Physics 1B - Chap 21 HW Solutions

Easy

1 $V_{rms} = 100V$
$R = 5\Omega$

(a) $V_{max} = \sqrt{2}\, V_{rms} = \boxed{141V = V_{max}}$

(b) $V_{rms} = I_{rms} R \rightarrow I_{rms} = \frac{100V}{5\Omega} = \boxed{20A}$

(c) $I_{max} = \sqrt{2}\, I_{rms} = \boxed{28.3A}$

(d) Power dissipated (ave) $= I_{rms}^2 R = (20A)^2 5\Omega = \boxed{2000W}$

2 (a) $P_{ave} = 75W$
$f = 60\,Hz$
$V_{max} = 170V$

$$P_{ave} = \frac{V_{ave}^2}{R} = \left(\frac{V_{max}}{\sqrt{2}}\right)^2 \frac{1}{R}$$

$$R = \frac{V_{max}^2}{2 P_{ave}} = \frac{170^2}{2(75)} = \boxed{193\Omega}$$

(b) $P_{ave} = 100W$

$$R = \frac{170^2}{2(100)} = \boxed{145\Omega}$$

8 $C = 2.2\mu F$

(a) $\Delta V_{rms} = 120V$
$f = 60\,Hz \rightarrow \omega = 2\pi f = 120\pi$

$\Delta V_{cmax} = I_{max} X_c$ and $X_c = \frac{1}{2\pi f C}$

$$I_{max} = \frac{\Delta V_{cmax}}{X_c} = (\sqrt{2}\, V_{rms})\, 2\pi f c = \sqrt{2}(120)(120\pi)\, 2.2\mu F$$

$$\boxed{I_{max} = 0.141A}$$

Easy

8-cont

(15) $\Delta V_{rms} = 240\,V$

$f = 50\,Hz$

$I_{max} = \sqrt{2}(240)(100\pi)(2.2\,\mu F) \rightarrow$ **$I_{max} = 0.235\,A$**

11 $f = 60\,Hz$

$V_{max} = 170\,V$

$I_{rms} = .75\,A$

find C

$\Delta V_{max} = I_{max}\,X_C$

$\Delta V_{max} = (\sqrt{2}\,I_{rms})\left(\frac{1}{2\pi f C}\right)$

$C = \frac{\sqrt{2}\,I_{rms}}{2\pi f}\,\frac{1}{V_{max}} = \frac{\sqrt{2}\,(.75A)}{2\pi(60)(170V)}$

$C = 16.5\,\mu F$

15 $X_L = 54\,\Omega$

$f = 60\,Hz$

$I_{max} = ?$ when connected to $f = 50\,Hz$ & $100\,V_{rms}$

step 1: find L: $X_L = 2\pi f L \rightarrow L = \frac{X_L}{2\pi f} \rightarrow$ **$L = .143\,H$**

$I_{max} = \frac{V_{max}}{X_{L(new)}} = \frac{\sqrt{2}\,V_{rms}}{2\pi f L} = \frac{\sqrt{2}\,(100V)}{2\pi(50)(.143)}$

$I_{max} = 3.15\,A$

Easy

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$f = 20\ Hz$

$V_{rms} = 50\ V$

$I_{max} = 80\ mA$

$L = ?$

$$I_{max} = \frac{V_{max}}{X_L} = \frac{\sqrt{2}\ V_{rms}}{2\pi f L}$$

solve for L

$$L = \frac{\sqrt{2}\ V_{rms}}{2\pi f\ I_{max}}$$

$$L = \frac{\sqrt{2}\,(50)}{2\pi\,(20)(80\,mA)} \rightarrow \boxed{L = 7.0\ H}$$

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$C = 40\ \mu F$

$R = 50\ \Omega$

$V_{rms} = 30\ V$

$f = 60\ Hz$

(a) $I_{rms} = ?$; $X_C = \frac{1}{2\pi(60)(40\,\mu F)} = 66.3\ \Omega$

$V_{rms} = I_{rms} \cdot Z$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{50^2 + (0 - 66.3\,\Omega)^2}$$

