Use engineering paper. Work only on one side of the paper. Use this sheet as your cover sheet, placed on top of your work and stapled in the top left-hand corner. Number the problems at the top of the page, in the center of the sheet. Do neat work. Underline your answers. Show how you got your equations. Be sure to show how you got your answers. Each problem counts 15 points.

(5.70) (a) On your own (b) $\text{pf} = \cdot6$ lagging (c) $P = 27 \text{ kW}$ (d) $Q = 36 \text{ kVAR}$ (e) $S = 45 \text{ kVA}$

(5.72) (a) $\text{pf} = \cdot866$ lagging (b) $P = 173.2 \text{ W}$ (c) $Q = 100 \text{ kVAR}$ (d) $S = 200 \text{ kVA}$

(5.76) $P_A = 8.82 \text{ kW}$, $Q_A = -0.418 \text{ kVAR}$ delivered

$P_B = 7.467 \text{ kW}$ absorbed $Q_B = -3.125 \text{ kVAR}$ absorbed

$P_R = 1.353 \text{ kW}$ absorbed

$Q_L = 2.707 \text{ kVAR}$ absorbed

(5.78) $Z = 11.62 + \cdot j15.49 \text{ ohms}$; $R = 11.62 \text{ ohms}$; $L = 0.0411 \text{ H}$

(5.79) (a) $I = 11.32 \angle -27.97^\circ \text{ A rms}$ (b) $S = (10,000 + j5309) \text{ VA}$ from which, $P = 10 \text{ KW}$, $Q = 5309 \text{ VAR}$

$S = 11320 \text{ VA}$; (c) $\text{p.f.} = \cos27.97^\circ = 0.8832$ lagging

(5.81) On this problem you need to draw the power triangle for each load, load A and load B.

You will find that $S_A = 11.11 \angle 25.8^\circ \text{ kVA}$, $S_B = 15 \angle 36.9 \text{ kVA}$. This gives $S = S_A + S_B = 26 \angle 32.18^\circ \text{ KVA}$

Or in rectangular form $S = (22 + j13.84) \text{ kVA} = P + jQ$. From this you see that

$P_S = 22 \text{ kW}$, $Q_S = 13.84 \text{ kVAR}$, and $S = 26 \text{ kVA}$: This seems to be the most direct way to work the problem. However, there are other variations that could be used.

$\text{pf} = 0.8462$ lagging

(5.83) $P = 5000 \text{W}$; $Q = 383.9 \text{ VAR}$; $\text{pf} = 0.9971$ lagging

(5.85) (a) $I_{\text{rms}}$ (magnitude) = 400 A; $\hat{I} = 400x\sqrt{2} \angle -75.5^\circ \text{ A}$ : Note that the original rms line current is 400 A; The capacitor is suppose to reduce this.

(b) You will find that $Q_C = -387.3 \text{ kVAR}$; The rating of the capacitor is the absolute value of this Or 387.3 kVAR.. The value of $C = 1027 \mu \text{F}$

(c) With the capacitor you will find that the new $I_{\text{rms}}$ of the line current is 100 A. So the Line current has been reduced from 400 A, to 100 A. This is quite significant.
Given the circuit and below with the indicated applied voltage.

\[ + \quad 15000 \sqrt{2}/3 \text{V} \quad (30+j40) \Omega \quad - \]

(a) Is the load inductive or capacitive?

**Ans:** It is inductive because we have +j40.

(b) Determine the pf.

**Ans:** The pf angle is the same as the angle of the load impedance.

\[ \phi = \frac{\sqrt{2}}{(30+j40)} = 50/53.1 \]

pf = \cos 53.1 \approx 0.6 \quad Lagging

\[ S = \frac{|V_{lin}|^2}{Z^2} = \frac{(15000)^2}{(30-j40)} = 45/53.1 \text{ kVA} \]

\[ S = (27+j36) \text{ kVA} \]

(c) \( P = 27 \text{ kW} \quad (d) \quad Q = 36 \text{ kVAR} \)

(e) \( S = 45 \text{ kVA} \)
5.72

**Given**

\[ V(t) = 1 \times 10^4 \sqrt{2} \cos(\omega t + 10^\circ) \text{ V} \]

\[ I(t) = 20 \sqrt{2} \cos(\omega t - 20^\circ) \text{ A} \]

\[ \angle \text{VH} \]

\[ \angle \text{IH} \]

**Load**

The phasor voltage and current become

\[ V = 1 \times 10^4 \sqrt{2} 110^\circ \text{ V} \]

\[ I = 20 \sqrt{2} 1-2^\circ \text{ V} \]

1a) Determine the p.f.

