

POWER AND ENERGY IN AC CIRCUIT

MECHANICAL WORK = FORCE $\times$ DISTANCE

ELECTRICAL WORK = $\begin{matrix} \text{ELECTRO} \\ \text{MOTIVE FORCE} \\ \text{(VOLTAGE)} \end{matrix} \times \begin{matrix} \text{ELECTRON MOVEMENT} \\ \text{(CURRENT)} \end{matrix}$

$$P = E \times I \quad (\text{WATT})$$

V - VOLT
I - AMP.

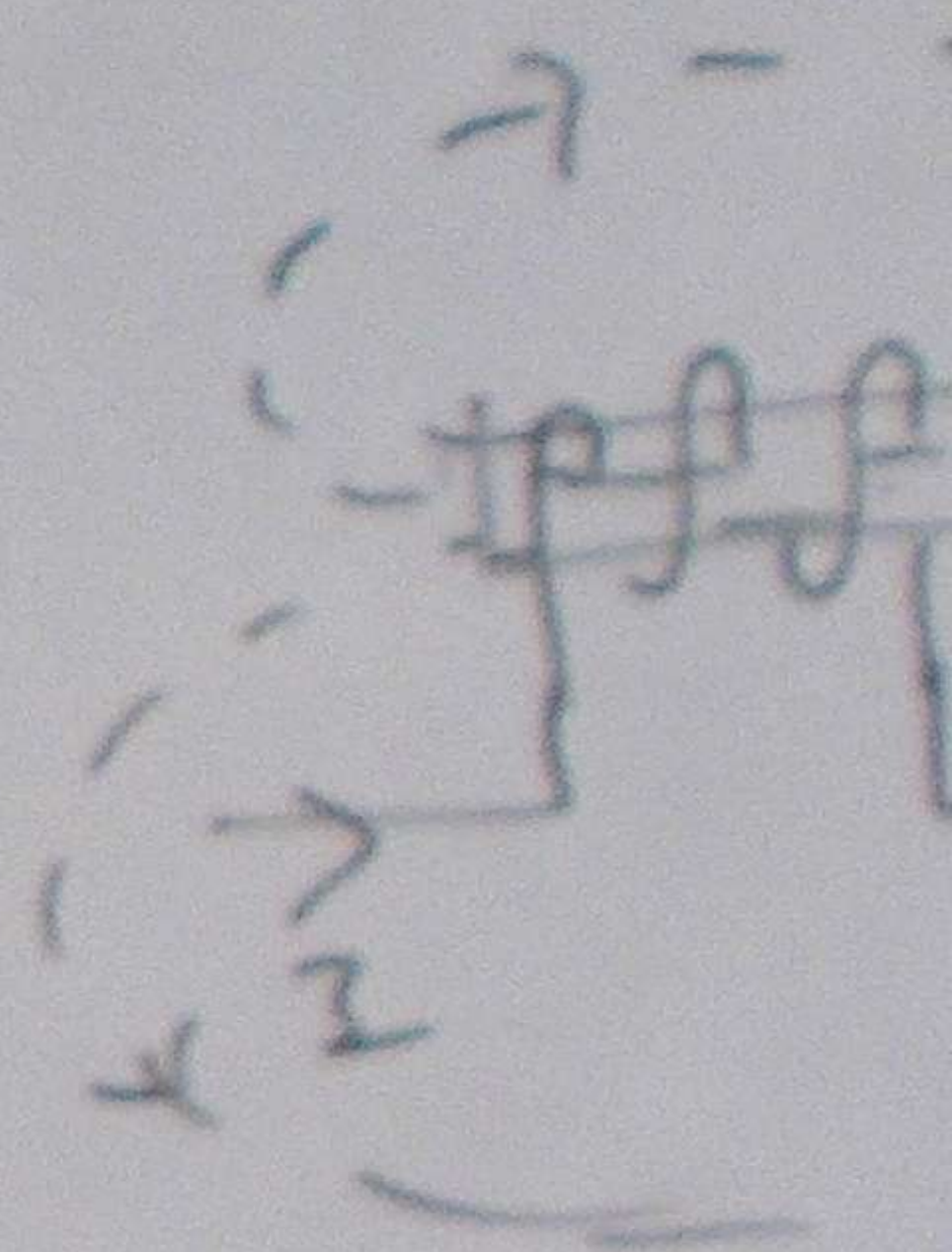
DEFINITION OF POWER

POWER IS THE RATE OF DOING WORK

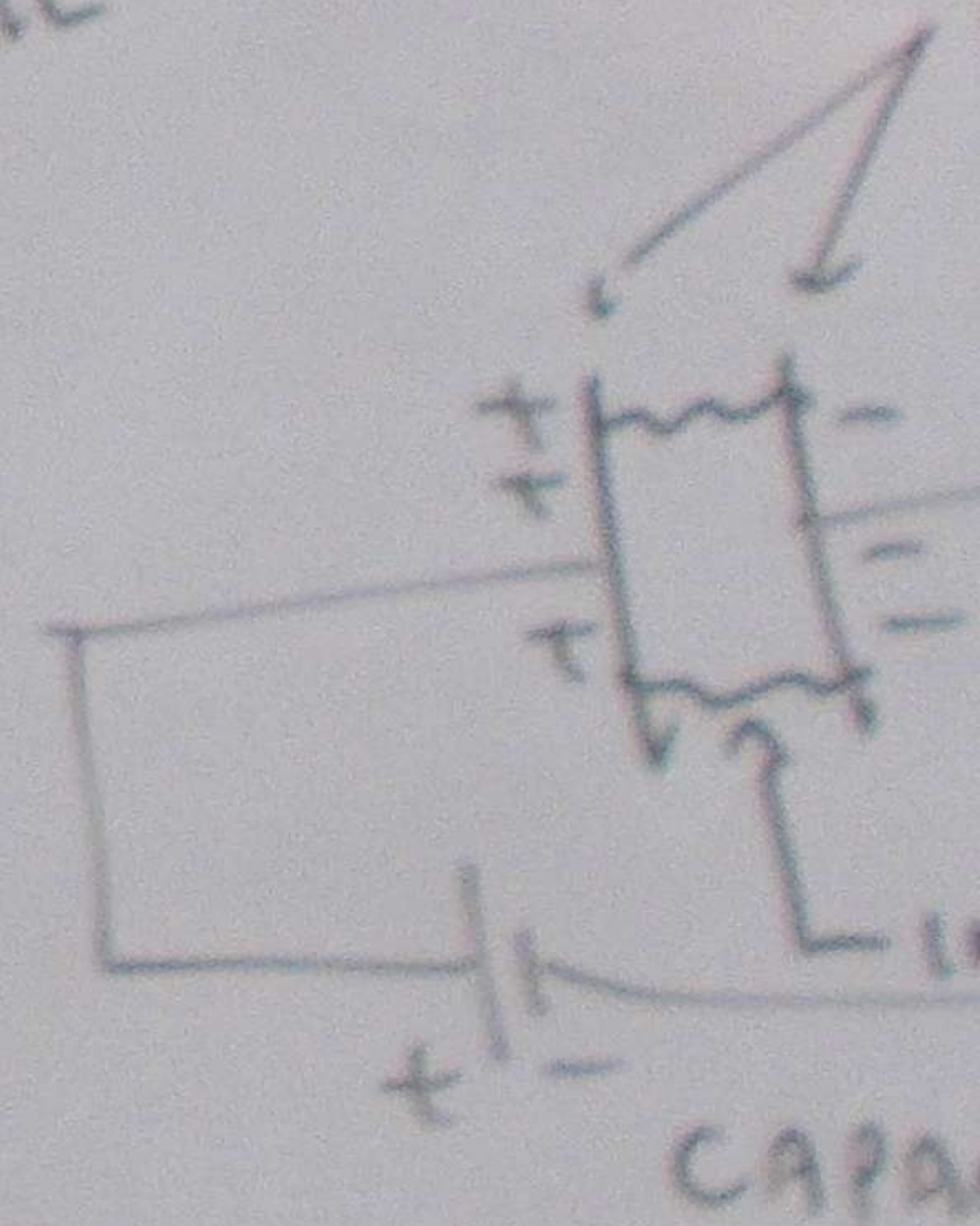
$$\text{POWER (P)} = E \times I = I^2 R = \frac{E^2}{R}$$

