Problem 1: A 100-V source, rated at 3,000 VA, delivers 20-A current to a single-phase electric motor. The motor causes the current to lag behind the voltage by \( \pi/3 \).

(i) Evaluate the apparent power drawn by the load and its power factor. (20 points)

(ii) Evaluate the active and reactive power drawn by the load and draw its power triangle. (30 points)

(iii) Indicate if the load behaves as a capacitive, inductive or purely resistive load. (20 points)

(iv) Determine how much additional load in kW of real power can be delivered from the source to the motor before the source reaches its full rated kVA (assume reactive power is fixed). (30 points)

i) Apparent Power is the magnitude of the complex power

\[
|S| = |V||I| = 100\text{ V} \times 20\text{ A} = \boxed{2000\text{ VA}}
\]

\[
P_F = \cos(\Theta) = \cos(\pi/3) = \boxed{\frac{1}{2}}
\]

ii) Active Power \( P = |S| \cos \Theta = 2000 \times \frac{1}{2} = \boxed{1000\text{ W}} \)

Reactive Power \( Q = |S| \sin \Theta = 2000 \times \sin(\pi/3) = 2000 \times \frac{\sqrt{3}}{2} = \boxed{1000\sqrt{3}\text{ VAR}} \)

Power Triangle

\[
\begin{align*}
P &= 1000\text{ W} \\
Q &= 1000\sqrt{3}\text{ VAR} \\
S &= 2000\text{ VA}
\end{align*}
\]
iii) The current lags behind the voltage, therefore the load is inductive.

iv) \( S_{\text{max}} = P_{\text{max}} + Q_{\text{old}} \)

\[
P_{\text{new}} = \sqrt{S_{\text{max}} - Q_{\text{old}}^2}
\]

\[
= \sqrt{(3000)^2 - (1000\sqrt{3})^2}
\]

\[
= 1000\sqrt{6} \text{ W}
\]

Additional power that can be provided

\[
\Delta P = P_{\text{max}} - P_{\text{initial}}
\]

\[
= 1000\sqrt{6} - 1000
\]

\[
= (\sqrt{6} - 1)1000 \text{ W}
\]