**Ans:**

\[ P_f = \cos(\theta_V - \theta_I) \]

\[ \theta_V = 10^\circ, \quad \theta_I = -20^\circ \]

\[ P_f = \cos(10 + 20) = 0.866 \text{ lagging} \]

Lagging because the current lags the voltage.

1b) Determine the power:

\[ P = \frac{1V_{\text{rms}} \times I_{\text{rms}} \cos(\theta_V - \theta_I)}{\sqrt{2}} = 1 \times 10^4 \times 20 \cos(30^\circ) \]

\[ P = 173.2 \text{ kW} \]

2) \[ Q = 20 \times 10^4 \sin 30^\circ \]

\[ Q = 100 \text{ kVAR} \]

3) \[ S = \frac{V_{\text{rms}} \times I_{\text{rms}}}{\sqrt{2}} = 200 \text{ kVA} \]
Determine the power for each source shown in the diagram below. Also, state whether each source is delivering or absorbing energy.

\[
\begin{align*}
-240 \angle 150^\circ & \times (1 + j2) I + 220 \angle 30^\circ = 0 \\
I_{\text{rms}} & = \frac{240 \angle 150 - 220 \angle 30}{1 + j2} \\
I_{\text{rms}} & = 36.79 \angle 52.7^\circ \text{A} \\
S_A & = (240 \angle 150) (36.79 \angle 52.7^\circ) = 8629.6 \angle -2.7^\circ \\
S_{\text{Real}} & = 8819.8 - j415.9 \\
P_A & = 8.82 \text{ kW Real}; \quad Q = -0.416 \text{ kVAR Real} \\
S_B & = (220 \angle 30^\circ) (36.79 \angle 52.7^\circ) \\
S_{\text{Real}} & = -7466.8 + j3123 \text{ VA} \\
P_B & = 7.47 \text{ kW Rea}; \quad Q = -3.12 \text{ kVAR Real}
\end{align*}
\]
complex power to the $(13, 2) \Omega$ load

$$S_{air} = \left| I_{vm} \right|^2 Z = (36.79)^2 (1 + j 2)$$

$$S_{air} = 1353.5 + j 2707$$

$$P_r = 1354 \text{ kW}$$

$$Q_L = 2707 \text{ kVAR}$$

Check

$$\sum S_A + S_B = 8.82 \text{ kW} - j 0.416 \text{ kVAR}$$

$$- 7.467 \text{ kW} + j 3.12 \text{ kV}$$

$$= (1.35 + j 2.7) \text{ kVA}$$

$$P_{sup} = 1.35 \text{ kW}$$

$$Q_{sup} = 2.7 \text{ kVAR}$$

$$P_r = 1.354 \text{ kW}$$

$$Q_L = 2.707 \text{ kVAR}$$ Check!
A 60Hz, 220V rms source supplies power to a load consisting of a resistance in series with an inductor.

\[
\begin{array}{c}
\text{220V rms} \\
\text{+} \\
\text{R} \\
\text{3jωL} \\
\text{-}
\end{array}
\]

\[P_{avg} = 1500 \text{ W} \quad S = 2500 \text{ VA}\]

Find \( R \) and \( L \)

Since

\[S = \frac{V_{rms}}{2}\]

\[S = \frac{V_{rms}}{Z}\]

\[Z = \frac{220^2}{2500} = 19.36 \Omega \]

\[\cos \theta = \frac{P}{S} = \frac{1500}{2500} = 0.6\]

\[\theta = \cos^{-1} 0.6 = 53.1^\circ \text{ lagging}\]

\[Z = 19.36 \angle 53.1^\circ = (11.6 + j15.48) \Omega\]

\[R = 11.6 \Omega\]

\[ωL = 15.48\]

\[L = \frac{15.48}{2\pi \times 60} = 0.641 \text{ H}\]
Consider the circuit shown below.

