Physics 1C Chapter 30 Problems

30.4) $N_1 = 25$, $N_2 = 350$

$\ell_1 = 0.21\,m$, $d_2 = 0.023\,m$

$I_2 = 0.150\,A$, $\frac{dI_1}{dt} = 1800\,A/s$

a) $\Phi_B = \int B \cdot dA$

$A = \pi\left(\frac{d_2}{2}\right)^2$

$\Phi_B = \mu_0 n I (\pi)\left(\frac{d_2}{2}\right)^2$

$n = 1666.67\,turns/m$

$\boxed{\Phi_B = 1.3\times10^{-7}\,Wb}$

b) $M = \left|\frac{\mathcal{E}_1}{\frac{dI_2}{dt}}\right|$

$\mathcal{E}_1^{(1)} = -N_1\frac{d\Phi_B}{dt}$

$M = \mu_0 n(\pi)\left(\frac{d_2}{2}\right)^2(25)$

$\boxed{M = 2.18\times10^{-5}\,H}$

c) $|\mathcal{E}_2| = M\left(\frac{dI_2}{dt}\right)$

$|\mathcal{E}_2| = 0.039\,V$

$\boxed{\mathcal{E}_2 = -0.039\,V}$

30.11) $\ell = 5cm = 0.05m$

$d = 0.150cm \rightarrow r = 7.5\times10^{-4}\,m$

$N = 50$

$L = -\mu_0 n^2 a^2 \pi x$

$n = \frac{N}{\ell} = 1000\,turns/m$

$L = \mu_0 n^2 r^2 \pi \ell$

$\boxed{L = 1.11\times10^{-7}\,H}$

30.19) $B = 4.30\,T$

$V = 15cm^3 = 1.5\times10^{-5}\,m^3$

$U = \int u_B dV = u_B V$

$u_B = \frac{B^2}{2\mu_0}$

$u_B = 7.36\times10^6$

$\boxed{U = 110.35\,J}$

30.30) $L = 6H$, $R = 8\Omega$, $\mathcal{E} = 5V$

a) $\boxed{0W}$

b) $U = \frac{1}{2}LI^2$

$I = \frac{\mathcal{E}}{R} = 0.625A$

$\boxed{U = 1.17J}$

c) $P = I^2R$

$\boxed{P = 3.13W}$

d) $P_{in} = P_{out}$

$\boxed{P_{in} = 3.13W}$

30.36) $C_{min} = 4.11\,pF$

a) $f = 1.68\,MHz$

$\omega = \sqrt{\frac{1}{LC}}$

$\omega^2 = \frac{1}{LC}$

$L = \frac{1}{\omega^2 C}$

$\omega = 2\pi f$

$L = \frac{1}{4\pi^2 f^2 C}$

$\boxed{L = 0.00218\,H}$

b) $f = 0.538\,MHz$

$\omega = 2\pi f$

$\omega = \sqrt{\frac{1}{LC}}$

$4\pi^2 f^2 = \frac{1}{LC}$

$C_{max} = \frac{1}{4\pi^2 f^2 L}$

$\boxed{C_{max} = 4.01\times10^{-11}\,F}$

30.40) $L = 0.800H$, $C = 3\mu F$, $R = 350\Omega$

$q = 2.8\times10^{-4}C$

a) $q = Ae^{-(R/2L)t}\cos\left(\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}\,t + \phi\right)$

$2.8\times10^{-4}C = A\cos\phi$

$\boxed{A = 2.8\times10^{-4}C}$

b) $\boxed{\phi = 0\,rads}$

c) $\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$

$T = \frac{2\pi}{\omega}$

$\boxed{T = 0.0103s}$

d) $t = 0.0103s$

$q = A e^{-(R/2L)t} \cos\left(\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}\, t\right)$

