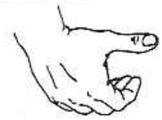
31.4 (a) $\mathcal{E} = -\frac{d\Phi_B}{dt} = -A\frac{dB}{dt} = \boxed{\frac{AB_{\max}}{\tau}e^{-t/\tau}}$

(b) $\mathcal{E} = \frac{(0.160\text{ m}^2)(0.350\text{ T})}{2.00\text{ s}}\, e^{-4.00/2.00} = \boxed{3.79\text{ mV}}$

(c) At $t = 0$, $\mathcal{E} = \boxed{28.0\text{ mV}}$

31.9 (a) $d\Phi_B = \mathbf{B}\cdot d\mathbf{A} = \frac{\mu_0 I}{2\pi x}L\,dx$: $\quad \Phi_B = \int_{x=h}^{h+w}\frac{\mu_0 IL}{2\pi}\frac{dx}{x} = \boxed{\frac{\mu_0 IL}{2\pi}\ln\left(\frac{h+w}{h}\right)}$

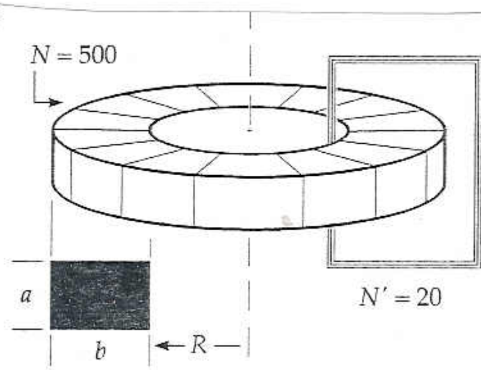


(b) $\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}\left[\frac{\mu_0 IL}{2\pi}\ln\left(\frac{h+w}{h}\right)\right] = -\left[\frac{\mu_0 L}{2\pi}\ln\left(\frac{h+w}{h}\right)\right]\frac{dI}{dt}$

$$\mathcal{E} = -\frac{(4\pi\times10^{-7}\text{ T}\cdot\text{m/A})(1.00\text{ m})}{2\pi}\ln\left(\frac{1.00+10.0}{1.00}\right)\left(10.0\ \frac{\text{A}}{\text{s}}\right) = \boxed{-4.80\ \mu\text{V}}$$

The long wire produces magnetic flux into the page through the rectangle (first figure, above). As it increases, the rectangle wants to produce its own magnetic field out of the page, which it does by carrying $\boxed{\text{counterclockwise}}$ current (second figure, above).

31.17 In a toroid, all the flux is confined to the inside of the toroid.



$$B = \frac{\mu_0 NI}{2\pi r} = \frac{500\,\mu_0 I}{2\pi r}$$

$$\Phi_B = \int B\,dA = \frac{500\,\mu_0 I_{\max}}{2\pi}\sin\omega t\int\frac{dz\,dr}{r}$$

$$\Phi_B = \frac{500\,\mu_0 I_{\max}}{2\pi}a\sin\omega t\ln\left(\frac{b+R}{R}\right)$$

$$\mathcal{E} = N'\frac{d\Phi_B}{dt} = 20\left(\frac{500\,\mu_0 I_{\max}}{2\pi}\right)\omega a\ln\left(\frac{b+R}{R}\right)\cos\omega t$$

$$\mathcal{E} = \frac{10^4}{2\pi}\left(4\pi\times10^{-7}\ \frac{\text{N}}{\text{A}^2}\right)(50.0\text{ A})\left(377\ \frac{\text{rad}}{\text{s}}\right)(0.0200\text{ m})\ln\left(\frac{(3.00+4.00)\text{ cm}}{4.00\text{ cm}}\right)\cos\omega t = \boxed{(0.422\text{ V})\cos\omega t}$$

31.35 (a) $\oint \mathbf{E}\cdot d\boldsymbol{\ell} = \left|\frac{d\Phi_B}{dt}\right|$

$2\pi r E = (\pi r^2)\frac{dB}{dt}$ so $E = \boxed{(9.87\text{ mV/m})\cos(100\,\pi t)}$

(b) The E field is always opposite to increasing B. $\therefore$ $\boxed{\text{clockwise}}$

31.36 For the alternator, $\omega = 3000\ \frac{\text{rev}}{\text{min}}\left(\frac{2\pi\text{ rad}}{1\text{ rev}}\right)\left(\frac{1\text{ min}}{60\text{ s}}\right) = 314\text{ rad/s}$

$$\mathcal{E} = -N\frac{d\Phi_B}{dt} = -250\frac{d}{dt}\left[(2.50\times10^{-4}\text{ T}\cdot\text{m}^2)\cos(314\,t/\text{s})\right] = +250(2.50\times10^{-4}\text{ T}\cdot\text{m}^2)(314/\text{s})\sin(314t)$$

(a) $\boxed{\mathcal{E} = (19.6\text{ V})\sin(314t)}$

(b) $\boxed{\mathcal{E}_{\max} = 19.6\text{ V}}$