Chapter 11

1. a. $B = \dfrac{\Phi}{A} = \dfrac{4\times10^{-4}\text{ Wb}}{0.01\text{ m}^2}$ = 4×10^{-2} Wb/m^2 = **0.04 Wb/m^2**

   b. **0.04 T**

   c. $F = NI$ = (40 t)(2.2 A) = **88 At**

   d. $0.04\cancel{T}\left[\dfrac{10^4\text{ gauss}}{1\cancel{T}}\right]$ = **0.4×10^3 gauss**

2. $0.2''\left[\dfrac{2.54\text{ cm}}{1''}\right]\left[\dfrac{1\text{ m}}{100\text{ cm}}\right]$ = 5.08 mm

   $1''\left[\dfrac{2.54\text{ cm}}{1''}\right]\left[\dfrac{1\text{ m}}{100\text{ cm}}\right]$ = 25.4 mm

   $A = \dfrac{\pi d^2}{4} = \dfrac{\pi(5.08\text{ mm})^2}{4}$ = 20.27×10^{-6} m^2

   $L = \dfrac{N^2\mu A}{\ell} = \dfrac{(200\text{ t})^2(4\pi\times10^{-7})(20.27\times10^{-6}\text{ m}^2)}{25.4\text{ mm}}$ = **40.1 μH**

3. a. $L = \dfrac{N^2\mu_r\mu_o A}{\ell} = \dfrac{(200\ t)^2(500)(4\pi\times10^{-7})(20.27\times10^{-6}\text{ m}^2)}{25.4\text{ mm}}$ = **20.06 mH**

   b. increase = change in μ_r
   $L_{new} = \mu_r L_o$

4. $L = N^2\dfrac{\mu_r\mu_o}{\ell} = \dfrac{(200\text{ t})^2(1000)(4\pi\times10^{-7})(1.5\times10^{-4}\text{ m}^2)}{0.15\text{ m}}$ = **50.27 mH**

5. $L = \dfrac{N^2\mu_r\mu_o A}{\ell}$

   a. $L' = (3)^2L_o = 9L_o$ = 9(4.7 mH) = **42.3 mH**

   b. $L' = \dfrac{1}{3}L_o = \dfrac{1}{3}$(4.7 mH) = **1.57 mH**

   c. $L' = \dfrac{(2)(2)^2}{\frac{1}{2}}L_o$ = 16 (4.7 mH) = **75.2 mH**

   d. $L' = \dfrac{\left(\frac{1}{2}\right)^2\frac{1}{2}(1500)L_o}{\frac{1}{2}}$ = 375(4.7 mH) = **1.76 mH**

6. a. 39×10^2 μH ± 10% ⇒ 3900 μH ± 10% ⇒ **3.9 mH ± 10%**

b. $68 \times 10^0\ \mu\text{H} \pm 5\% =$ **68 μF ± 5%**

c. **47 μH ± 10%**

d. $15 \times 10^2\ \mu\text{H} \pm 10\% = 1500\ \mu\text{H} \pm 10\% =$ **15 mH ± 10%**

7. $e = N\dfrac{d\phi}{dt} = (50\text{ t})(120\text{ mWb/s}) = \mathbf{6.0\ V}$

8. $e = N\dfrac{d\phi}{dt} \Rightarrow \dfrac{d\phi}{dt} = \dfrac{e}{N} = \dfrac{20\text{ V}}{200\text{ t}} = \mathbf{100\ mWb/s}$

9. $e = N\dfrac{d\phi}{dt} \Rightarrow N = e\left(\dfrac{1}{\frac{d\phi}{dt}}\right) = 42\text{ mV}\left(\dfrac{1}{3\text{ m Wb/s}}\right) = \mathbf{14\ turns}$

10. a. $e = L\dfrac{di_L}{dt} = (22\text{ mH})(1\text{ A/s}) = \mathbf{22\ mV}$

b. $e = L\dfrac{di_L}{dt} = (22\text{ mH})(20\text{ mA/ms}) = \mathbf{440\ mV}$

$e = L\dfrac{di_L}{dt} = (22\text{ mH})\left(\dfrac{6\text{ mA}}{100\ \mu\text{s}}\right) = \mathbf{1.32\ V}$

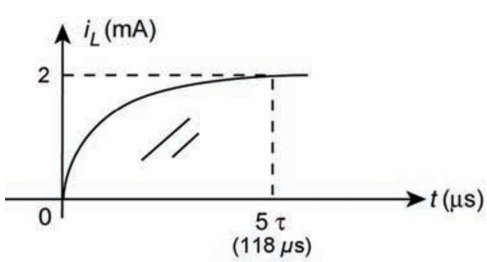
11. a. $\tau = \dfrac{L}{R} = \dfrac{470\text{ mH}}{20\text{ k}\Omega} = \mathbf{23.5\ \mu s}$