R = RESISTANCE

ENERGY STORED IN M

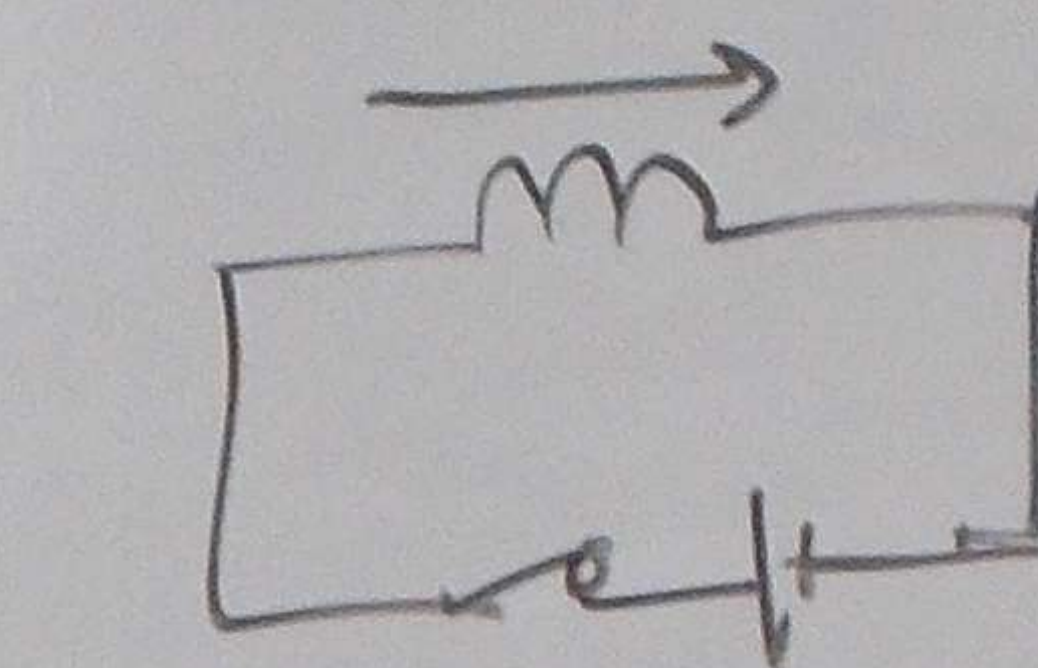
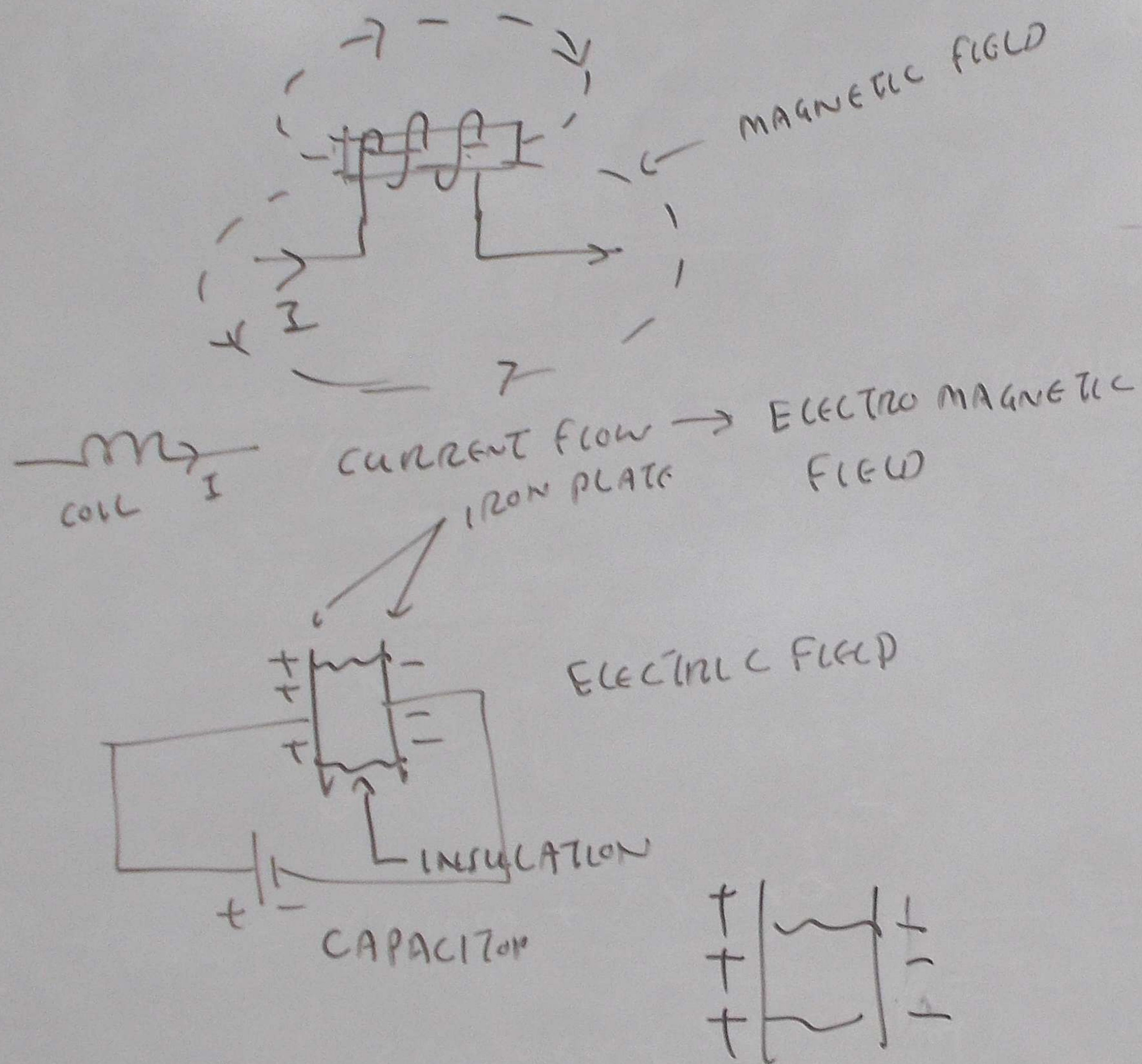


