29.10

$$\Phi_{B_f} = NBA$$

$$\Phi_{B_i} = NBA \cos 53.0^\circ$$

$$\therefore \Delta\Phi_B = NBA(1 - \cos 53.0^\circ)$$

$$\Rightarrow \mathcal{E} = -\frac{\Delta\Phi_B}{\Delta t} = -\frac{NBA(1-\cos 53.0^\circ)}{\Delta t}$$

$$= -\frac{(80)(1.10\,T)(0.400\,m)(0.25\,m)(1-\cos 53.0^\circ)}{0.0600\,s}$$

$$\Rightarrow |\mathcal{E}| = 58.4\,V$$

29.4

$$\mathcal{E} = \frac{\Delta\Phi_B}{\Delta t} = \frac{NBA}{\Delta t} = IR = \left(\frac{Q}{\Delta t}\right)R$$

$$\Rightarrow QR = NBA$$

$$\Rightarrow Q = \frac{NBA}{R}$$

$$\therefore B = \frac{QR}{NA} = \frac{(3.56\times10^{-5}\,C)(60.0\,\Omega + 45.0\,\Omega)}{(120)(3.20\times10^{-4}\,m^2)}$$

$$= 0.0973\,T$$

29.15

(a) If B increases into the page, induced magnetic field must oppose that change and point in the opposite direction, thus requiring a counterclockwise current in the loop.

(b) If B is decreasing, then the induced field must point in the same direction, and the current is clockwise.

(c) If B is constant, then $\Delta\Phi_B = 0$, and current is zero.

29.23

(a) $\mathcal{E} = vBL = (5.00\ m/s)(0.450\ T)(0.300\ m)$
$= 0.675\ V$

(b) The potential difference between the ends of the rod is just the motional emf,
$V = 0.675\ V$

(c) The positive charges are moved to end b, so b is at a higher potential.

(d) $E = \frac{V}{L} = \frac{0.675\ V}{0.300\ m} = 2.25\ \frac{V}{m}$

(e) b.

29.42

(a) $j_D = \varepsilon_0 \frac{dE}{dt} = \varepsilon_0 \frac{i_C}{\varepsilon_0 A} = \frac{i_C}{A}$

$= \frac{0.280\ A}{\pi (0.0400\ m)^2} = 55.7\ A/m^2$

(b) $\frac{dE}{dt} = \frac{j_D}{\varepsilon_0} = \frac{55.7\ A/m^2}{\varepsilon_0} = 6.29 \times 10^{12}\ V/m \cdot s$

(c) Ampere's Law $\Rightarrow$

$r < R: \quad B = \frac{\mu_0}{2\pi} \frac{r}{R^2} i_D = \frac{\mu_0}{2\pi} \frac{0.0200\ m}{(0.0400\ m)^2} (0.280\ A)$

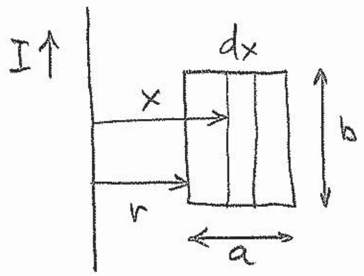
$= 7.0 \times 10^{-7}\ T$

(d) $r < R: \quad B = \frac{\mu_0 r}{2\pi R^2} i_D = \frac{\mu_0}{2\pi} \frac{(0.0100\ m)}{(0.0400\ m)^2} (0.280)$

$= 3.5 \times 10^{-7}\ T$

29.53

(a) (i) $|\mathcal{E}| = \left|\dfrac{d\Phi_B}{dt}\right|$



For the narrow strip of width dx at x from the wire,

$$B = \frac{\mu_0 I}{2\pi x}.$$

Thus, $d\Phi_B = B\,b\,dx = \dfrac{\mu_0 I b}{2\pi}\,\dfrac{dx}{x}$

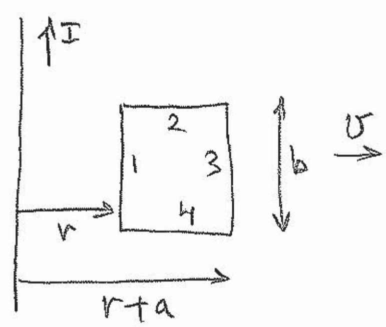
$$\Rightarrow \Phi_B = \int d\Phi_B = \left(\frac{\mu_0 I b}{2\pi}\right)\int_r^{r+a} \frac{dx}{x}$$

$$= \left(\frac{\mu_0 I b}{2\pi}\right)\ln\left(\frac{r+a}{r}\right)$$

$$\frac{d\Phi_B}{dt} = \frac{d\Phi_B}{dr}\,\frac{dr}{dt} = \frac{\mu_0 I b}{2\pi}\left[-\frac{a}{r(r+a)}\right]v$$

$$\therefore |\mathcal{E}| = \frac{\mu_0 I a b v}{2\pi r(r+a)}$$

(ii) $\mathcal{E} = Bvl$ for a bar of length l moving at speed v perpendicular to B.



The emf in each side is

$$\mathcal{E}_1 = \left(\frac{\mu_0 I}{2\pi r}\right) v b$$

$$\mathcal{E}_3 = \left(\frac{\mu_0 I}{2\pi (r+a)}\right) v b$$

$$\mathcal{E}_2 = \mathcal{E}_4 = 0$$

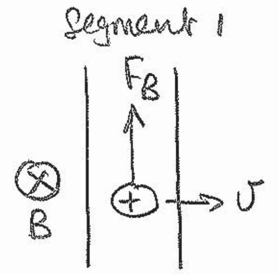
Both $\mathcal{E}_1$ and $\mathcal{E}_3$ are directed toward the top, so they oppose each other. Net is $\mathcal{E} = \mathcal{E}_1 - \mathcal{E}_3$

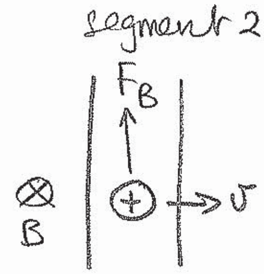
$$= \frac{\mu_0 I v b}{2\pi}\left(\frac{1}{r} - \frac{1}{r+a}\right) = \frac{\mu_0 I a b v}{2\pi r(r+a)}$$

This agrees with the answer in (i).

(b) (i) $\vec{B}$ is $\otimes$. Φ_B is $\otimes$ and decreasing, so the flux Φ_{ind} of the induced current is $\otimes$ and the current is clockwise.

(ii)





B is larger on 1 since it is closer to the wire, so $F_{B_1} > F_{B_2}$, and induced current is clockwise. This agrees with the result from Lenz's law.

(c) When $v = 0$, the induced emf should be 0. When $a \to 0$, $\Phi_B \to 0$ and $\mathcal{E} \to 0$. When $r \to \infty$, $B \to 0$, so Φ_B and $\mathcal{E} \to 0$.