Problem Set #13 Solutions - Chapter 33 - 9, 42, 44, 54, 80, 84

9. If we call the secondary windings N_2 and N_3, we have $e_2/e_1 = N_2/N_1$ and $e_3/e_1 = N_3/N_1$, which combines to $e_3/e_2 = N_3/N_2$;

$(11\text{ V})/(220\text{ V}) = N_3/(1000\text{ turns})$, which gives $N_3 = \boxed{50\text{ turns}}$.

42. For the maximum voltages to be equal, we have $I_{\text{max}}R = I_{\text{max}}X_C = I_{\text{max}}X_L$, or $R = X_C = X_L$, which gives

$1/wC = R$, or $C = \boxed{1/2\text{p}fR}$;

$wL = R$, or $L = \boxed{R/2\text{p}f}$.

44. We find the equivalent values for each of the components:

two resistors in series: $R_{\text{eq}} = R_1 + R_2$;

two capacitors in series: $1/C_{\text{eq}} = 1/C_1 + 1/C_2$;

two inductors in series: $L_{\text{eq}} = L_1 + L_2$.

For the reactances, we have

$X_{C\text{eq}} = 1/wC_{\text{eq}} = 1/wC_1 + 1/wC_2 = X_{C1} + X_{C2}$;

$X_{L\text{eq}} = wL_{\text{eq}} = wL_1 + wL_2 = X_{L1} + X_{L2}$.

The total impedance is

$$Z_{\text{total}} = [(X_{L\text{eq}} - X_{C\text{eq}})^2 + R_{\text{eq}}^2]^{1/2} = \{[(X_{L1} + X_{L2}) - (X_{C1} + X_{C2})]^2 + (R_1 + R_2)^2\}^{1/2}$$

54. The impedance is

$Z = e_{\text{max}}/I_{\text{max}} = 170\text{ V}/0.4\text{ A} = 425\ \Omega = \boxed{0.4\text{ k}\Omega}$.

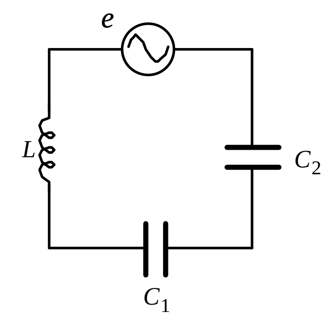
From $P = I_{\text{rms}}^2 R = (I_{\text{max}}/\text{v}2)^2 R$ we get

$R = 2P/I_{\text{max}}^2 = 2(18\text{ W})/(0.4\text{ A})^2 = 225\ \Omega = \boxed{0.2\text{ k}\Omega}$.

Finally, from $Z = [R^2 + (wL)^2]^{1/2}$ we solve for L:

$L = (Z^2 - R^2)^{1/2}/w = [(425\ \Omega)^2 - (225\ \Omega)^2]^{1/2}/[2\pi(60\text{ Hz})] = 0.956\text{ H} \,\tilde{}\, \boxed{1\text{ H}}$.

80. The equivalent capacitance of the two capacitors in series is



$C = C_1C_2/(C_1 + C_2)$

$= (4\ m\text{F})(9\ m\text{F})/(4\ m\text{F} + 9m\text{F}) = 2.8\ m\text{F}.$

The reactances are

$X_C = 1/wC = 1/[2\text{p}(600\text{ Hz})(2.8 \times 10^{-6}\text{ F})] = 95\Omega;$

$X_L = wL = 2\text{p}(600\text{ Hz})(70 \times 10^{-6}\text{ H}) = 0.26\ \Omega.$

The impedance of the circuit is

$Z = |X_L - X_C\ | = |(95\ \Omega) - (0.26\ \Omega)| = 95\ \Omega.$

(a) We find the maximum current from

$V_0 = I_0Z;$

$4\text{V} = I_0(95\ \Omega)$, which gives $I_0 = \boxed{0.042\text{A}}$.

(b) We have

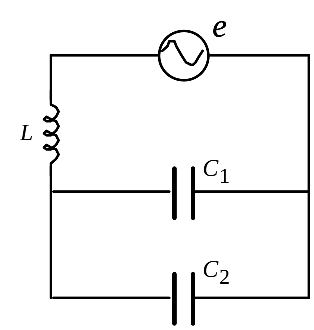
$w_0 = (1/LC)^{1/2} = [1/(70 \times 10^{-6}\text{ H})(2.8 \times 10^{-6}\text{ F})]^{1/2} = 7.1 \times 10^4\text{ rad/s},$

so the resonant frequency is

$f_0 = w_0/2\text{p} = (7.1 \times 10^4\text{ rad/s})/2\text{p} = \boxed{1.1 \times 10^4\text{ Hz}}$.

84. The equivalent capacitance of the two capacitors in parallel is

$C = C_1 + C_2 = 20\ m\text{F} + 30\ m\text{F} = 50\ m\text{F}.$



The reactances are

$X_{C1} = 1/wC_1 = 1/[2\text{p}(400\text{ Hz})(20 \times 10^{-6}\text{ F})] = 20\ \Omega;$

$X_{C2} = 1/wC_2 = 1/[2\text{p}(400\text{ Hz})(30 \times 10^{-6}\text{ F})] = 13\ \Omega;$

$X_C = 1/wC = 1/[2\text{p}(400\text{ Hz})(50 \times 10^{-6}\text{ F})] = 8.0\ \Omega;$

$X_L = wL = 2\text{p}(400\text{ Hz})(10 \times 10^{-3}\text{ H}) = 25\ \Omega.$

The impedance of the circuit is

$Z = [(X_L - X_C)^2]^{1/2} = |25\ \Omega - 8.0\ \Omega| = 17\ \Omega.$

(a) The maximum current in the circuit, which is the maximum current in the inductor, is

$I_0 = I_L = V_0/Z = (12 \text{ V})/(17\ \Omega) = \boxed{0.71 \text{ A}}$.

The voltage across the equivalent capacitance is the voltage across each capacitor:

$I_0 X_C = I_{C1} X_{C1} = I_{C2} X_{C2}$;

$(0.71 \text{ A})(8.0\ \Omega) = I_{C1}(20\ \Omega) = I_{C2}(13\ \Omega)$, which gives $I_{C1} = \boxed{0.28 \text{ A}}$, and $I_{C2} = \boxed{0.44 \text{ A}}$.

(b) The resonant frequency is

$f_0 = w_0/2\text{p} = (1/2\text{p})/(LC)^{1/2} = (1/2\text{p})/[(10 \times 10^{-3} \text{ H})(50 \times 10^{-6} \text{ F})]^{1/2} = \boxed{225 \text{ Hz}}$.