coil I current

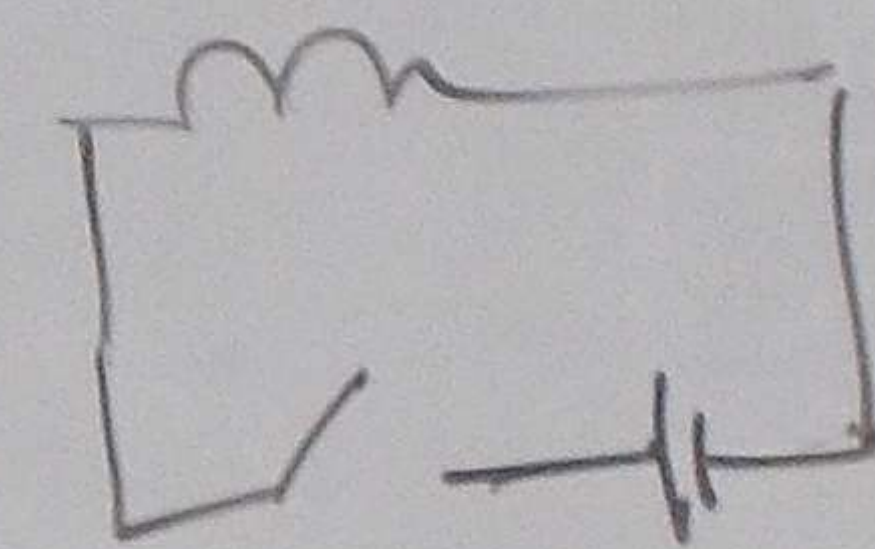


CAPACITOR

ENERGY STORED IN MAGNETIC OR ELECTRIC FIELD



SWITCH ON - IT STORES THE ENERGY IN TERM OF MAGNETIC FIELD



THIS MAGNETIC FIELD FORCES THE CURRENT FLOW

CHARGES CAN ALSO RELEASE THE ELECTRICAL CURRENT

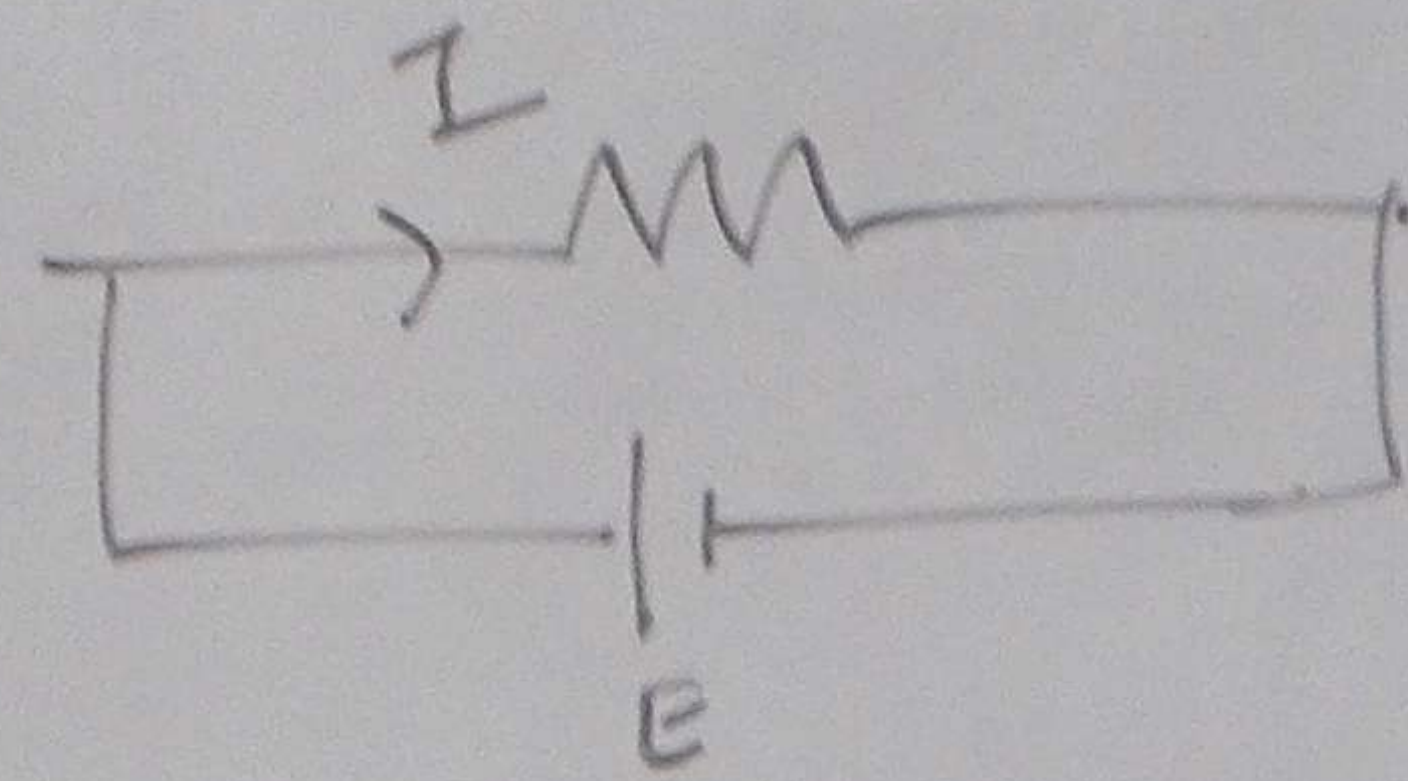
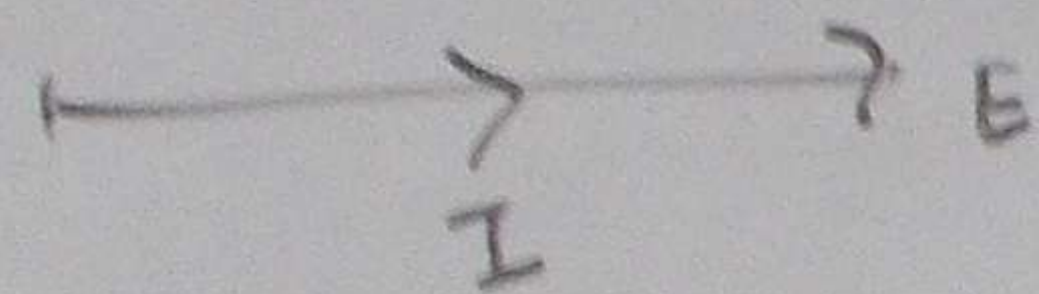
IN DC CIRCUIT, USING R-L AND R-C CIRCUIT, THE ENERGY IS CONSUMED BY THE RESISTOR. SOME ENERGY IS SUPPLIED FROM SOURCE TO ESTABLISH MAGNETIC FIELD IN INDUCTOR (OR) ELECTRIC FIELD IN CAPACITOR.

