} \]
\[ E = \vec{v}_B \cdot \frac{B}{L} = 0.48 \text{ V} \]

b) \( \theta \) changes move to \( \theta \) so it is at higher potential
c) \[ \vec{E} = \frac{\vec{v}_B}{L} = 2.25 \text{ V/m toward } \vec{E} \]
d) \( \vec{v} \) does
e) if \( \vec{v} \) along axis of rod \( \vec{F}_B \perp \vec{rood} \) so if it \( \vec{F}_B = 0 \Rightarrow \vec{E} = 0 \)

\[ E = -N \frac{d\phi_B}{dt} \]
all inside \( \frac{d\phi_B}{dt} = 0 \Rightarrow E = 0 \) \( \therefore \)

\[ b) \frac{d\phi_B}{dt} = \vec{B} \cdot \frac{dA}{dt} = \vec{B} \frac{dx}{dt} = \vec{B} \cdot v \]
\[ E = \vec{B} \cdot v = 1.25 (\cdot 4) (0.02) = 10^{-2} \text{ V} \]

\[ c) \text{ all outside} \frac{d\phi_B}{dt} = 0 \Rightarrow E = 0 \]
29.52 \ |E| = \frac{N d\Phi}{\text{out}}

\[ \omega \]

\text{Side view}

\[ \theta = \omega t \]

\[ \frac{d\Phi}{\text{out}} = \frac{d}{\text{out}} \overline{B} \cdot \vec{A} = B A \frac{\frac{4}{\pi} \omega t}{\text{out}} \]

\[ = -BA \omega \sin \omega t \]

\[ \frac{d\Phi}{\text{out}} \]

\[ \overline{B} \cdot \vec{A} \]

\[ \frac{4}{\pi} \omega t \]

\[ \text{out} \]

\[ = -BA \omega \sin \omega t \]

a) So \( |E| = NBA \omega \sin \omega t \)

Want \( |E|_{\text{max}} = 9.1 V = NBA \omega \)

\[ A = \frac{|E|_{\text{max}}}{NB \omega} = \frac{9}{(2000)(8 \times 10^{-5})(60\pi/60)} = 17.9 \text{ m}^2 \]

b) \( v_{\text{tran}} = \frac{R \omega}{4} \)

\[ \pi R^2 = A \Rightarrow R = \frac{\sqrt{A}}{\pi} \]

\[ v_{\text{tran}} = \omega \sqrt{\frac{4}{\pi}} = 7.5 \text{ m/s} \]

Pretty big hoop so will need to be made very rigid and probably very hard to maintain angular speed.
Consider a 1.5 V battery with a 0.3 Ω resistor attached to two conducting, frictionless rails 0.200 m apart. The entire apparatus is in a uniform magnetic field \( B \) directed out of the page and of magnitude 0.400 T perpendicular to the rails. A conducting bar can slide over the rails perpendicular to them as well as to the field. All other resistances in the problem are negligible compared to the 0.3 Ω resistor. The bar is placed on the rails, starts from rest, and is observed to accelerate.

(a) What is the direction of the bar's acceleration?
\[ F = \ell I B \] is to the left. (-2)

(b) What is the direction of the emf induced in the bar?
will oppose change in \( \Phi_B \) ⇒ produce \( \mathbf{B} \) out of page ⇒ \( E \) is up in bar (counterclockwise in loop).

(c) Use Faraday's Law to calculate the magnitude of the induced emf when the bar reaches a speed of 12.0 m/s.
\[ |E| = N \frac{d\Phi_B}{dt} = \ell B \frac{d(lx)}{dt} = BL \frac{dl}{dt} = BLv = (9)(0.2)(12) \]
\[ |E| = 0.96 \text{ V} \]

(d) Calculate the current in the bar when its speed is 12.0 m/s.
\[ \text{Loop rule: } 1.5 - 0.96 - \ell I(0.3) = 0 \]
\[ I = \frac{1.5 - 0.96}{0.3} = 1.8 \text{ A} \]
Physics 24 Test-Level Problems for Recitation 20

1. The figure shows a bar magnet moving upward along the vertical axis toward a horizontal coil. The poles of the bar magnets are labeled X and Y. As the bar magnet approaches the coil it induces an electric current in the direction indicated on the figure. What are the correct polarities of the magnet?

[A] X = south, Y = north
[B] X = negative, Y = positive
[C] X = positive, Y = negative
[D] X = north, Y = south

2. A wire carrying a constant current \( i \) is moved toward a conducting loop with speed \( v \) as shown. The direction of the induced current in the loop is

[A] clockwise
[B] out of the page
[C] there is no induced current
[D] counterclockwise

3. A circular conducting coil contains 100 turns of wire and has a diameter \( D \) and a total resistance of 10.0 \( \Omega \). The coil is rotated at 120 rev/sec about a vertical axis through its center (see figure) in a region of uniform magnetic field \( B = 0.25 \, T \) directed into the plane of the paper.

(a) The coil is initially oriented so that its plane coincides with that of the paper. Calculate the emf in the coil as a function of time. Leave your answer in terms of the coil diameter \( D \).

(b) The maximum current induced in the coil is found to be 0.40 A. What is the diameter of the coil?

(c) When the induced emf is a maximum what is the orientation of the coil with respect to the magnetic field and what is the torque exerted on the coil by the magnetic field at this instant?

4. \( \oint \vec{E} = 0 \) and \( \oint \vec{B} = 0 \),

\[ E \mid_{t=0} = N B A \cos \omega t \chi \]

\[ \Rightarrow \cos \chi = 1 \]

\[ \phi = 0 \]

5. \( I = \frac{E_{\text{max}}}{R} \)

\[ I_{\text{max}} = \frac{E_{\text{max}}}{R} = \frac{E_{\text{max}}}{R} \]

\[ I_{\text{max}} = \frac{E_{\text{max}}}{R} \]

\[ \frac{4 I_{\text{max}} R}{N B \pi w} = D^2 \Rightarrow D = 1.64 \, \text{cm} \]

6. \( \vec{E}_{\text{max}} \) when \( \sin \omega t = 1 \Rightarrow \theta = \omega t = \frac{\pi}{2} \) or plane of coil \( \perp \) to page.

\[ \vec{F} = \vec{E} \times \vec{B} \Rightarrow \vec{F} = \mu B = N A B \]

\[ \vec{F} = 2.11 \times 10^{-3} \, \text{N} \, \text{m} \]