

Homework for the week of November 17. 8th week of classes.
Ch. 29: 7, 8, 11, 12, 20, 28, 33, 38, 48, 54

7. (a) When the plane of the loop is perpendicular to the field lines, the flux is given by the maximum of Eq. 29-1a.

$$\Phi_B = BA = B\pi r^2 = (0.50 \text{ T})\pi(0.080 \text{ m})^2 = \boxed{1.0 \times 10^{-2} \text{ Wb}}$$

(b) The angle is $\theta = \boxed{55^\circ}$

(c) Use Eq. 29-1a.

$$\Phi_B = BA \cos \theta = B\pi r^2 \cos 55^\circ = \boxed{5.8 \times 10^{-3} \text{ Wb}}$$

8. (a) As the resistance is increased, the current in the outer loop will decrease. Thus the flux through

the inner loop, which is out of the page, will decrease. To oppose this decrease, the induced current in the inner loop will produce a flux out of the page, so the direction of the induced current will be counterclockwise.

(b) If the small loop is placed to the left, the flux through the small loop will be into the page and

will decrease. To oppose this decrease, the induced current in the inner loop will produce a flux into the page, so the direction of the induced current will be clockwise.

11. (a) The magnetic flux through the loop is into the paper and decreasing, because the area is decreasing. To oppose this decrease, the induced current in the loop will produce a flux

into the paper, so the direction of the induced current will be clockwise.

(b) The average induced emf is given by the “difference” version of Eq. 29-2b.

$$|\mathbf{e}_{\text{avg}}| = \frac{\Delta \Phi_B}{\Delta t} = \frac{B|\Delta A|}{\Delta t} = \frac{(0.75 \text{ T})\pi[(0.100 \text{ m})^2 - (0.030 \text{ m})^2]}{0.50 \text{ s}}$$

$$= 4.288 \times 10^{-2} \text{ V} \approx \boxed{4.3 \times 10^{-2} \text{ V}}$$

(c) We find the average induced current from Ohm’s law.

$$I = \frac{\mathbf{e}}{R} = \frac{4.288 \times 10^{-2} \text{ V}}{2.5 \Omega} = \boxed{1.7 \times 10^{-2} \text{ A}}$$

12. As the loop is pulled from the field, the flux through the loop decreases, causing an induced EMF whose magnitude is given by Eq. 29-3, $\mathbf{e} = Blv$. Because the inward flux is decreasing, the induced flux will be into the page, so the induced current is clockwise, given by $I = \mathbf{e}/R$. Because this current in the left-hand side of the loop is in a downward magnetic field, there will be a magnetic force to the left. To keep the rod moving, there must be an equal external force to the right, given by

$$F = I l B.$$

$$F = I l B = \frac{\mathbf{e}}{R} l B = \frac{Blv}{R} l B = \frac{B^2 l^2 v}{R} = \frac{(0.650 \text{ T})^2 (0.350 \text{ m})^2 (3.40 \text{ m/s})}{0.280 \Omega} = \boxed{0.628 \text{ N}}$$

20. The induced emf is given by Eq. 29-2a. Since the field is uniform and is perpendicular to the area, the flux is simply the field times the area.

$$\mathbf{e} = -\frac{d\Phi_B}{dt} = -B \frac{dA}{dt} = -(0.28 \text{ T})(-3.50 \times 10^{-2} \text{ m}^2/\text{s}) = \boxed{9.8 \text{ mV}}$$

Since the area changes at a constant rate, and the area has not shrunk to 0 at $t = 2.00 \text{ s}$, the emf is the same for both times.

28. Because the velocity is perpendicular to the magnetic field and the rod, we find the induced emf from Eq. 29-3.

$$\mathbf{e} = Blv = (0.800 \text{ T})(0.120 \text{ m})(0.150 \text{ m/s}) = \boxed{1.44 \times 10^{-2} \text{ V}}$$

33. (a) As the rod moves through the magnetic field an emf will be built up

across the rod, but no current can flow. Without the current, there is no force to oppose the motion of the rod, so yes, the rod travels at constant speed.

- (b) We set the force on the moving rod, obtained in Example 29-8, equal to the mass times the acceleration of the rod. We then write the acceleration as the derivative of the velocity, and by separation of variables we integrate the velocity to obtain an equation for the velocity as a function of time.

$$F = ma = m \frac{dv}{dt} = -\frac{B^2 l^2}{R} v \rightarrow \frac{dv}{v} = -\frac{B^2 l^2}{mR} dt$$

$$\int_{v_0}^v \frac{dv'}{v'} = -\frac{B^2 l^2}{mR} \int_0^t dt' \rightarrow \ln \frac{v}{v_0} = -\frac{B^2 l^2}{mR} t \rightarrow \boxed{v(t) = v_0 e^{-\frac{B^2 l^2}{mR} t}}$$

The magnetic force is proportional to the velocity of the rod and opposes the motion. This results in an exponentially decreasing velocity.

38. From Eq. 29-4, the peak voltage is $\mathbf{e}_{\text{peak}} = NB\omega A$. Solve this for the rotation speed.

$$\mathbf{e}_{\text{peak}} = NB\omega A \rightarrow \omega = \frac{\mathbf{e}_{\text{peak}}}{NBA} = \frac{120 \text{ V}}{480(0.550 \text{ T})(0.220 \text{ m})^2} = 9.39 \text{ rad/s}$$

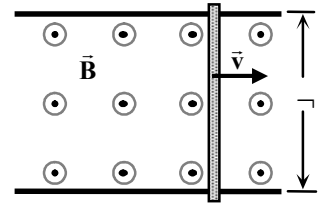
$$f = \frac{\omega}{2\pi} = \frac{9.39 \text{ rad/s}}{2\pi \text{ rad/rev}} = \boxed{1.49 \text{ rev/s}}$$

48. (a) Use Eqs. 29-5 and 29-6 to relate the voltage and current ratios.

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}; \frac{I_s}{I_p} = \frac{N_p}{N_s} \rightarrow \frac{V_s}{V_p} = \frac{I_p}{I_s} \rightarrow V_s = V_p \frac{I_p}{I_s} = (120 \text{ V}) \frac{0.35 \text{ A}}{7.5 \text{ A}} = \boxed{5.6 \text{ V}}$$

- (b) Because $V_s < V_p$, this is a step-down transformer.

54. We choose a circular path centered at the origin with radius 10 cm. By symmetry the electric field is uniform along this path and is parallel to the path. We then use Eq. 29-8 to calculate the electric field at each point on this path. From the electric field we calculate the force on the charged particle.



$$\oint \vec{E} \cdot d\vec{l} = E(2\pi r) = -\frac{d\Phi_B}{dt} = -(\pi r^2) \frac{dB}{dt}$$

$$F = QE = -Q \frac{r}{2} \frac{dB}{dt} = -(1.0 \times 10^{-6} \text{ C}) \frac{0.10 \text{ m}}{2} (-0.10 \text{ T/s}) = \boxed{5.0 \text{ nN}}$$

Since the magnetic field points into the page and is decreasing, Lenz's law tells us that an induced circular current centered at the origin would flow in the clockwise direction.

Therefore, the force on a positive charge along the positive x-axis would be down, or in the

$-\hat{j}$ direction.