Physics 25 Practice Problems Chapter 22

1. A 0.80 T magnetic field makes an angle of 25 degrees with respect to the normal line of a circular coil whose radius is 0.10 m. The angle is then changed to 50 degrees. By how much does the magnetic flux through the coil change?

2. A 100-turn square coil of side length 0.20 m, is directly facing a magnetic field of strength 0.05 T. Over a time period of only one millisecond, the coil is rotated 70 degrees. What was the average emf induced in the coil?

3. A flexible plane ring of wire has an area 0.16 m^2. The ring is directly facing a 0.02 T magnetic field. A person holding the ring at opposite sides suddenly pulls on the ring in opposite directions, "snapping" the ring down to zero area over a period of 0.05 second. What average emf was induced in the ring?

4. A coil with 400 circular turns of wire faces a 0.06 T magnetic field. The area of the coil is 0.02 m^2. Over a period of 5.0 ms, the magnetic field strength increases to 0.09 T. What average emf was induced in the coil during this period?

5. A coil of 1000 turns has an area A = 0.04 m^2. It directly faces a magnetic field. Over a 6 millisecond time period, the coil experiences an average induced emf of 500 volts. Assuming the magnetic field increased, what was this increase.

6. A coil has a single turn and faces a magnetic field of 1.70 T. An emf of 2.6 V is induced in this coil because the coil's area is changing. What is value of $|\Delta A|/t$, the absolute value of the time rate of change of area?

7. A coil of 50 turns of wire of area 1.5×10^{-3} m^2, and 140-ohms resistance, faces a magnetic field ($\theta_o = 0$). The coil is then rotated 90 degrees ($\theta = 90^o$). During the time the rotation is occurring, a charge of 8.5×10^{-5} C flows in the coil. What is the magnetic field, B?

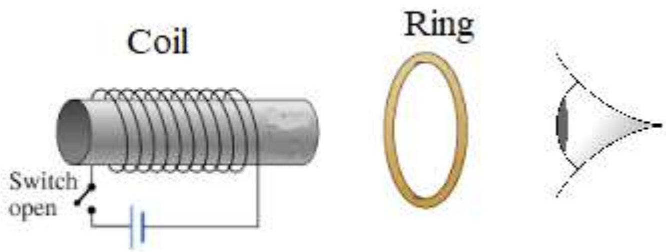
8. A ring of wire whose resistance is 0.03 ohms faces a magnetic field ($\theta = 0$), which increases by 0.60 T over a period of 0.45 s. The area of the ring is 0.07 m^2. What average power is consumed by the wire?

9. The magnetic flux that passes through a 12-turn coil of wire changes from 4.0 T-m^2 to 9.0 T-m^2 in 0.050 s. The average induced current in the coil is 230 A. What is the resistance of the coil?

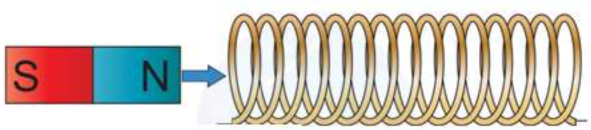
10. When the switch connected to the coil below is closed, it takes a finite period time for the current in to coil to reach its final value, and during that time the magnetic field from the coil fluxes through the ring, and is increasing.

What is the direction of the induced current in the ring as seen by the observer?

Clockwise, or counter-clockwise?

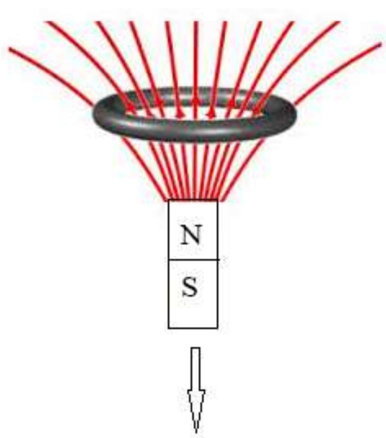


11. In the circuit below, what is the polarity of the magnet side of the coil, and what is the direction of the induced current, as seen by an observer riding with the bar magnet?