$\boxed{q = 2.94 \times 10^{-5} C}$

30.45) $B = 0.4T$

$r = 25000km = 2.5 \times 10^7 m$

$\rho = 3 \times 10^{-4} kg/m^3$

$U = \int u_B dV = u_B V$

$u_B = \frac{B^2}{2\mu_0}$

$u_B = 63661.98 J/m^3$

$u_B V = \frac{1}{2} m v^2$

$m = \rho V$

$\sqrt{\frac{2u_B}{\rho}} = v$

$\boxed{v = 20601.27 m/s}$

30.46) a) $\int \vec{B} \cdot d\vec{s} = \mu_0 I_{enc}$

$B(2\pi r) = \mu_0 I_{enc}$

$\boxed{B(r) = \frac{\mu_0 I_{enc}}{2\pi r} = \frac{\mu_0 i}{2\pi r}}$

b) $d\Phi_B = B \cdot dA$

$dA = l\,dr$

$\boxed{d\Phi_B = \frac{\mu_0 i}{2\pi r} l\,dr}$

c) $\Phi_B = \frac{\mu_0 i l}{2\pi} \int_a^b \frac{dr}{r}$

$\boxed{\Phi_B = \frac{\mu_0 i l}{2\pi} \ln\left(\frac{b}{a}\right)}$

d) $L = \left|\frac{\mathcal{E}_i}{di/dt}\right|$

$\boxed{L = \frac{\mu_0 l}{2\pi} \ln\left(\frac{b}{a}\right)}$

e) $U = \frac{1}{2} L I^2$

$\boxed{U = \frac{\mu_0 i^2 l}{4\pi} \ln\left(\frac{b}{a}\right)}$

30.52) $L = 0.400H$, $R_1 = 8\Omega$, $R_2 = 5\Omega$

$\mathcal{E} = 48V$

a) $\mathcal{E} = IR$

$I = \frac{\mathcal{E}}{R}$

$R_{eq} = 13\Omega$

$\boxed{I = 3.69A}$

b) $i_1 = i_2$ @ $t = 0$

$\boxed{i_2 = 3.69A}$

c) $\boxed{i_1 = 0}$

d) $I = \frac{\mathcal{E}}{R}$

$\boxed{I = 6A}$

e) $\boxed{0A}$

f) $\boxed{6A}$

g) $\mathcal{E} - R_1 i_1 - R_2 i_2 = 0$

$R_2 i_2 = L \frac{di_2}{dt}$

$\mathcal{E} - R_1 i_1 - L \frac{di_2}{dt} = 0$

$i_1 = \frac{\mathcal{E} - L\frac{di_2}{dt}}{R_1}$

$i_2 = L \frac{\frac{di_2}{dt}}{R_2}$

$i_3 = i_1 - i_2$

$i = \frac{\mathcal{E} - L\frac{di}{dt}}{R_1} - L\frac{\frac{di}{dt}}{R_2}$

$R_1 R_2 i = R_2 \mathcal{E} - R_2 L \frac{di}{dt} - R_1 L \frac{di}{dt}$

$R_1 R_2 i - R_2 \mathcal{E} = L \frac{di}{dt}(-R_2 - R_1)$

$\frac{di}{dt} = \frac{-R_2(R_1 i - \mathcal{E})}{L(R_1 + R_2)}$

$\frac{di}{(R_1 i - \mathcal{E})} = \frac{-R_2}{L(R_1+R_2)} dt$

$u = R_1 i - \mathcal{E}$, $du = R_1$

$\frac{1}{R_1} \ln|R_1 i - \mathcal{E}| = \frac{-R_2 t}{L(R_1+R_2)}$

$\ln|R_1 i - \mathcal{E}| = \frac{-R_1 R_2 t}{L(R_1+R_2)}$

$R_1 i - \mathcal{E} = e^{\frac{-R_1 R_2}{L(R_1+R_2)} t}$

$\boxed{i = \frac{\mathcal{E}}{R_1}\left(1 - e^{\frac{-R_1 R_2}{L(R_1+R_2)} t}\right)}$