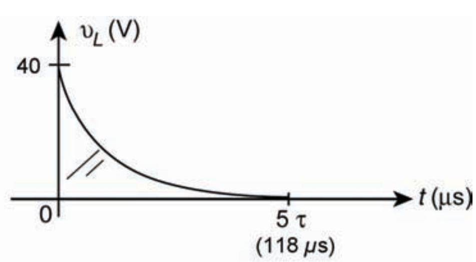
b. $i_L = \dfrac{E}{R}(1 - e^{-t/\tau}) = \dfrac{40\text{ V}}{20\text{ k}\Omega}(1 - e^{-t/\tau})$
$= \mathbf{2\ mA(1 - e^{-t/23.5\ \mu s})}$

c. $\upsilon_L = Ee^{-t/\tau} = \mathbf{40\ V}\boldsymbol{e}^{\mathbf{-t/23.5\ \mu s}}$
$\upsilon_R = i_R R = i_L R = E(1 - e^{-t/\tau}) = \mathbf{40\ V(1 - e^{-t/23.5\ \mu s})}$

d. i_L: 1τ = **1.264 mA**, , 3τ = **1.9 mA**, 5τ = **1.986 mA**
υ_L: 1τ = **14.72 V**, 3τ = **1.96 V**, 5τ = **280 mV**

e.





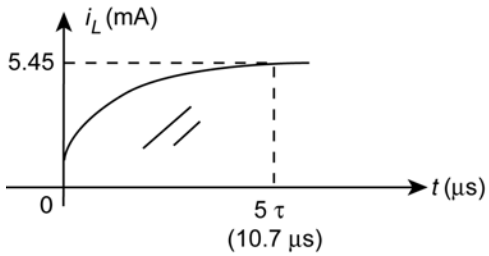
12. a. $\tau = \dfrac{L}{R} = \dfrac{4.7\text{ mH}}{2.2\text{ k}\Omega} = \mathbf{2.14\ \mu s}$

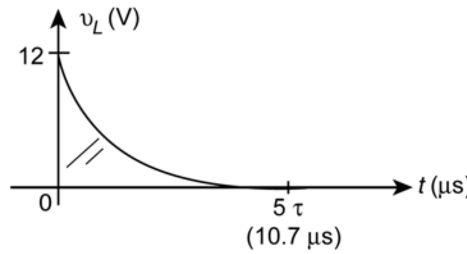
b. $i_L = \dfrac{E}{R}(1 - e^{-t/\tau}) = \dfrac{12\text{ V}}{2.2\text{ k}\Omega}(1 - e^{-t/\tau}) = \mathbf{5.45\text{ mA}(1 - e^{-t/2.14\,\mu s})}$

c. $\upsilon_L = Ee^{-t/\tau} = \mathbf{12\text{ V}e^{-t/2.14\,\mu s}}$
$\upsilon_R = i_R R = i_L R = E(1 - e^{-t/\tau}) = \mathbf{12\text{ V}(1 - e^{-t/2.14\,\mu s})}$

d. i_L: 1τ = **3.45 mA**, , 3τ = **5.18 mA**, 5τ = **5.41 mA**
υ_L: 1τ = **4.42 V**, 3τ = **0.60 V**, 5τ = **0.08 V**

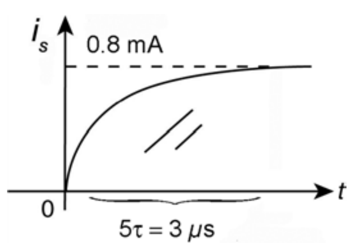
e.





13. a. $\tau = \dfrac{L}{R} = \dfrac{12\text{ mH}}{20\text{ k}\Omega} = 0.6\ \mu s$
$\upsilon_L = (28\text{ V} - 12\text{ V})e^{-t/0.6\mu s} = \mathbf{16\text{ V}e^{-t/0.6\mu s}}$

b. $i_s = i_R = i_L = \dfrac{E}{R}(1 - e^{-t/\tau}) = \dfrac{16\text{ V}}{20\text{ k}\Omega}(1 - e^{-t/0.6\mu s}) = \mathbf{0.8\text{ mA}(1 - e^{-t/0.6\mu s})}$



c. $5\tau = 5(0.6\ \mu s) = \mathbf{3\ \mu s}$

14. $i_L = \dfrac{18\text{ V}}{R_T}(1 - e^{-t/\tau})$

$R_T = \dfrac{18\text{ V}}{15\text{ mA}} = \mathbf{1.2\text{ k}\Omega}$

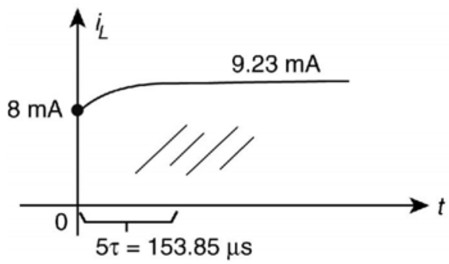
$5\tau = 5\left(\dfrac{L}{R}\right) = 15\ \mu s$: $L = \dfrac{R(15\ \mu s)}{5} = \dfrac{1.2\text{ k}\Omega(15\ \mu s)}{5}$