12. The bar magnet in the figure below is falling away from the stationary ring. As seen by the bar magnet, what is the polarity of the bottom of the ring, and what is the direction of the induced current, as seen by the magnet?

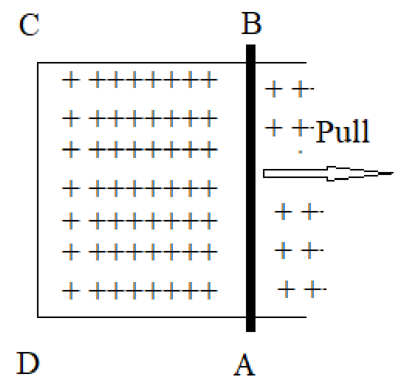
If the bar magnet were instead stationary, and the ring falling, what would be the polarity of the bottom of the ring?



13.

A metal bar is being pulled to the right, causing it to slide over a C-shaped metal track.

What is the direction of current around the ABCDA ring? Clockwise, or counter-clockwise?



14. The resistance per mile of a 50 megawatt (MW) power line from a power plant to a city 30 miles away is 0.34 Ω/mi. What would have to be the output voltage in order that the percentage power loss due to I^2R heating be 4.0%?

Solutions

1.

$\Delta\Phi = \Phi - \Phi_o$

$= BA \cos\theta - BA \cos\theta_o$

$= BA (\cos\theta - \cos\theta_o)$

$= (0.80)\,\pi(0.10)^2 (\cos 50 - \cos 25)$

$= -0.0066$ T-m^2

2. $BA = (0.05)(0.20^2)$

$= 0.0020$ T-m^2

$\Delta\Phi = BA \cos\theta - BA \cos\theta_o$

$= BA (\cos\theta - \cos\theta_o)$

$= (0.002) (\cos 70 - \cos 0)$

$= - 0.0013$ T-m^2

$\varepsilon = N\,|\Delta\Phi| / t$

$= 100\,|-0.0013| / 0.001$

$= 130$ volts

3.

Coil faces field:

$\theta_o = 0 \quad \cos\theta_o = 1$

$\theta = 0 \quad \cos\theta = 1$

$\Delta\Phi = BA - BA_o$

$= B(A - A_o)$

$= 0.02\,(0 - 0.16)$

$= -0.0032$ T-m^2

$\varepsilon = N\,|\Delta\Phi|/t$

$= |-0.0032| / (0.05)$

$= 0.064$ volts

4.

Coil faces field:

$\theta_o = 0 \quad \cos\theta_o = 1$

$\theta = 0 \quad \cos\theta = 1$

$\Delta\Phi = BA - B_oA$

$= 0.09\,(0.02) - 0.06\,(0.02)$

$= 6.0 \times 10^{-4}$ T-m^2

$\varepsilon = N\,|\Delta\Phi|/t$

$= 400\,(6.0 \times 10^{-4}) / 5 \times 10^{-3}$

$= 48.0$ V

5. Coil faces field:

$\theta_o = 0 \quad \cos\theta_o = 1$

$\theta = 0 \quad \cos\theta = 1$

ΔB is positive, so we remove the absolute values signs around $\Delta\Phi$ below.

$\varepsilon = N\,\Delta\Phi/t$

$500 = 1000\,(\Delta\Phi)/0.006$

$\Delta\Phi = 0.003$ T-m^2

$\Delta\Phi = BA - B_oA$

$= (B - B_o)\,A$

$= (\Delta B)\,(0.04\text{ m}^2)$

$(\Delta B)\,(0.04\text{ m}^2) = 0.003$ T-m^2

$\Delta B = 0.075$ T

7. A coil of 50 turns of wire of area 1.5×10^{-3} m^2, and 140-ohms resistance, faces a magnetic field ($\theta_o = 0$). The coil is then rotated 90 degrees ($\theta = 90^o$). During the time the rotation is occurring, a charge of 8.5×10^{-5} C flows in the coil. What is the magnetic field, B?