h) $i = 3A$

$\boxed{t = 0.09s}$

i) $\frac{di}{dt} = \frac{-R_2(R_1 i - \mathcal{E})}{L(R_1+R_2)} = 23.07 A/s$

$i_2 = \frac{L\, di/dt}{R_2}$

$\boxed{i_2 = 1.85A}$

j) $i_3 = i_1 - i_2$

$3A = i_1 - 1.85A$

$\boxed{i_1 = 4.85A}$

30.60) $I = 3.50A, L = 2.0mH$

a) $U = \frac{1}{2}LI^2$

$U = \frac{1}{2}(2)(3.50)^2$

$U = 12.25 mJ$

$U = \frac{1}{2}CV^2$

$Q = CV$

$U = \frac{1}{2}\frac{Q^2}{C}$

$\frac{1}{2}LI^2 = \frac{1}{2}\frac{Q^2}{C}$

$CLI^2 = Q^2$

$Q = I\sqrt{LC}$

$\boxed{Q = 0.35 mC}$

b) $\boxed{0A}$

30.61) $\mathcal{E} = 65V, R_1 = 45\Omega$

$R_2 = 26\Omega, L = 0.29H$

a) @ $t = 0$

$\boxed{V_{ab} = \mathcal{E} = 65V}$

b) $\boxed{a}$

c) $V_{cd} = V_{ab}$

$\boxed{V_{cd} = 65V}$

d) $\boxed{c}$

e) $i_1 = i_2 + i_3 \rightarrow i_2 = i_1 - i_3$

$\mathcal{E} = R_1 i_2$

$\mathcal{E} = R_2 i_3 + L\frac{di_3}{dt}$

$\frac{di_3}{dt} = 0$

$V_{cd} = 0$

$i_2 R_2 = \mathcal{E}$

$i_2 = \mathcal{E}/R_2 = 2.5A$

$V_{ab} = R_1 i_2$

$\boxed{V_{ab} = 112.5V}$

f) $\boxed{b}$

g) $V_{cd} = V_{ab} + i_2 R_2$

$\boxed{V_{cd} = 177.5V}$

h) $\boxed{d}$

30.63) $\mathcal{E} = 36V, R_0 = 50\Omega, R = 150\Omega$

$L = 4H$

a) $\boxed{0A}$

b) $V = IR$

$I = 0$

$\boxed{V = 0}$

c) $\mathcal{E} = V_{ac} + V_{cb}$

$\mathcal{E} = 0V + V_{cb}$

$\boxed{V_{cb} = 36V}$

d) $R_{eq} = R_0 + R$

$R_{eq} = 200\Omega$

$\mathcal{E} = R_0 I + RI$

$I = \frac{\mathcal{E}}{R_{eq}}$

$\boxed{I = 0.18A}$

e) $V_{ac} = R_0 I$

$\boxed{V_{ac} = 9V}$

f) $\mathcal{E} = V_{ac} + V_{cb}$

$\mathcal{E} = 9V + V_{cb}$

$\boxed{V_{cb} = 27V}$

g) $I = I_0(1 - e^{-R/L t})$

$\boxed{i = 0.180(1 - e^{-t/0.020})}$

h) $V = iR$

$\boxed{V = 9(1 - e^{-t/0.020})}$

i) $V_{cb} = \mathcal{E} - V$

$V_{cb} = 36 - 9 + 9e^{-t/0.020}$

$\boxed{V_{cb} = 9(3 + e^{-t/0.020})}$

30.66) a) $\mathcal{E} = L_1\frac{di}{dt} + L_2\frac{di}{dt} + RI$

$\frac{di}{dt} = 0$

$\mathcal{E} = RI$

$I = \frac{\mathcal{E}}{R}$

$\boxed{I = 0.6A}$

b) $U = \frac{1}{2}I^2(L_1+L_2)$

$U = \frac{1}{2}Q^2/C$

$U = \frac{1}{2}Q^2\left(\frac{1}{C_1}+\frac{1}{C_2}\right)$

$\frac{1}{2}I^2(L_1+L_2) = \frac{1}{2}Q^2\left(\frac{1}{C_1}+\frac{1}{C_2}\right)$

