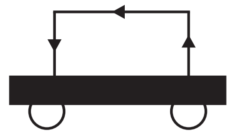
6. (a)



Lenz's law states that the direction of induced current will be such that the flux produced by this current will oppose the change in flux from the external magnetic field that induced the current. When the front edge of the loop is at 0.12 m, not all of the loop is in the magnetic field. Since the cart is moving to the right, more of the loop is entering the field which constitutes an increase in flux into the plane of the page within the loop. According to Lenz's law, the induced current must produce a magnetic field out of the plane of the page to oppose this increase in flux into the plane of the page. A counterclockwise current, as shown above, would produce a magnetic field into the plane of the page.

(b) i. $I = \frac{\varepsilon}{R} = \frac{Blv}{R} = \frac{(2.0\ \text{T})(0.10\ \text{m})(3.0\ \text{m/s})}{4.0\ \Omega}$

$\boxed{I = 0.15\ \text{A}}$

ii. $F = IlB = (0.15\ \text{A})(0.10\ \text{m})(2.0\ \text{T})$

$\boxed{F = 0.030\ \text{N}}$

(c) The net force on the loop would be zero at that instant because the flux is not changing at that moment, so there would be no induced current, and therefore, no force from the magnetic field.

3. (a) $V = IR$

$Blv = IR$

$(0.80\ \text{T})(0.52\ \text{m})(1.8\ \text{m/s}) = I(3.0\ \Omega)$

$\boxed{I = 0.25\ \text{A}}$

(b) $\Sigma F = F_A - F_B - F_R = 0$

$F_A = F_B + F_f = IlB + \mu F_N = (0.25\ \text{A})(0.52\ \text{m})(0.80\ \text{T}) + (0.20)(0.22\ \text{kg})(9.8\ \text{m/s})$

$\boxed{F_A = 0.54\ \text{N}}$

(c) $P = \dfrac{E}{t}$

$E = Pt = I^2Rt = (0.25\ \text{A})^2(3.0\ \Omega)(2.0\ \text{s})$

$\boxed{E = 0.38\ \text{J}}$

(d) $P = \dfrac{W}{t}$

$W = Pt = F_A vt = (0.54\ \text{N})(1.8\ \text{m/s})(2.0\ \text{s})$

$\boxed{W = 1.9\ \text{J}}$

(e) The work done by the string pulling the rod includes work done against the friction between the surfaces of the moving Metal Rod and the two conducting rails. If this friction could be eliminated, the work done by the string would equal the energy dissipated in the resistor according to the Work-Energy Theorem and Kirchoff's loop rule.

3. (a) $R_{Wire} = \rho \frac{L}{A}$

$$3.50\ \Omega = \left(1.7 \text{ x } 10^{-8}\ \Omega \cdot \text{m}\right) \frac{L}{3.5 \text{ x } 10^{-9}\ \text{m}^2}$$

$\boxed{L = 0.72 \text{ m}} = 72 \text{ cm}$

$V = IR$ or $R_{Total} = \frac{V}{I} = \frac{16 \text{ V}}{4.0 \text{ A}} = 4.0\ \Omega$

$R_{Total} = R_{Internal} + R_{Wire}$

$4.0\ \Omega = 0.5\ \Omega + R_{Wire}$

$R_{Wire} = 3.5\ \Omega$

(b)