$Z = 83\ \Omega$

$$I_{rms} = \frac{V_{rms}}{Z} = \boxed{.36\ A}$$

(c) $\Delta V_C = I X_C$

$= (.36\,A)(66.3\,\Omega)$

$\boxed{\Delta V_{C_{rms}} = 23.9\ V}$

(b) V_{rms} on Resistor

$$V_{rms} = I_{rms} R = .36A\,(50\,\Omega) = \boxed{18\ V}$$

(d) phase angle $= \phi = \tan^{-1} \frac{X_L - X_C}{R} = \frac{0 - 66.3}{50}$

$$\boxed{\phi = -53°}$$

Easy

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$R = 50\,\Omega$

$C = 30\,\mu F$

$f = 60\,Hz$

$V_{rms} = 100V$

ⓐ find power factor and P_{ave}

first, $X_C = \frac{1}{2\pi f C} = 88.4\,\Omega$

Thus $\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right) = \tan^{-1}\left(\frac{0 - 88.4}{50}\right)$

$\phi = -60.5°$, so $\boxed{\cos\phi = .492}$

$P_{ave} = V_{rms} I_{rms} \cos\phi$; we need I_{rms} first

$I_{rms} = \frac{V_{rms}}{Z}$ so we need Z

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

$Z = \sqrt{50^2 + (0 - 88.4)^2} = 102$

$P_{ave} = V_{rms} \frac{V_{rms}}{Z} \cos\phi$

$P_{ave} = \frac{(100V)^2 (.492)}{102\,\Omega}$

$\boxed{P_{ave} = 48.4W}$

ⓑ repeat w/ $L = 0.3H$ instead of capacitor

Now $X_C = 0$ and $X_L = 2\pi f L = 113\,\Omega$

and $Z = \sqrt{50^2 + 113^2} = Z = 123.7\,\Omega$

$\phi = \tan^{-1}(113/50) = 66.1°$ $\boxed{\cos\phi = .404}$

$P_{ave} = \frac{V_{rms}^2}{Z} \cos\phi = \frac{100^2}{123.7}(.404) = \boxed{32.7W = P_{ave}}$

Easy

[40] Need 6 Vrms, have 120 Vrms

$N_{primary} = 400$ turns, $I_s = 500\,mA$

(a) $\Delta V_2 = \frac{N_2}{N_1} \Delta V_1$ So since we start with 120 V and we only want to end with 6 V, we want **less turns**

(b) Find $I_{primary}$

We can get this using the fact that power in = power out so $I_p V_p = I_s V_s$

or $I_p = I_s \frac{V_s}{V_p} = 500\,mA \left(\frac{6V}{120V}\right) = \boxed{25\,mA}$

(c) find $N_{secondary}$ from $\Delta V_2 = \frac{N_2}{N_1} \Delta V_1$ we obtain

$N_2 = N_1 \frac{\Delta V_2}{\Delta V_1} = 400 \left(\frac{6V}{120V}\right) = \boxed{20 \text{ turns}}$

Medium

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$\omega = 120\pi$

$\Delta V_{max} = 140\text{ V}$

$C = 6\ \mu F$

$L = 0$, $R = 0$ } b/c it says "purely capacitive"

Find I_{rms} → $I_{rms} = \frac{V_{rms}}{X_c} = \frac{V_{max}/\sqrt{2}}{1/(2\pi f)C}$ ($2\pi f = \omega$)

$$I_{rms} = \frac{140V/\sqrt{2}}{1/(120\pi)(6\mu F)} = \boxed{0.224\text{ A}}$$

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$L = 400\text{ mH}$

$C = 4.43\ \mu F$

$R = 500\ \Omega$

$f = 50\text{ Hz}$

$I_{max} = 250\text{ mA}$

ⓐ find V_{max} $\quad V_{max} = I_{max} Z$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$; find X_L & X_C

$X_L = 2\pi f L = 126\ \Omega$

$X_C = 1/2\pi f C = 719\ \Omega$

$$Z = \sqrt{500^2 + (126 - 719)^2} = 775\ \Omega$$

$$V_{max} = 250\text{ mA}(775\ \Omega) = \boxed{194\text{ V}}$$

ⓑ find phase angle ϕ

$$\phi = \tan^{-1}\frac{X_L - X_C}{R} = \tan^{-1}\left(\frac{126 - 719}{500}\right) = \boxed{-50^\circ = \phi}$$

Note: The (−) sign means the voltage lags the current.