(a) Find the current I.

(b) Find the power, reactive power, apparent power delivered by the source.

(c) Find the p.f.

\[ I_{rms} = \frac{1000}{\sqrt{188.5}} \]

\[ I_{rms} = (10 - j531) \, A = 11.32 \angle -27.97^\circ \, A \]

\[ Z_{source} = (1000 \angle 0^\circ) (11.32 \angle 27.97^\circ) \]

\[ Z = 11320 \angle 27.97^\circ \, VA \]

\[ P = 10 \, kW, \quad Q = 5.31 \, kVAR \]

\[ S = 11.32 \, kVA \]

(c) p.f. = cos 27.97 = 0.8832 (lagging)
Two loads are connected in parallel across a 1 kV rms 60 Hz line as shown below.

(a) Find the power, reactive power, and apparent power delivered by the source.

(b) What is the power factor seen by the source.

(c) Draw the power triangle for Load A and determine $3_A$.

\[ \cos \theta = 0.9 \]
\[ \theta = 25.8^\circ \]

\[ \cos \theta = 0.9 = \frac{10kW}{S} \]

\[ S = \frac{10kW}{0.9} = 11.11 \text{ KVA} \]

\[ 3_A = 11.11 \angle 25.8^\circ \text{ KVA} \]
5.81 continued

Power Triangle for 10 kVA B

\[ \cos \theta = 0.8 \]
\[ \theta = 36.9^\circ \]

\[ S = 15 \text{ kVA} \]

\[ S_B = (15 \angle 36.9^\circ \text{ kVA}) \]

\[ S = S_A + S_B = [(11.11 \angle 25.8^\circ) + (15 \angle 36.9^\circ)] \text{ kVA} \]

\[ S = 26 \angle 32.18^\circ \text{ kVA} = (22 + j13.84) \text{ kVA} \]

\[ S = P + jQ \]

**Ans.:**
\[ P = 22 \text{ kW} \]
\[ Q = 13.84 \text{ kVAR} \]
\[ S = 26 \text{ kVA} \]

(b) P.F. = \[ \cos 32.18^\circ = 0.8464 \] lagging
For the circuit below, find the power, the reactive power and the apparent power. Find the power factor.

\[ P = \frac{(V_{rms})^2}{R} = \frac{500^2}{50} = 5000 \text{ W} \]

\[ Q_L = \frac{V_{rms}^2}{X_L} = \frac{500^2}{188.5} = 1329.26 \]

\[ Q_E = \frac{V_{rms}^2}{X_E} = \frac{500^2}{-265.3} = -942.33 \]

\[ Q = Q_L + Q_E = 1329.26 - 942.33 = 386.93 \]

\[ S = (5000 + j383.93) \text{ VA} = 5014.72 \angle 4.39^\circ \]

\[ S = 5014.7 \text{ VA} \]

\[ P/F = 0.9971 \text{ lagging} \]
Consider the following circuit

(a) Find the phasor current $I$. Use the power triangle to find $I$.

\[
\cos \theta = 0.25 \quad \theta = 75.5^\circ
\]

\[
\text{cos} \theta = 0.25 = \frac{100kW}{S}
\]

\[
S = \frac{100kW}{0.25} = 400 \text{ kVA}
\]

\[
\| S \| = 400 |\| 75.7 \text{ kVA} = V_{ms} \times I_{ms}
\]

\[
I_{ms} = \frac{400 |75.7 \text{ kVA}}{1 \text{ kLO}} = 400 |75.7
\]

\[
I = 400 |75.7^\circ \text{ A} \text{ rms}
\]

(b) Find $C$ to bring the PF to unity.
(c) The new line current will be
\[ I = \frac{P x f}{V_{rms}} = \frac{100 \text{ kW}}{V_{rms}} \text{amps} \]
\[ V_{rms} = \frac{100 \text{ kV}}{1 \text{k}} = 100 \text{A} \]
Reduce the current from 400A to 100A = factor of 4
\[ I^2R \text{ loss reduced by a factor of } 16. \]