$Q^2 = \frac{I^2(L_1+L_2)}{\left(\frac{1}{C_1}+\frac{1}{C_2}\right)}$

$Q^2 = \frac{0.0072}{0.7071}$

$\boxed{Q = 3.24\times10^{-4}\,C}$

c) $Q_1 = Q_2$

$\boxed{Q = 3.24\times10^{-4}\,C}$

d) $t = \frac{1}{\omega}2\pi\left(\frac{2\pi}{\omega}\right)$

$\boxed{t = 8.45\times10^{-4}\,s}$

30.71) $q(t) = q_{t2}$

$q(0) = 0$

a) $\mathcal{E} = R_1 i_1 + L\frac{di_1}{dt}$

$\mathcal{E} = R_2 i_2 + q/C$

$\mathcal{E} - R_1 i_1 = L\frac{di_1}{dt}$

$\frac{di_1}{dt} = \frac{\mathcal{E}-R_1 i_1}{L}$

$\frac{di_1}{\mathcal{E}-R_1 i_1} = \frac{1}{L}dt$

$-\frac{1}{R_1}\ln|\mathcal{E}-R_1 i_1| = \frac{t}{L}$

$\boxed{i_1 = \frac{\mathcal{E}}{R_1}\left(1-e^{-R_1/L\,t}\right)}$

b) $q(t) = Q_f(1-e^{-t/CR})$

$q(t) = CV(1-e^{-t/CR})$

$\frac{dq}{dt} = i = CV\left(\frac{d}{dt}\right)(1-e^{-t/CR})$

$i = CV\left(-\frac{1}{CR}\right)e^{-t/CR}$

$i_2 = +\frac{V}{R}e^{-t/CR}$

$\boxed{i_{12} = \frac{\mathcal{E}}{R_2}e^{-t/CR_2}}$

c) $q(t) = CV(1-e^{-t/CR})$

$\boxed{q_2 = C\mathcal{E}\left(1-e^{-t/CR_2}\right)}$

d) $\boxed{0A}$

e) $i_2(0) = \frac{\mathcal{E}}{R_2}$

$\boxed{i_2(0) = 0.0093A}$

f) $i_1(\infty) = \frac{\mathcal{E}}{R_1}$

$\boxed{i_1(\infty) = 1.48A}$

g) $\boxed{i_C(0) = 0A}$

h) $i_1(t) = i_2(t)$

$\frac{\mathcal{E}}{R_1}\left(1-e^{-R_1/L\,t}\right) = \frac{\mathcal{E}}{R_2}e^{-t/CR_2}$

$\frac{R_2}{R_1}\left(1-e^{-R_1 t/L}\right) = e^{-t/CR_2}$

$\frac{R_2}{R_1} - \frac{R_2}{R_1}e^{-R_1 t/L} = e^{-t/CR_2}$

$e^x = 1+x+\frac{x^2}{2!}+\dots$

$\frac{R_2}{R_1} - \frac{R_2}{R_1}\left(1-\frac{R_1 t}{L}+\frac{R_1^2t^2}{L^2}\right) = 1-\frac{t}{CR_2}+\frac{t^2}{C^2R_2^2}$

$R_2 - R_2\left(1-\frac{R_1 t}{L}+\frac{R_1^2t^2}{L^2}\right) = R_1 - \frac{R_1 t}{CR_2}+\frac{R_1t^2}{C^2R_2^2}$

$R_2 - R_2 + \frac{R_1R_2t}{L} - \frac{R_1^2t^2R_2}{L^2} = R_1 - \frac{R_1t}{CR_2}+\frac{R_1t^2}{C^2R_2^2}$

$R_1R_2tL - R_1^2t^2R_2 = R_1L^2 - \frac{R_1tL^2}{CR_2}+\frac{R_1t^2L^2}{C^2R_2^2}$

$R_2Lt - R_1R_2t^2 = L^2 - \frac{L^2t}{CR_2}+\frac{L^2t^2}{C^2R_2^2}$

$\boxed{t = 0.0016s}$

i) $i_1(0.0016) = 0.978A$

$\boxed{i_1 = 0.009A}$

j) $i_{final} = 1.48A$

$i = 0.74A$

$i_{tot} = \frac{\mathcal{E}}{R_1}\left(1-e^{-R_1/L\,t}\right)+\frac{\mathcal{E}}{R_2}e^{-t/CR_2}$

$\boxed{t = 0.18s}$