POWER IN AC CIRCUIT

WHEN A SINUSOIDAL VOLTAGE IS APPLIED TO THE CIRCUIT, THE CURRENT WILL ALSO BE SINUSOIDAL

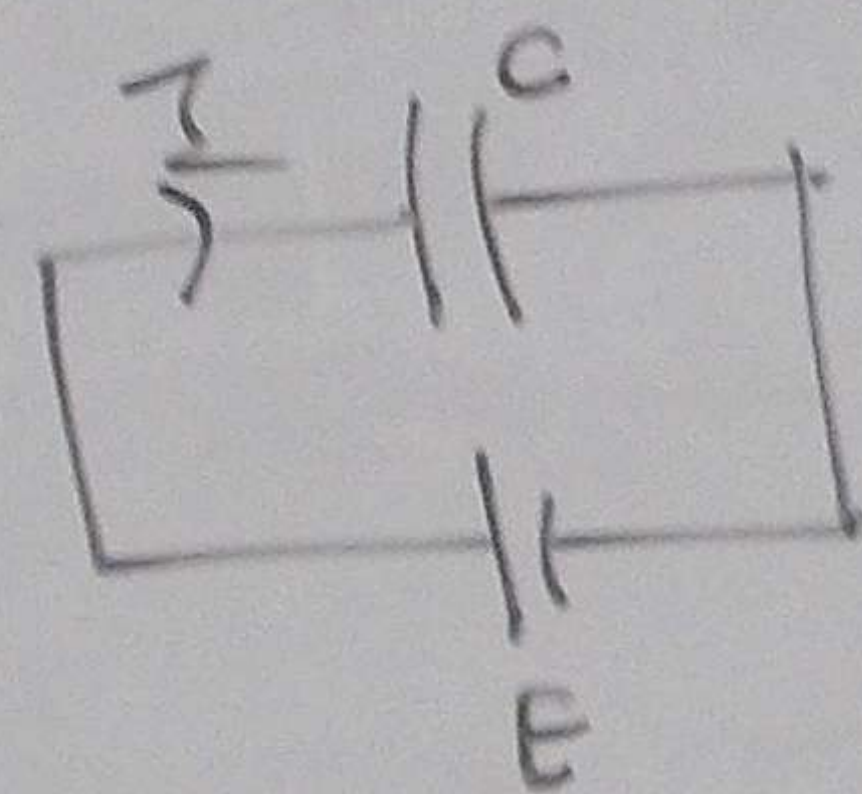
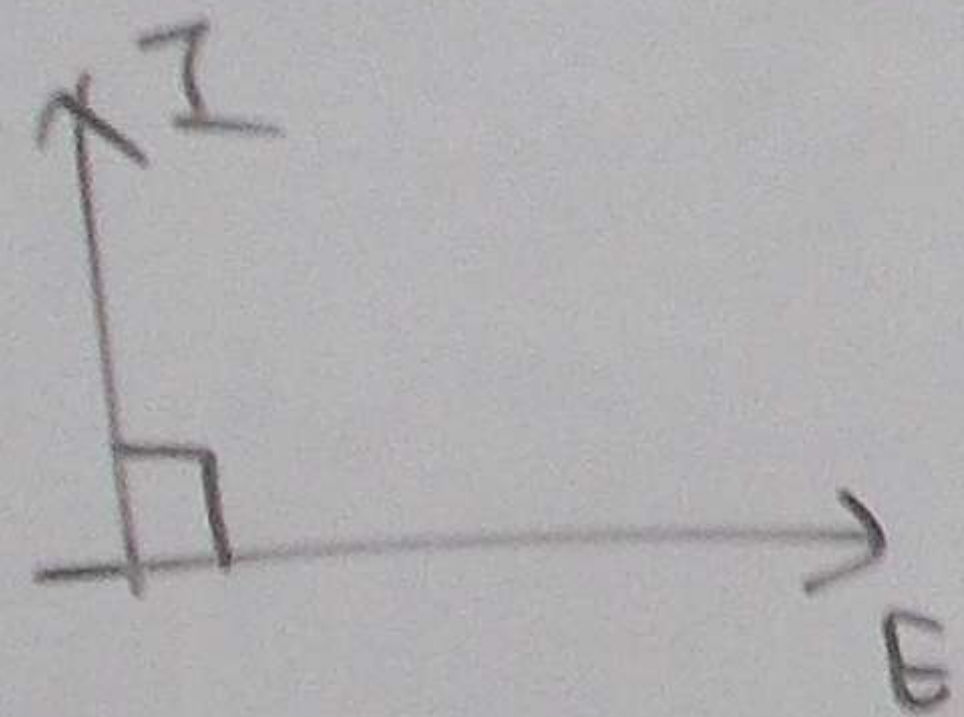
PHASE RELATIONSHIP