_X_Upward ___Downward

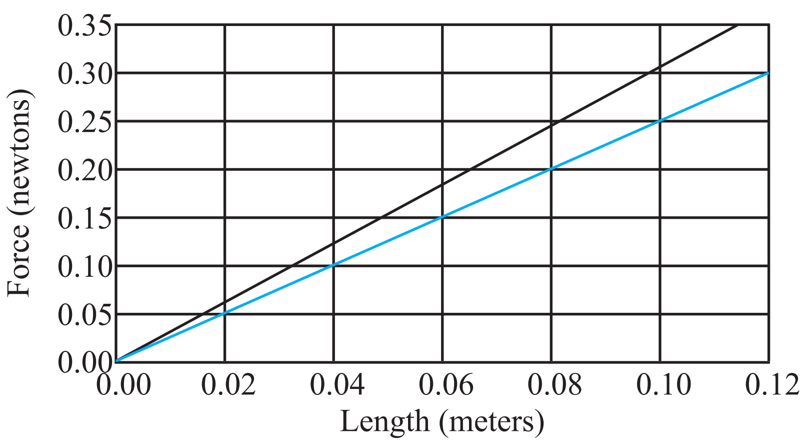
Using the right-hand rule to show the direction of the force from a magnetic field on a current-carrying wire, the fingers point in the direction of the current and the wrist is rotated (keeping the fingers in the direction of the current) until the palm is facing the magnetic field (so the fingers can curl in the direction of the magnetic field), then the direction the thumb is facing shows the direction of this force on the wire which is down in this instance. According to Newton's third law, the reaction force on the magnet from the wire will be in the opposite direction which is upward.

(c) $\boldsymbol{F} = I\boldsymbol{lB}\sin\theta$

$$0.060 \text{ N} = (4.0 \text{ A})(0.020 \text{ m})B\sin(90)$$

$\boxed{B = 0.75 \text{ T}}$

(d)



(e) The magnetic field is not constant between the two pole faces. The strength of magnetic field decreases as the location of the wire moves away from the center of the pole faces and towards the edges. Similarly, the direction of the magnetic field becomes less perpendicular to the pole faces as the location of the wire moves away from the center of the pole faces and towards the edges, therefore, the angle, θ, between the direction of the field and the length of wire segment in the field becomes smaller. There is significant fringing of the field at the edges of the pole faces. The longer the segment of wire between the two pole faces, the more of it is exposed to the fields near the edges of the poles where the field is weaker and less perpendicular to the pole faces. Since, $F = IlB\sin\theta$, the force on the wire segment will become increasingly less than expected as the length of the segment is increased.

2. (a) Into the page

(b) The force from the magnetic field on the moving ions is always at right angles to the direction of their instantaneous velocity. Since there is no component of this force parallel to the direction of the velocity, this force neither increases nor decreases the speed of the moving ions (no tangential accelerations). This force simply changes the direction of the instantaneous velocity. Thus, it is a centripetal force.

(c) $\sum F = F_B = ma_C$

$$qvB = m\frac{v^2}{r}$$

$$v = \frac{qBr}{m} = \frac{2\left(1.60 \text{ x } 10^{-19} \text{ C}\right)\left(0.090 \text{ T}\right)\left(\frac{1.75 \text{ m}}{2}\right)}{1.45 \text{ x } 10^{-25} \text{ kg}}$$

$$\boxed{v = 1.74 \text{ x } 10^{5} \text{ m/s}}$$

(d) $\Delta PE = \Delta KE$

$$q\varepsilon = \tfrac{1}{2}mv^2$$

$$2\left(1.60 \text{ x } 10^{-19} \text{ C}\right)\varepsilon = \tfrac{1}{2}\left(1.45 \text{ x } 10^{-25} \text{ kg}\right)\left(1.74 \text{ x } 10^{5} \text{ m/s}\right)^2$$

$$\boxed{\varepsilon = 6860 \text{ V}}$$

3. (a) $\phi = \mathbf{B} \bullet \mathbf{A} = BA\cos\theta = (0.030T) \bullet (0.20\text{ m})^2$

$$\boxed{\phi = 0.00120\text{Tm}^2}$$

(b) $\varepsilon = \dfrac{\Delta\phi}{\Delta t} = \dfrac{0.20\text{ T} - 0.030\text{ T}}{0.50\text{ s}}$

$$\boxed{\varepsilon = 0.34\text{ V}}$$

(c) i. $I = \dfrac{\varepsilon}{R} = \dfrac{0.34\text{ V}}{0.60\ \Omega}$

$$\boxed{I = 0.57\text{ A}}$$

ii.