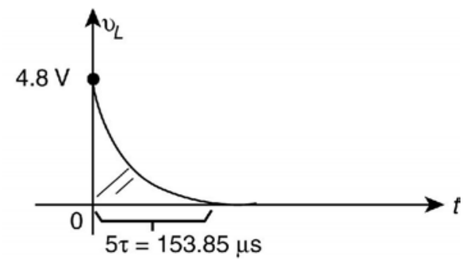
$= \mathbf{3.6\text{ mH}}$

15. a. $i_L = I_f + (I_i - I_f)e^{-t/\tau}$
$I_i = 8\text{ mA}$, $I_f = \dfrac{E}{R} = \dfrac{36\text{ V}}{3.9\text{ k}\Omega} = \mathbf{9.23\text{ mA}}$, $\tau = \dfrac{L}{R} = \dfrac{120\text{ mH}}{3.9\text{ k}\Omega} = 30.77\ \mu s$

$i_L = 9.23\text{ mA} + (8\text{ mA} - 9.23\text{ mA})e^{-t/30.77\,\mu s}$
$i_L = \mathbf{9.23\text{ mA} - 1.23\text{ mA}e^{-t/30.77\,\mu s}}$
$+E - \upsilon_L - \upsilon_R = 0$ and $\upsilon_L = E - \upsilon_R$
$\upsilon_R = i_R R = i_L R = (8\text{ mA})(3.9\text{ k}\Omega) = 31.2\text{ V}$
$\upsilon_L = E - \upsilon_R = 36\text{ V} - 31.2\text{ V} = 4.8\text{ V}$
$\upsilon_L = \mathbf{4.8\text{ V}e^{-t/30.77\,\mu s}}$

b.



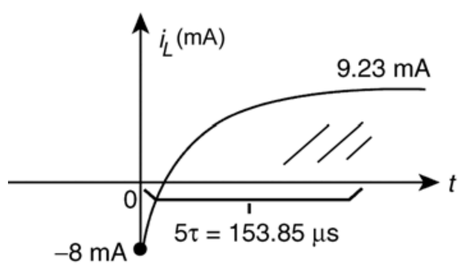


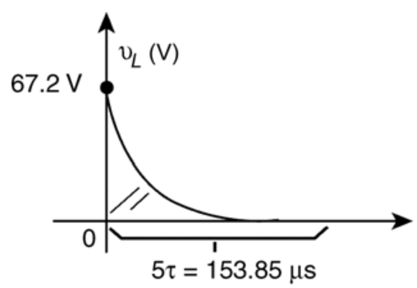
16. a. $I_i = -8\text{ mA},\ I_f = 9.23\text{ mA},\ \tau = \frac{L}{R} = \frac{120\text{ mH}}{3.9\text{ k}\Omega} = 30.77\,\mu s$

$i_L = I_f + (I_i - I_f)e^{-t/\tau}$
$\quad = 9.23\text{ mA} + (-8\text{ mA} - 9.23\text{ mA})e^{-t/30.77\,\mu s}$
$i_L = \mathbf{9.23\text{ mA} - 17.23\text{ mA}\ e^{-t/30.77\,\mu s}}$

$+E - \upsilon_L - \upsilon_R = 0$ (at $t = 0^-$)
but, $\upsilon_R = i_R R = -i_L R = (-8\text{ mA})(3.9\text{ k}\Omega) = -31.2\text{ V}$
$\upsilon_L = E - \upsilon_R = 36\text{ V} - (-31.2\text{ V}) = 67.2\text{ V}$
$\upsilon_L = \mathbf{67.2\text{ V}\ e^{-t/30.77\,\mu s}}$

b.





c. Final levels are the same. Transition period defined by 5τ is also the same.

17. a. $\tau = \frac{L}{R} = \frac{100\text{ mH}}{R_1 + R_2} = \frac{100\text{ mH}}{3.4\text{ k}\Omega} = 29.41\,\mu s$

At 0^+ $\upsilon_{R_2} = \frac{2.2\text{ k}\Omega(20\text{ V})}{2.2\text{ k}\Omega + 1.2\text{ k}\Omega} = 12.94\text{ V}$

$\upsilon_{R_2} = \mathbf{12.94Ve^{-t/29.41\,\mu s}}$

b. $i_L = \frac{E}{R_1 + R_2}(1 - e^{-t/\tau}) = \frac{20\text{ V}}{3.4\text{ k}\Omega}(1 - e^{-t/29.41\,\mu s})$
$i_L = \mathbf{5.88\text{ mA}(1 - e^{-t/29.41\,\mu s})}$