PURE RESISTIVE CIRCUIT



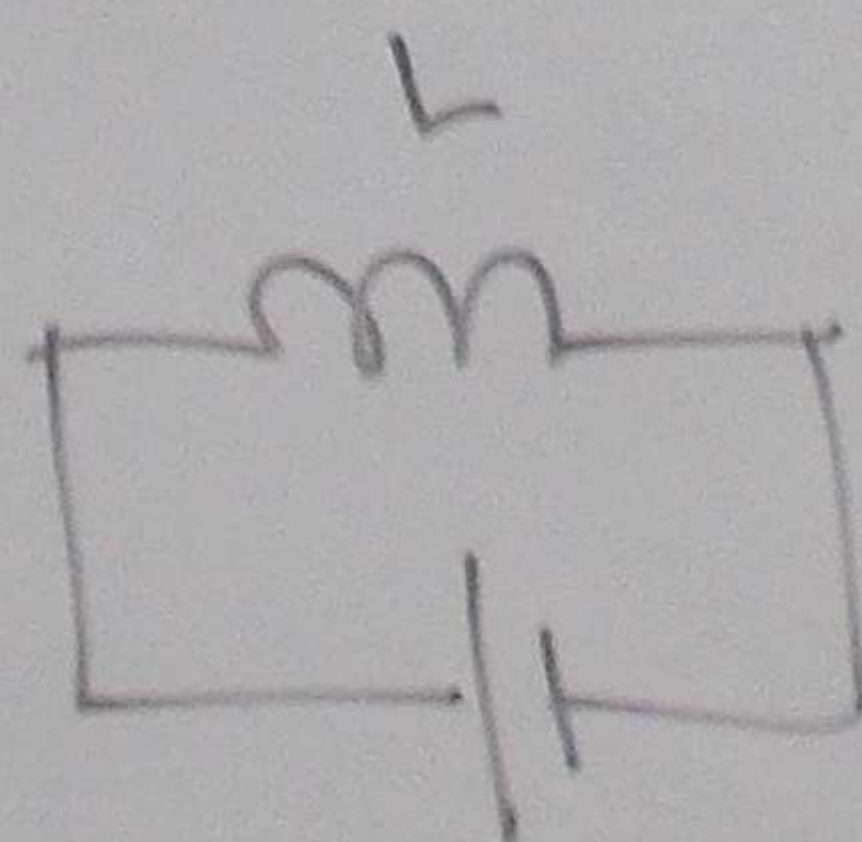
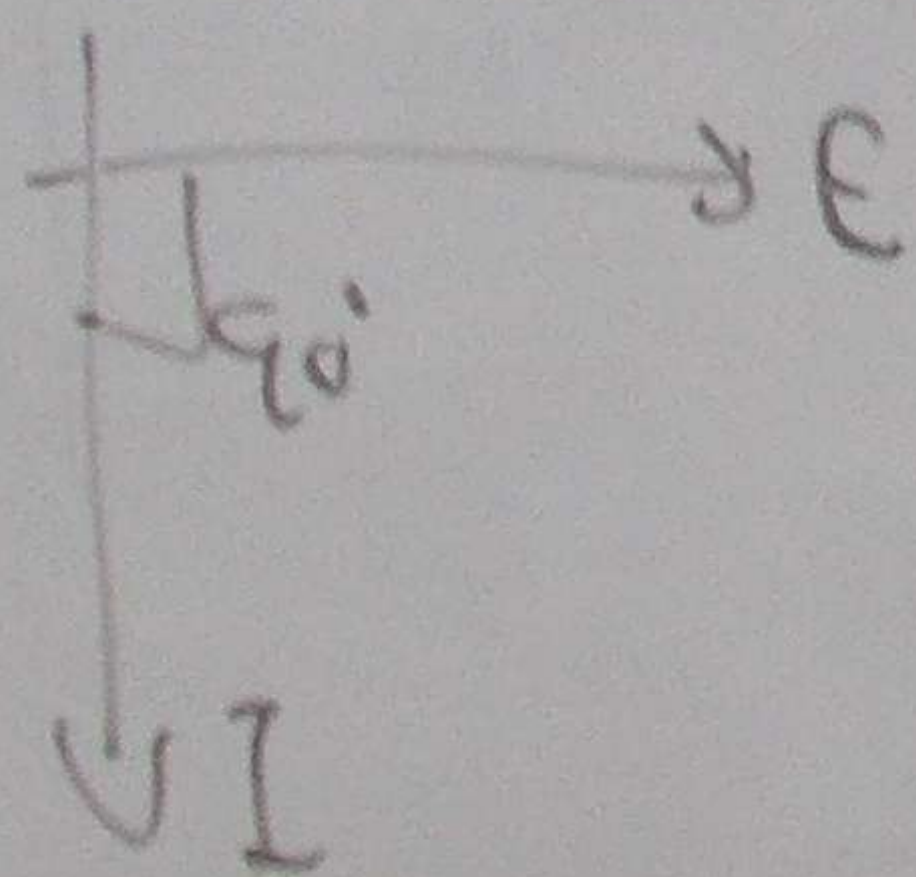
VOLTAGE AND CURRENT
IN PHASE

