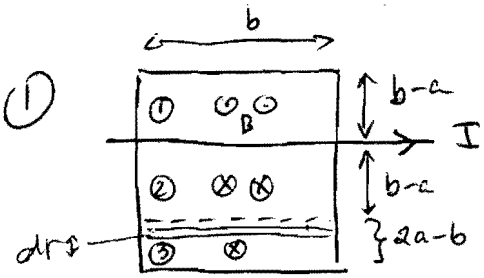
(1)



(a) It is clear that the upward flux in region ① cancels the downward flux in region ②. The net flux is then the flux in region ③.

Choose a small strip of width dr and length b. On that strip $B = \mu_0 I / 2\pi r$.

Flux through strip $d\Phi_{IB} = B\,dA = \dfrac{\mu_0 I}{2\pi r}\, b\, dr$

Total flux: $\Phi_B = \displaystyle\int_{b-a}^{a} \frac{\mu_0 I}{2\pi r}\, b\, dr$

$$= \frac{\mu_0 I b}{2\pi} \int_{b-a}^{a} \frac{dr}{r} = \frac{\mu_0 I b}{2\pi} \ln\left(\frac{a}{b-a}\right)$$

(b) $\dfrac{d\Phi_B}{dt} = \dfrac{\mu_0 b}{2\pi} \ln\left(\dfrac{a}{b-a}\right) \dfrac{dI}{dt}$ $\qquad \dfrac{dI}{dt} = 9t - 10$

$$= (2\times10^{-7})(0.16) \ln\left(\frac{0.12}{0.04}\right) (9\times3 - 10)$$

$$= 5.98 \times 10^{-7}\ \text{V}$$

(c) I is increasing so (downward) flux is increasing. Induced current must produce upward flux, so induced current is counterclockwise.

(2)

Consider induced emf in vertical sides.

$v = \omega \frac{D}{2}$ $\qquad \mathcal{E}_{ind} = BLv$ in each side

Total $\mathcal{E}_{ind} = 2BLvN = 2BL\omega\frac{D}{2}N = BL\omega DN$

$$= (0.5\ \text{T})(0.50\ \text{m})(0.30\ \text{m})(100\ \text{turn})\left(1000\ \frac{\text{rev}}{\text{min}}\right)\left(\frac{1\ \text{min}}{60\ \text{s}}\right)\left(\frac{2\pi\ \text{rad}}{1\ \text{rev}}\right)$$

$$= 5500\ \text{V}.$$

(3) (a) Just after the switch is closed, no current flows through the inductor, so $I_2 = 0$.

$$I_1 = \frac{\mathcal{E}}{R_1} = \frac{10\,V}{5\,\Omega} = 2.0\,A$$

$$I = I_1 + I_2 = 2.0\,A$$

$$\Delta V_L + \Delta V_{R_2} = \mathcal{E} \qquad \text{but } \Delta V_{R_2} = 0 \quad (\text{because } I_2 = 0)$$

$$\Rightarrow \Delta V_L = \mathcal{E} = 10\,V$$

$$\frac{dI_2}{dt} = \frac{\Delta V_L}{L} = \frac{10\,V}{5.0\,H} = 2.0\,A/s$$

(b) $$I_1 = \frac{\mathcal{E}}{R_1} = 2.0\,A$$

$$\frac{dI_2}{dt} = 0 \Rightarrow \Delta V_L = 0 \Rightarrow \Delta V_{R_2} = 10\,V$$

$$I_2 = \frac{\Delta V_{R_2}}{R_2} = \frac{10\,V}{10\,\Omega} = 1.0\,A$$

$$I = I_1 + I_2 = 3.0\,A$$

$$\frac{dI_2}{dt} = 0 \quad \text{and} \quad \Delta V_L = 0.$$