_____ Clockwise __**X**__ Counterclockwise

The flux is increasing into the page during this time, so, according to Lenz's law the induced voltage will create a current that produces a flux opposite to the change in flux. According to the right-hand rule tp predict the direction of a magnetic field created by a current-carrying wire, the current would have to be counterclockwise to create a magnetic field (thus, a flux) out of the page (opposite the increase into the page). More specifically, this right-hand rule states to put the thumb of the right hand in the direction of the current, the way the fingers can curl is the direction of the magnetic field created by the current. The counterclockwise current produces a magnetic field out of the page in the plane of the page.

(d) You can rotate the orientation of the loop so that the loop rotates in a circle (either clockwise or counterclockwise) when viewed from above (the top of the page) or below (the bottom of the page). This will change the flux passing through the face of the coil even though the magnetic field strength remained constant. This change in flux will induce a voltage, and, therefore, a current.

3. (a) $x = x_o + v_o t + \frac{1}{2}at^2$ $\quad$ $F = ma$

$x = 0 + 0 + \frac{1}{2}\frac{F}{M}t^2$ $\quad$ $a = \frac{F}{M}$

$$\boxed{x = \frac{1}{2}\frac{F}{M}t^2}$$

(b) $v^2 = v_o^2 + 2a(x - x_o)$

$v^2 = 0 + 2\frac{F}{M}(L - 0)$

$$\boxed{v = \sqrt{\frac{2FL}{M}}}$$

(c) $\Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mv_o^2$ $\quad$ **OR** $W = \Delta KE$

$\Delta KE = \frac{1}{2}M\left(\sqrt{\frac{2FL}{M}}\right)^2 - 0 = \frac{1}{2}M\left(\frac{2FL}{M}\right)$ $\quad$ $FL = KE_f - KE_i = KE_f - 0$

$$\boxed{\Delta KE = FL}$$ $\quad$ $\Delta KE = FL$

(d) The direction of the magnetic field must be out of the page toward the reader. To determine this direction use the right-hand rule that governs the direction of the force on a current-carrying wire in the presence of a magnetic field. This rule stipulates that the fingers are placed in the direction of the current, the wrist is rotated so that the fingers can curl in the direction of the magnetic field resulting in the thumb pointing in the direction of the force on the wire. (More formally, $\mathbf{F} = I\ell \times \mathbf{B}$ so the fingers are put in the direction of $I\ell$ and curled in the direction of **B** with the thumb again demonstrating the direction of the force on the wire). Here, the directions of the current and the force are known. So, the fingers are place in the direction of the current (toward the top of the page) and the wrist is rotated so that the thumb can point to the right in the direction of the force, resulting in the fingers being able to curl out of the page showing the direction of the magnetic field.

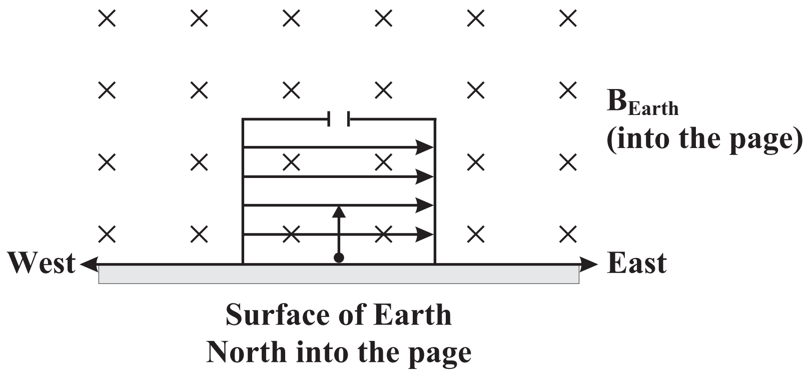
(e) From part (c) above, $W = \Delta KE$ $\quad$ $F = I\ell B\sin\theta$ (or $\mathbf{F} = I\ell \times \mathbf{B}$)