PURE CAPACITIVE CIRCUIT



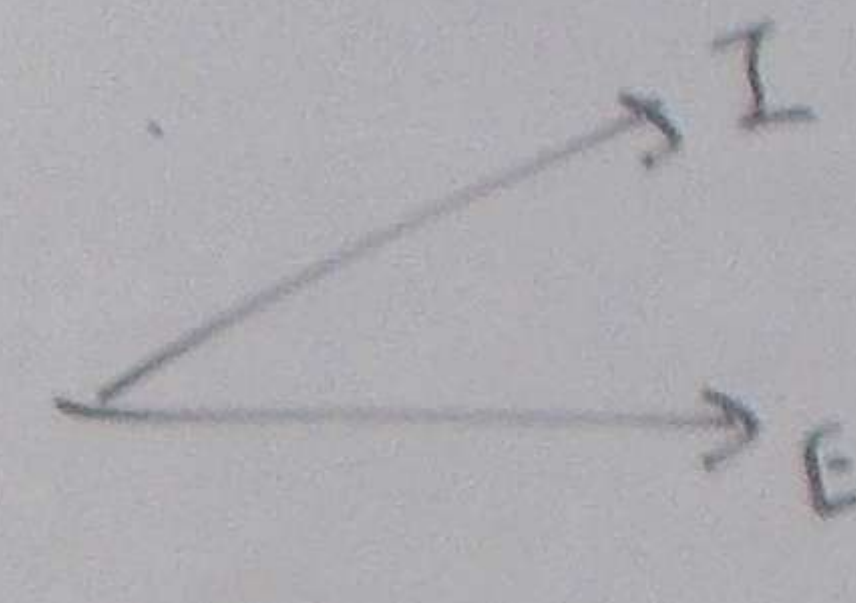
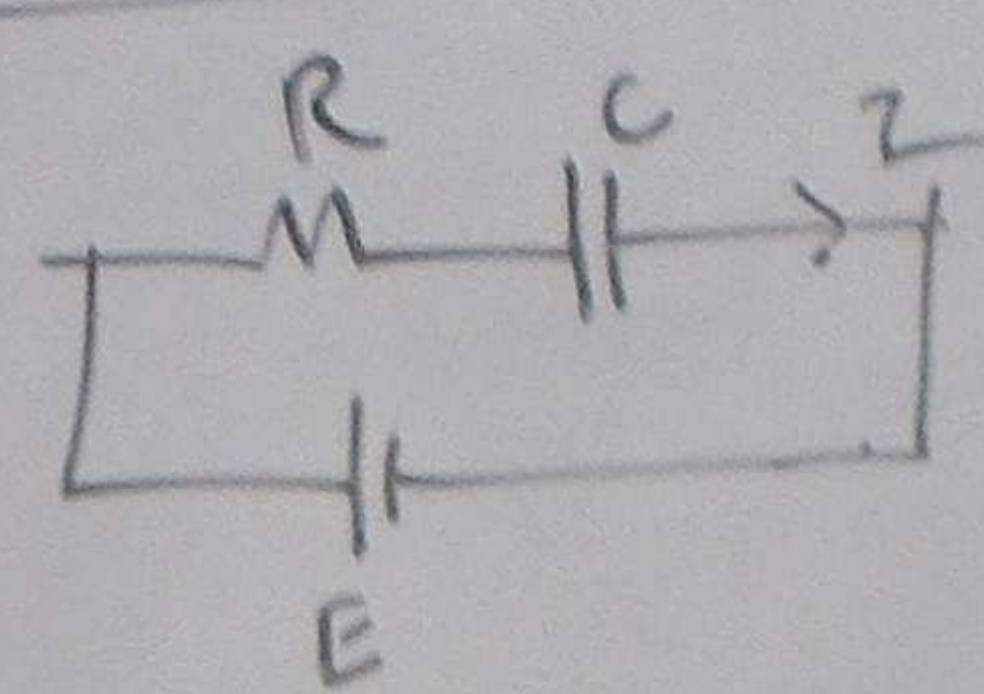
CURRENT LEADS THE
VOLTAGE BY 90°

PURE INDUCTIVE CIRCUIT



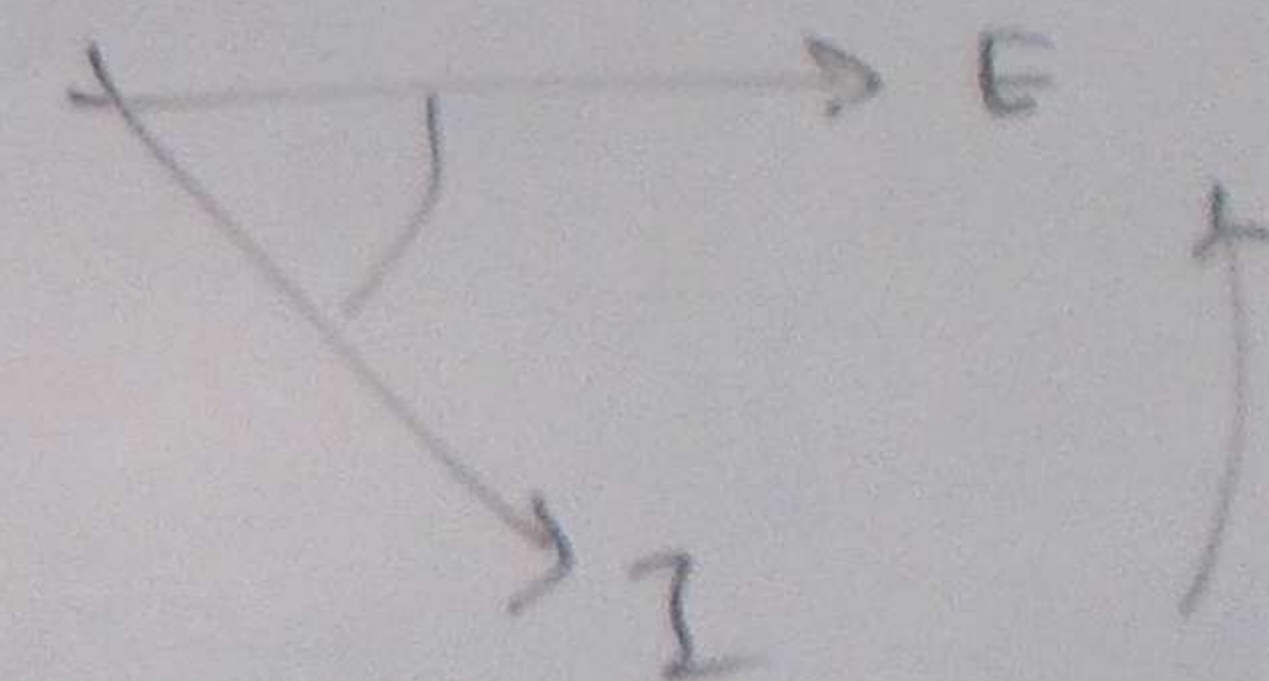
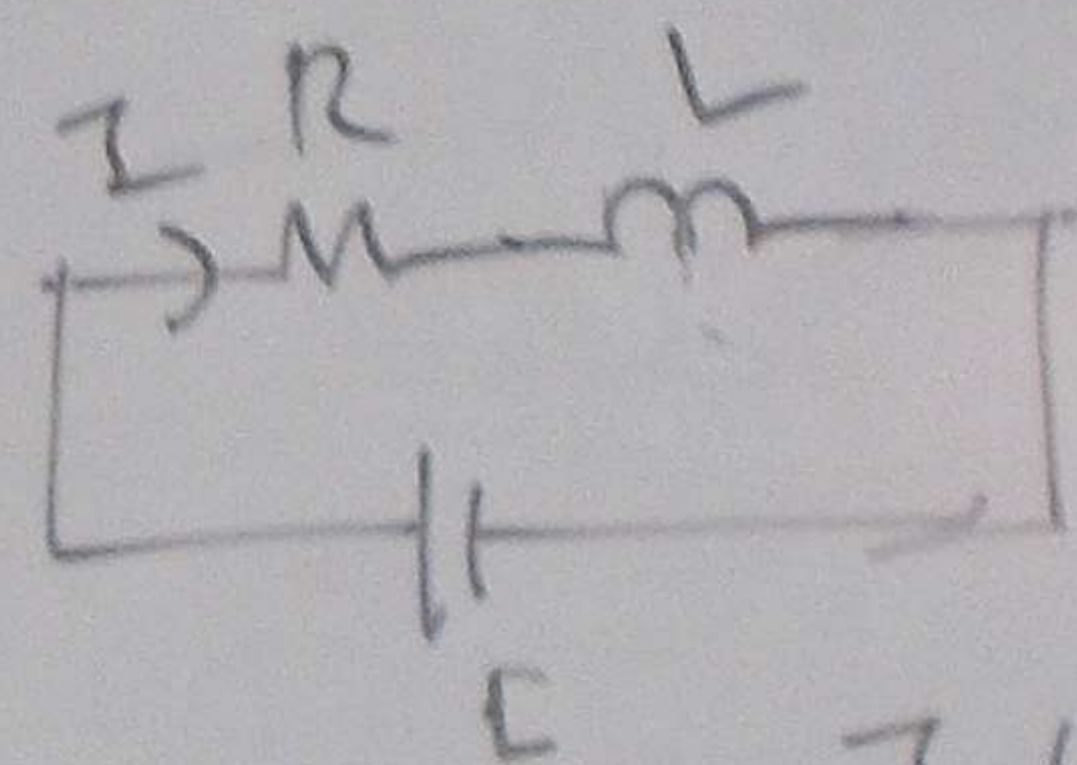
CURRENT LAGS VOLTAGE
BY 90°

