

40. Since  $N\Phi_B = Li$ , we obtain

$$\Phi_B = \frac{Li}{N} = \frac{(8.0 \times 10^{-3} \text{ H})(5.0 \times 10^{-3} \text{ A})}{400} = 1.0 \times 10^{-7} \text{ Wb.}$$

44. Since  $\varepsilon = -L(di/dt)$ , we may obtain the desired induced emf by setting

$$\frac{di}{dt} = -\frac{\varepsilon}{L} = -\frac{60 \text{ V}}{12 \text{ H}} = -5.0 \text{ A/s,}$$

or  $|di/dt| = 5.0 \text{ A/s}$ . We might, for example, uniformly reduce the current from 2.0 A to zero in 40 ms.

51. The current in the circuit is given by  $i = i_0 e^{-t/\tau_L}$ , where  $i_0$  is the current at time  $t = 0$  and  $\tau_L$  is the inductive time constant ( $L/R$ ). We solve for  $\tau_L$ . Dividing by  $i_0$  and taking the natural logarithm of both sides, we obtain

$$\ln\left(\frac{i}{i_0}\right) = -\frac{t}{\tau_L}.$$

This yields

$$\tau_L = -\frac{t}{\ln(i/i_0)} = -\frac{1.0 \text{ s}}{\ln((10 \times 10^{-3} \text{ A})/(1.0 \text{ A}))} = 0.217 \text{ s.}$$

Therefore,  $R = L/\tau_L = 10 \text{ H}/0.217 \text{ s} = 46 \Omega$ .

56. From the graph we get  $\Phi/i = 2 \times 10^{-4}$  in SI units. Therefore, with  $N = 25$ , we find the self-inductance is  $L = N\Phi/i = 5 \times 10^{-3} \text{ H}$ . From the derivative of Eq. 30-41 (or a combination of that equation and Eq. 30-39) we find (using the symbol  $V$  to stand for the battery emf)

$$\frac{di}{dt} = \frac{V}{R} \frac{R}{L} e^{-t/\tau_L} = \frac{V}{L} e^{-t/\tau_L} = 7.1 \times 10^2 \text{ A/s.}$$

62. (a) From Eq. 30-49 and Eq. 30-41, the rate at which the energy is being stored in the inductor is

$$\frac{dU_B}{dt} = \frac{d\left(\frac{1}{2} Li^2\right)}{dt} = Li \frac{di}{dt} = L \left( \frac{\varepsilon}{R} (1 - e^{-t/\tau_L}) \right) \left( \frac{\varepsilon}{R} \frac{1}{\tau_L} e^{-t/\tau_L} \right) = \frac{\varepsilon^2}{R} (1 - e^{-t/\tau_L}) e^{-t/\tau_L}.$$

Now,

$$\tau_L = L/R = 2.0 \text{ H}/10 \Omega = 0.20 \text{ s}$$

and  $\mathcal{E} = 100 \text{ V}$ , so the above expression yields  $dU_B/dt = 2.4 \times 10^2 \text{ W}$  when  $t = 0.10 \text{ s}$ .

(b) From Eq. 26-22 and Eq. 30-41, the rate at which the resistor is generating thermal energy is

$$P_{\text{thermal}} = i^2 R = \frac{\mathcal{E}^2}{R^2} (1 - e^{-t/\tau_L})^2 R = \frac{\mathcal{E}^2}{R} (1 - e^{-t/\tau_L})^2.$$

At  $t = 0.10 \text{ s}$ , this yields  $P_{\text{thermal}} = 1.5 \times 10^2 \text{ W}$ .

(c) By energy conservation, the rate of energy being supplied to the circuit by the battery is

$$P_{\text{battery}} = P_{\text{thermal}} + \frac{dU_B}{dt} = 3.9 \times 10^2 \text{ W}.$$

We note that this result could alternatively have been found from Eq. 28-14 (with Eq. 30-41).