6. Coil faces field: $\theta_o = 0 \quad \cos\theta_o = 1$ $\theta = 0 \quad \cos\theta = 1$ $\Delta\Phi = B\,(\Delta A)$ $\varepsilon = \|\Delta\Phi\| / t$ $= B\,\|\Delta A\| / t$ $\Delta A\| / t = \varepsilon / B$ $= 2.6 / 1.7$ $= 1.53$ m^2/s	**7.** $N = 50$ $A = 1.5 \times 10^{-3}$ m^2 $R = 140\ \Omega$ $Q = 8.5 \times 10^{-5}$ C $\Delta\Phi = \Phi - \Phi_o$ $= BA \cos 90 - BA \cos 0$ $= 0 - BA$ $\|\Delta\Phi\| = BA$ $\varepsilon = IR$ $N(BA)/t = (Q/t)\,R$ Multiply by t and substitute values: $50\,(B)(1.5 \times 10^{-3}) = 8.5 \times 10^{-5}\,(140)$ $B = 0.16$ T	**8.** $N = 1$ $\theta_o = 0 \quad \cos\theta_o = 1$ $\theta = 0 \quad \cos\theta = 1$ $\Delta\Phi = BA - B_oA$ $= (B - B_o)A$ $= (\Delta B)\,A$ $= (0.60)(0.07)$ $= 0.042$ T-m^2 $\varepsilon = N\,\|\Delta\Phi\| / t$ $= (1)(0.042)/0.45$ $= 0.093$ volt $P = \varepsilon^2 / R$ $= 0.093^2 / 0.03$ $= 0.29$ watt

9.

$\varepsilon = N\,|\Delta\Phi|\,/t$
$= 12\,(5.0)/0.050$
$= 1200$ volts

Ohm's Law:

$R = \varepsilon/I$
$= 1200/230$
$= 5.2\ \Omega$

10.

Remember the rules: If an observer sees clockwise current, she sees the south side of the ring. If she sees counter-clockwise current, she sees the north side.

The ring-side of the coil is "north," so the coil-side of the ring must be north in order that the ring be repelled by the coil. Thus, the coil sees the north side of the ring, and counter-clockwise current, while the eye sees the the south side and clockwise current.

11.

The magnet-side of the coil needs to be "north" to reduce the speed of the approaching north end of the magnet.

Observer sees counter-clockwise current.

12. Magnet falling away from the magnet: Bottom face of ring is south in order that it pull *up* on the north face of the falling magnet to oppose the pull *down* on the magnet by Earth. Observer on magnet, looking upward, sees clockwise current.

If the ring is falling, the polarity of the bottom of the ring is "north" in order that the magnet's north push up on the ring's north to oppose Earth's downward pull on the ring.

13.

As the rod moves to the right, the area of the ABCDA ring increases, so the flux into the plane through the growing area of the ring increases.. This increase in external flux *into* the plane must be countered by a self-flux *out of* the plane. Thus, the induced B field (not shown) through the ring will point *out* of the plane, and therefore the induced current is counter-clockwise.

A second way of determining that the current flows from A to B is to note that in order that the person's pull on the rod to the right must be countered by a pull to the left by the magnetic field. By the right hand rule, this is accomplished if the current flows from A to B: Thumb points from A to B, fingers into the sheet, so the right-hand palm faces to the left.

14.

Four percent of 50 MW:
$0.04\,(5.0 \times 10^7) = 2.0 \times 10^6$

$R = (0.34\ \Omega/\text{mi})(30\ \text{mi})$
$\quad = 10.20\ \Omega$

Require: $I^2R = 2.0 \times 10^6$ W

$I^2\,(10.20) = 2.0 \times 10^6$ W
$I = 442.81$ A

Power Output is 50 MW:
$I\varepsilon = 5.0 \times 10^7$ W
$(442.81)\varepsilon = 5.0 \times 10^7$
$\varepsilon = 112{,}915$ V