1. Serway, Problem 31.9

   Solution

   The induced current in the ring is given by

$$
\begin{aligned}
I &= \frac{|\mathcal{E}|}{R} \\
&= \frac{1}{R}\left|-\frac{d\Phi_B}{dt}\right| \\
&= \frac{1}{2R}\frac{d}{dt}BA\cos\theta \\
&= \frac{A}{2R}\frac{dB}{dt} \\
&= \frac{A}{2R}\frac{d}{dt}\mu_0 nI \\
&= \frac{\mu_0 nA}{2R}\frac{dI}{dt} \\
&= \frac{\mu_0 n\pi r^2}{2R}\frac{dI}{dt} \\
&= \frac{(4\pi\times10^{-7})(1000)\pi(0.03)^2}{2(0.0003)}(270) \\
&= \boxed{1.6\,\mathrm{A}},
\end{aligned}
$$

   which itself induces a magnetic field of strength

$$
\begin{aligned}
B &= \frac{\mu_0 I}{2r} \\
&= \frac{(4\pi\times10^{-7})(1.6)}{2(0.05)} \\
&= \boxed{20\,\mu\mathrm{T}},
\end{aligned}
$$

   directed to the $\boxed{\text{left}}$.

2. Serway, Problem 31.17

   Solution

The length of the wire is given by

$$\begin{aligned} l &= N4s \\ &= N4\sqrt{A} \\ &= N4\left(\frac{\mathcal{E}}{N\cos\theta\dfrac{dB}{dt}}\right)^{1/2} \\ &= \sqrt{\frac{16N\mathcal{E}\Delta t}{\cos\theta(B_\mathsf{f}-B_\mathsf{i})}} \\ &= \sqrt{\frac{16(50)(0.08)(0.4)}{\cos\frac{\pi}{6}(6\times10^{-4}-2\times10^{-4})}} \\ &= \boxed{272\,\mathrm{m}}. \end{aligned}$$

3. Serway, Problem 31.23

   Solution

   The force applied is given by

$$\begin{aligned} F_\mathsf{app} &= \frac{B^2l^2v}{R} \\ &= \frac{(2.5)^2(1.2)^2(2)}{6} \\ &= \boxed{3\,\mathrm{N}}, \end{aligned}$$

   and the power (rate at which energy is delivered to the resistor) is

$$\begin{aligned} \mathscr{P} &= F_\mathsf{app}v \\ &= (3)(2) \\ &= \boxed{6\,\mathrm{W}}. \end{aligned}$$

4. Serway, Problem 31.33

   Solution

We solve Faraday's Law for the electric field on a circular path of radius r_1 as follows:

$$\begin{aligned}
\oint \mathbf{E}\cdot d\mathbf{s} &= -\frac{d\Phi_B}{dt} \\
2\pi r_1 E &= -\pi r_1^2 \frac{dB}{dt} \\
E &= -\frac{r_1}{2}\frac{d}{dt}\left(0.0300t^2 + 1.40\right) \\
&= -\frac{r_1}{2}0.06t \\
&= -\frac{0.02}{2}(0.06)(3) \\
&= \boxed{1.8\times 10^{-3}\,\frac{\mathrm{N}}{\mathrm{C}}\text{ up \& left}}.
\end{aligned}$$

5. Serway, Problem 31.35

   Solution

   The maximum emf is given by

$$\begin{aligned}
\mathcal{E}_{\mathsf{max}} &= NAB\omega \\
&= (1000)(0.1)(0.2)2\pi(60) \\
&= \boxed{7.54\,\mathrm{kV}},
\end{aligned}$$

   occurring at

$$\theta = \omega t = \sin^{-1} 1 = \boxed{\{0,\pi\}}.$$

6. Serway, Problem 31.67

   Solution

   The emf induced in the coil is given by

$$\begin{aligned}
\mathcal{E} &= -N\frac{d\Phi_B}{dt} \\
&= -N\frac{\mu_0 L}{2\pi}\frac{dI}{dt}\int_h^{h+w}\frac{1}{r}dr \\
&= N\frac{\mu_0 L}{2\pi}\ln\left(\frac{h}{h+w}\right) I_{\mathsf{max}}\frac{d}{dt}\sin(\omega t+\phi) \\
&= N\frac{\mu_0 L}{2\pi}\ln\left(\frac{h}{h+w}\right)\omega I_{\mathsf{max}}\cos(\omega t+\phi) \\
&= 100\frac{(4\pi\times 10^{-7})(0.2)}{2\pi}\ln\left(\frac{0.05}{0.05+0.05}\right)(200\pi)(50)\cos(200\pi t+\phi) \\
&= \boxed{-8.7\times 10^{-3}\cos(200\pi t+\phi)\,\mathrm{V}}.
\end{aligned}$$

Bonus (1 point) Serway, Problem 27.56

Solution

The resistance in a horizontal slice of the truncated cone is

$$\begin{aligned} dR &= \frac{\rho dz}{A} \\ &= \frac{\rho dz}{\pi r^2} \\ &= \frac{\rho dz}{\pi \left(b - \frac{b-a}{h} z\right)^2}, \end{aligned}$$

and the total resistance is

$$\begin{aligned} R &= \frac{\rho}{\pi} \int_0^h \frac{dz}{\left(b - \frac{b-a}{h} z\right)^2} \\ &= \frac{\rho}{\pi} \left[\frac{h}{(b-a)\left(b - \frac{b-a}{h} z\right)} \right]_0^h \\ &= \frac{\rho}{\pi} \left\{ \left[\frac{h}{(b-a)(b-b+a)} \right] - \left[\frac{h}{(b-a)b} \right] \right\} \\ &= \frac{\rho}{\pi} \left(\frac{h}{ab} \right), \qquad \text{qed.} \end{aligned}$$

Another Bonus (1 point) Serway, Problem 27.57

Solution

The resistance in a vertical slice of the wedge is

$$\begin{aligned} dR &= \frac{\rho dx}{A} \\ &= \frac{\rho dx}{wy} \\ &= \frac{\rho dx}{w\left[y_1 + \frac{x}{L}(y_2 - y_1)\right]}, \end{aligned}$$

and the total resistance

$$
\begin{aligned}
R &= \frac{\rho}{w}\int_0^L \frac{dx}{\left[y_1 + \frac{x}{L}(y_2 - y_1)\right]} \\
&= \frac{\rho L}{w(y_2 - y_1)} \ln\left[y_1 + \frac{x}{L}(y_2 - y_1)\right]_0^L \\
&= \frac{\rho L}{w(y_2 - y_1)} \ln(y_2 - y_1) \\
&= \frac{\rho L}{w(y_2 - y_1)} \ln\frac{y_2}{y_1}, \qquad \text{qed.}
\end{aligned}
$$