Physics 104 : Discussion 6b

28. Find the direction of the current through the resistor in Figure P20.28, (a) at the instant the switch is closed, (b) after the switch has been closed for several minutes, and (c) at the instant the switch is opened.

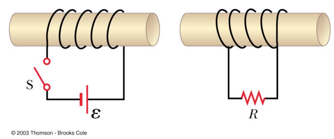

Figure P20.28

20.28 When the switch is closed, the current from the battery produces a magnetic field directed toward the right along the axis of both coils.

(a) As the battery current is growing in magnitude, the induced current in the rightmost coil opposes the increasing rightward directed field by generating a field toward to the left along the axis. Thus, the induced current must be left to right through the resistor.

(b) Once the battery current, and the field it produces, have stabilized, the flux through the rightmost coil is constant and there is no induced current.

(c) As the switch is opened, the battery current and the field it produces rapidly decrease in magnitude. To oppose this decrease in the rightward directed field, the induced current must produce a field toward the right along the axis, so the induced current is right to left through the resistor.

46. Consider the circuit in Figure P20.46, taking **ε** 6.00 V, L = 8.00 mH, and R = 4.00 **Ω**. (a) What is the inductive time constant of the circuit? (b) Calculate the current in the circuit 250 μs after the switch is closed. (c) What is the value of the final steady-state current? (d) How long does it take the current to reach 80.0% of its maximum value?

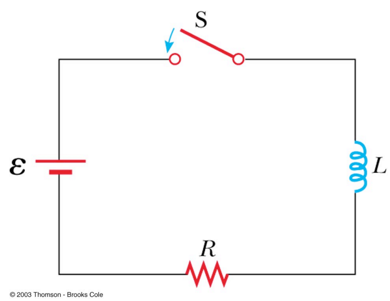

Figure P20.46

20.46 (a) $\tau = \frac{L}{R} = \frac{8.00 \text{ mH}}{4.00\ \Omega} = \boxed{2.00 \text{ ms}}$

(b) $I = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau}\right) = \left(\frac{6.00 \text{ V}}{4.00\ \Omega}\right)\left(1 - e^{-250\times10^{-6} \text{ s}/2.00\times10^{-3} \text{ s}}\right) = \boxed{0.176 \text{ A}}$

(c) $I_{max} = \frac{\mathcal{E}}{R} = \frac{6.00 \text{ V}}{4.00\ \Omega} = \boxed{1.50 \text{ A}}$

(d) $I = I_{max}\left(1 - e^{-t/\tau}\right)$ yields $e^{-t/\tau} = 1 - I/I_{max}$,

and $t = -\tau \ln\left(1 - I/I_{max}\right) = -\left(2.00 \text{ ms}\right)\ln\left(1 - 0.800\right) = \boxed{3.22 \text{ ms}}$

62. An aluminum ring of radius 5.00 cm and resistance 3.00×10^{-4} **Ω** is placed around the top of a long air-core solenoid with 1 000 turns per meter and smaller radius 3.00 cm as in Figure P20.62. If the current in the solenoid is increasing at a constant rate of 270 A/s, what is the induced current in the ring? Assume that the magnetic field produced by the solenoid over the area at the end of the solenoid is one-half as strong as the field at the center of the solenoid. Assume that the solenoid produces a negligible field outside its cross-sectional area.

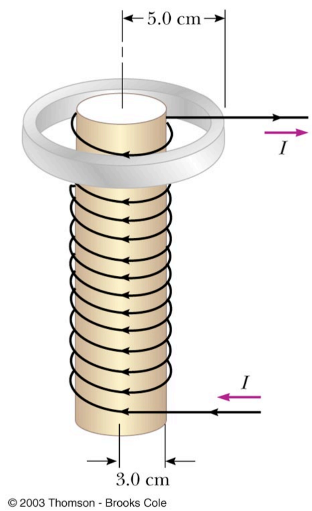

Figure P20.62

20.62 The induced emf in the ring is

$$|\mathcal{E}| = \frac{\Delta\Phi_B}{\Delta t} = \frac{(\Delta B)A_{solenoid}}{\Delta t} = \frac{\left(\Delta B_{solenoid}/2\right)A_{solenoid}}{\Delta t} = \frac{1}{2}\left[\mu_0 n\left(\frac{\Delta I_{solenoid}}{\Delta t}\right)\right]A_{solenoid}$$

$$= \frac{1}{2}\left[\left(4\pi \times 10^{-7}\ \mathrm{T\cdot m/A}\right)(1000)(270\ \mathrm{A/s})\left(\pi\left[3.00\times 10^{-2}\ \mathrm{m}\right]^2\right)\right] = 4.80\times 10^{-4}\ \mathrm{V}$$

Thus, the induced current in the ring is

$$I_{ring} = \frac{|\mathcal{E}|}{R} = \frac{4.80\times 10^{-4}\ \mathrm{V}}{3.00\times 10^{-4}\ \Omega} = \boxed{1.60\ \mathrm{A}}$$