RC CIRCUIT



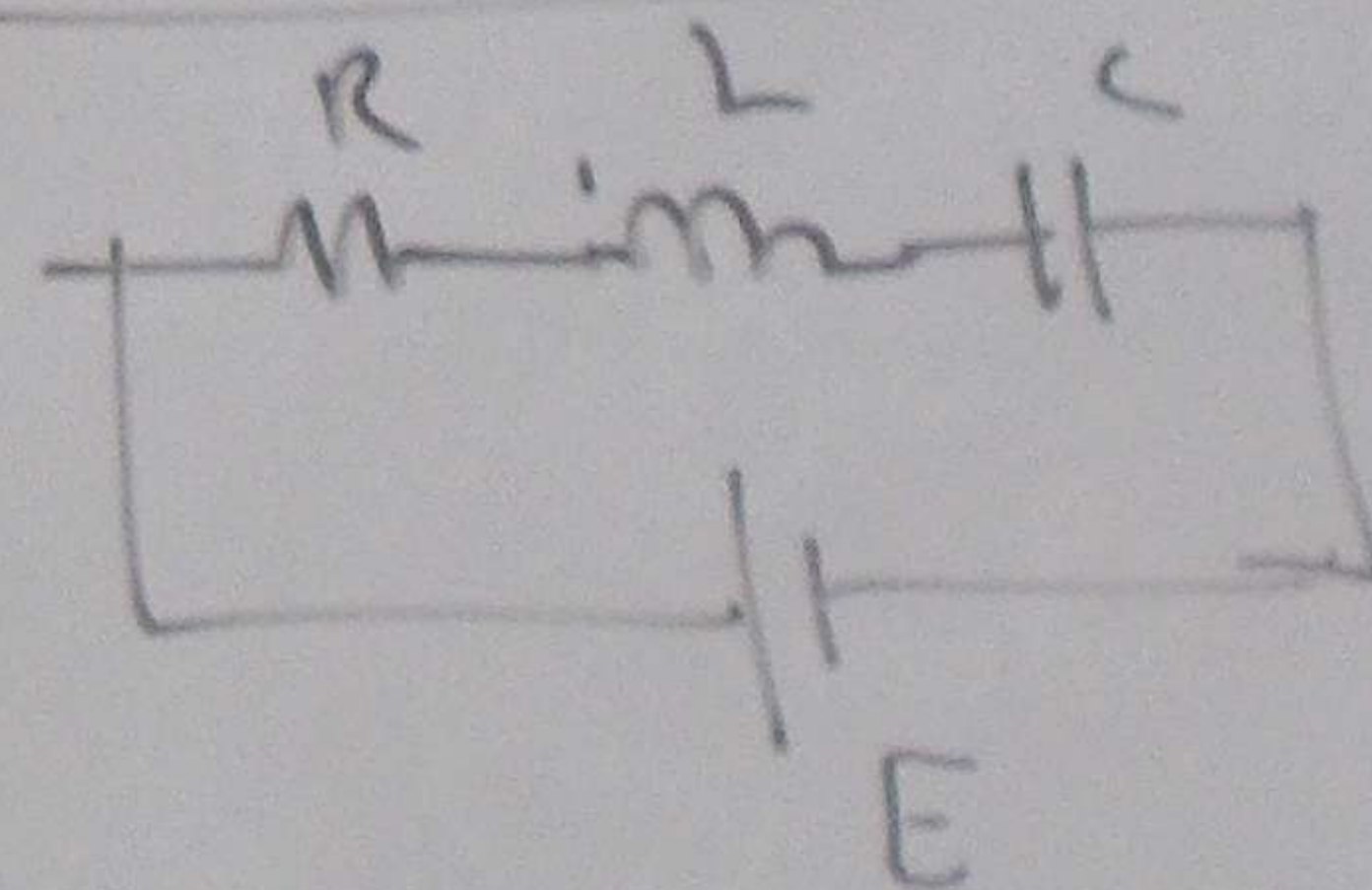
I LEADS E BY BETWEEN 0 AND 90°

RL CIRCUIT



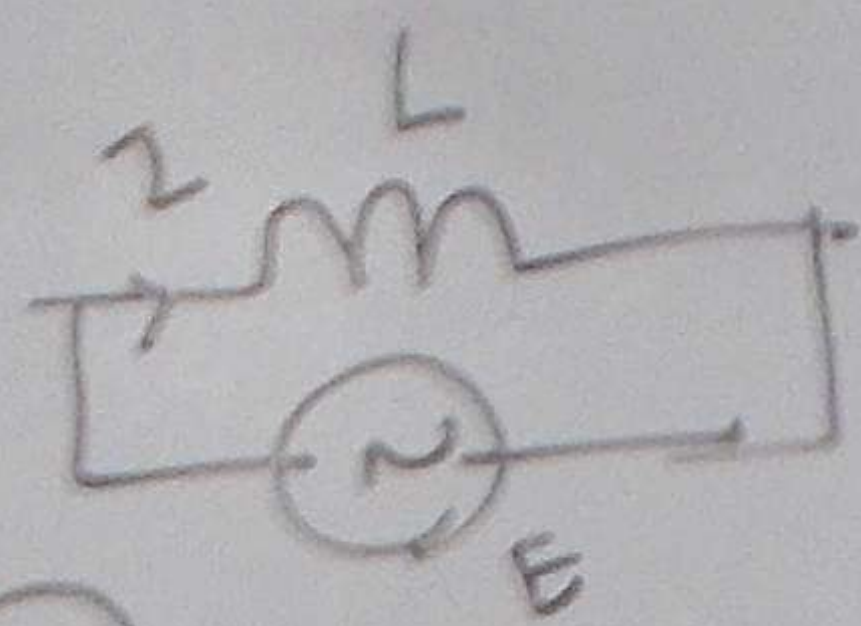
I LAGS E BY BETWEEN 0 AND 90°

RLC CIRCUIT



$X_L > X_C$ - I LAGS E
 $X_C > X_L$ I LEADS E

POWER IN PURE INDUCTIVE AC CIRCUIT



$$e = E_{\max} \sin \omega t \quad \begin{matrix} E_{\max} \\ \text{(TIME-DOMAIN)} \end{matrix}$$

$$= \frac{E_{\max}}{\sqrt{2}} \angle 0 \quad \begin{matrix} \text{(PHASOR-DOMAIN)} \end{matrix}$$

$$\omega = 2\pi f \quad f \rightarrow \text{FREQUENCY (Hz)}$$

$$i = I_{\max} \sin(\omega t - 90^\circ)$$

$$= \frac{I_{\max}}{\sqrt{2}} \angle -90^\circ$$

$$\text{Power} = E_{\max} \sin \omega t \times I_{\max} \sin(\omega t - 90^\circ)$$