Medium

21

$R = 900\,\Omega$ $X_L = 2\pi f L = 3770\,\Omega$

$C = 0.25\,\mu F$

$L = 2.5\,H$ $X_C = 1/2\pi f C = 2650\,\Omega$

$f = 240\,Hz$

$\Delta V_{max} = 140\,V$

(a) Find Z; need X_L & X_C first; see above

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{900^2 + 1120^2} = \boxed{1440\,\Omega}$$

(b) $$I_{max} = \frac{V_{max}}{Z} = \frac{140V}{1440\,\Omega} = \boxed{.097\,A}$$

(c) phase angle:

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right) = \tan^{-1}\left(\frac{1120}{900}\right) = \boxed{51.2^\circ}$$

(d) since ϕ is (+), the voltage leads and the current lags.

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$C = 200\,\mu F$

$L = 100\,mH$

$R = 20\,\Omega$

$V_{max} = 100V \longrightarrow V_{rms} = 70.7V$

(a) $f = 60\,Hz$ find P_{ave} and $\cos\phi$

$X_C = 1/2\pi f C = \underline{13.3\,\Omega}$; $X_L = 2\pi f L = \underline{37.7\,\Omega}$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{20^2 + 24.4^2} = \underline{\underline{31.5\,\Omega}}$$

Medium

[30-cont] $\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right) = \tan^{-1}\left(\frac{24.4}{20}\right) = 50.7°$

$\boxed{\cos\phi = .634}$

$P_{ave} = V_{rms} I_{rms} \cos\phi = V_{rms}\left(\frac{V_{rms}}{Z}\right)\cos\phi$

$= \frac{(70.7\,V)^2}{31.5\,\Omega}(.634) = \boxed{P_{ave} = 101\,W}$

(b) $f = 50\,Hz \rightarrow$ get new X_C, X_L, Z values

$X_C = 15.9\,\Omega$
$X_L = 31.4\,\Omega$
$Z = 25.3\,\Omega$

$\phi = \tan^{-1}\left(\frac{31.4 - 15.9}{20}\right) = 37.8°$

$\boxed{\cos\phi = .79}$

$P_{ave} = \frac{70.7}{25.3}(.79) = \boxed{156\,W = P_{ave}}$

[33] $R = 12\,\Omega$
$C = 1.4\,pF = 1.4 \times 10^{-12}\,F$
$f_0 = 88.9\,MHz$

$L = ?$ $\qquad f_0 = \frac{1}{2\pi\sqrt{LC}} \rightarrow L = \left(\frac{1}{2\pi f}\right)^2 \frac{1}{C}$

$L = \frac{1}{[2\pi(88.9 \times 10^6)]^2 (1.4 \times 10^{-12})} \rightarrow \boxed{L = 2.3\,\mu H}$

Medium

41) $V_1 = 3600V$
$V_2 = 120V$

$P_2 = 1000 kW$ @ 90% efficiency

(a) $P_1 = ?$ well $\frac{P_2}{P_1} = 90\% = .9 \rightarrow P_1 = \frac{P_2}{.9}$

$P_1 = \frac{1000 kW}{.9} = \boxed{1111 kW = P_1}$

(b) current $I_1 = ?$
$P_1 = I_1 V_1 \rightarrow I_1 = \frac{P_1}{V_1} = \frac{1111 kW}{3600 V} = \boxed{309 A}$

(c) current $I_2 = ?$ $I_2 = \frac{P_2}{V_2} = \frac{1000 kW}{120 V} = \boxed{8.3 kA}$

Hard

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$R = 25\,\Omega$

① Get Reactance

$L = 6\,mH \rightarrow X_L = 22.6\,\Omega$

$C = 25\,\mu F \rightarrow X_C = 10.6\,\Omega$

② Get Impedence

$Z = \sqrt{25^2 + (22.6 - 10.6)^2}$

$Z = 27.7\,\Omega$

$V_{rms} = 10V$

$f = 600\,Hz$

③ Get Irms

$I_{rms} = \frac{V_{rms}}{Z} = .36\,A$

ⓐ get sum of voltages

$\Delta V_R = I_{rms} R = 9V$

$\Delta V_C = I_{rms} X_C = 3.82$

$\Delta V_L = I_{rms} X_L = 8.14$

$\sum \Delta V = 21$ Volts

Thus the sum of the voltages does NOT equal the total voltage. This is because they are not in phase.

ⓑ which is greatest: P_R, P_L, P_C

Recall that a perfect capacitor and inductor store energy but do not lose energy. Thus the resistor is the only element with power dissipated $\boxed{P_R}$

ⓒ P_{ave} (total) $= I_{rms} V_{rms} \cos\phi$

but since we know only the resistor has power loss we can use

$P = I_{rms}^2 R = (.36\,A)^2\, 25\,\Omega = \boxed{3.24\,W}$