$FL = \frac{1}{2}mv^2 - \frac{1}{2}mv_o^2$ $\quad$ $F = (200\text{ A})(0.10\text{ M})(5\text{ T})\sin 90 = 100\text{ N}$

$(100\text{ N})(10\text{ m}) = \frac{1}{2}(0.5\text{ kg})v^2 - \frac{1}{2}(0.5\text{ kg})(0\text{m/s})$

$$\boxed{v = 20\text{ m/s}}$$

5. (a)



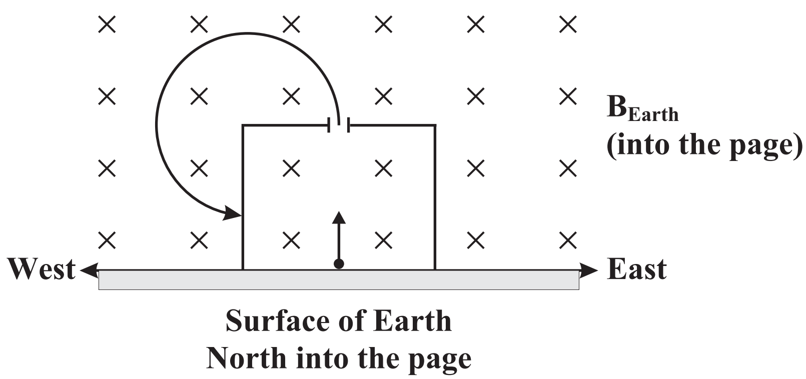
(b) $\Sigma F = F_B - F_E = ma$

$\Sigma F = e\mathbf{v}B_{Earth} - eE = 0$

$e\mathbf{v}B_{Earth} = eE$

$$\mathbf{v} = \frac{E}{B_{Earth}}$$

(c)



(d) $\Sigma F = F_B = ma_C$

$\Sigma F = e\mathrm{v}B_{Earth} = m_p a_C$

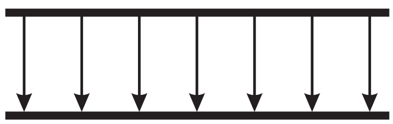
$$a_C = \frac{e\mathbf{v}B_{Earth}}{m_p}$$

7. (a)

__ Positive **X** Negative __ Neutral __ It cannot be dtermined from this information.

The right-hand rule (put your fingers in the direction of the moving charged particles, rotate your wrist until your fingers can curl in the direction of the magnetic field, and your thumb will indicate the direction of the magnetic force on the moving charges, thus, the direction of the center of the circular path followed by these moving charges) is for positive charges. Applying the right-hand rule to these charges gives a direction toward the center of the circular path that is toward the top of the page which is opposite that shown in the diagram. [or the left-hand rule would give the results in the diagram].

(b)



(c) In the region between the plates both a magnetic force and electrostatic force are acting on the moving charges.

$\Sigma F = F_m - F_e = ma = 0$

$qvB = qE$

$E = vB = (1.96 \times 10^6 \text{ m/s})(0.20 \text{ T})$

$E = 3.8 \times 10^5 \text{ V/m}$

$V = Ed = (3.8 \times 10^5 \text{ V/m})(6.0 \times 10^{-3} \text{ m})$

$V = 2.28 \times 10^3 \text{ V} = 2280 \text{ V}$

(d) In the region outside the plates only a magnetic force is acting on the moving charges resulting in circular motion.

$\Sigma F = F_m = F_c$

$qvB = m\frac{v^2}{R}$

$\frac{q}{m} = \frac{v}{BR} = \frac{1.9x10^6 \, m/s}{(0.20T)(0.10m)}$

$\frac{q}{m} = 9.5 \times 10^7 \text{ C/kg}$

Units Analysis:

$$\frac{1}{Ts} = \frac{1}{(N/A \bullet M) \bullet s} = \frac{A \bullet m}{N \bullet s} = \frac{\frac{C}{s} m}{(kg \frac{m}{s^2}) s} = \frac{C}{kg}$$