$$= E_{\max} \sin \omega t \times I_{\max} [\sin \omega t \cos 90^\circ - \cos \omega t \sin 90^\circ]$$

$$\sin(A-B) = \sin A \cos B - \cos A \sin B$$

$$= E_{\max} \sin \omega t \times I_{\max} (-\cos \omega t)$$

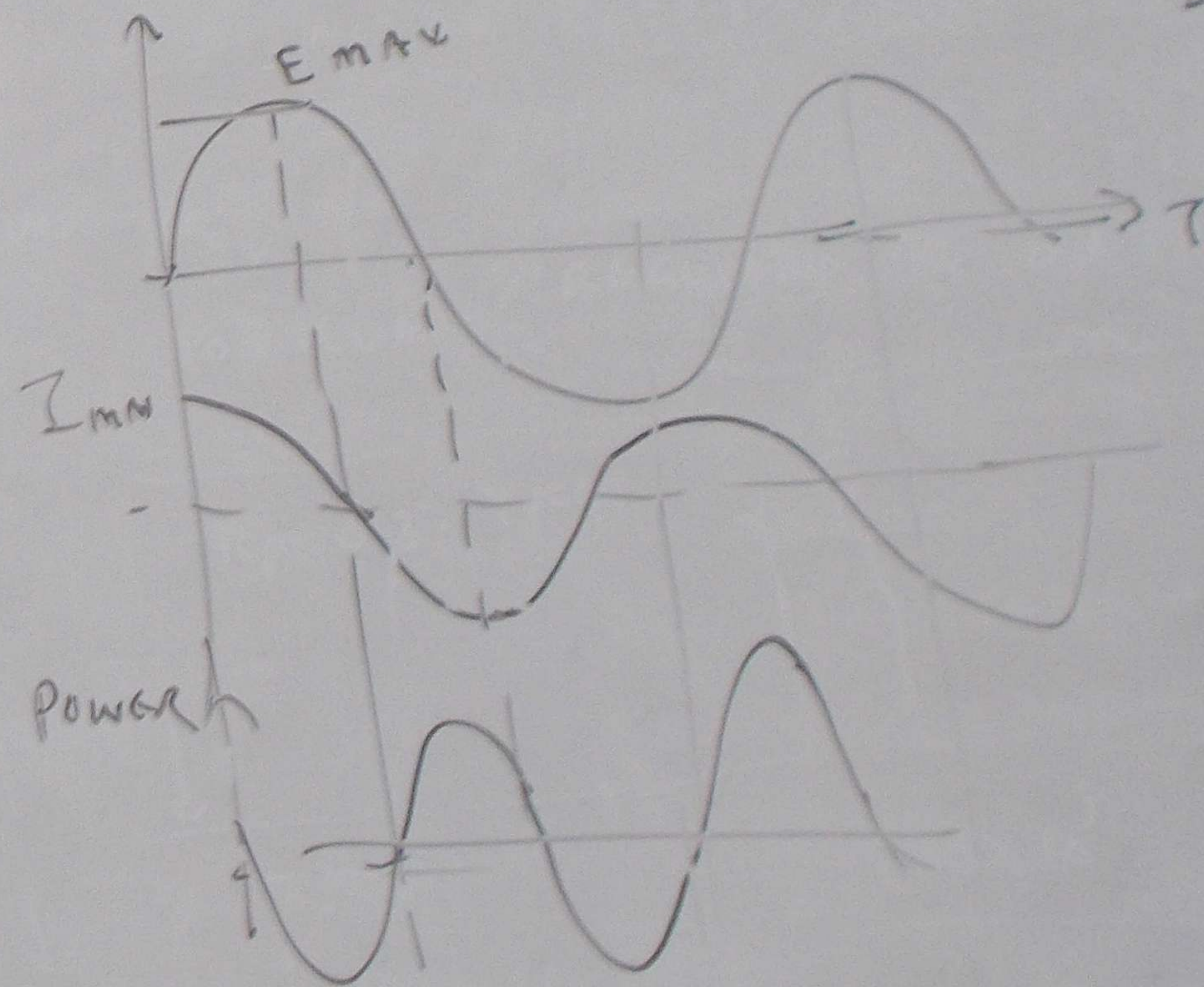
$$\text{Power} = -E_{\max} I_{\max} \sin \omega t \cos \omega t$$

$$\sin 2A = 2 \sin A \cos A$$

$$\sin 2\omega t = 2 \sin \omega t \cos \omega t$$

$$\sin \omega t \cos \omega t = \frac{\sin 2\omega t}{2}$$

$$\text{Power} = -\frac{1}{2} E_{\max} I_{\max} \sin 2\omega t$$



$$E_{\max} = +$$

$$I_{\max} = +$$

$$\text{Power} = -$$

$$E_{\max} = +$$

$$I_{\max} = -$$

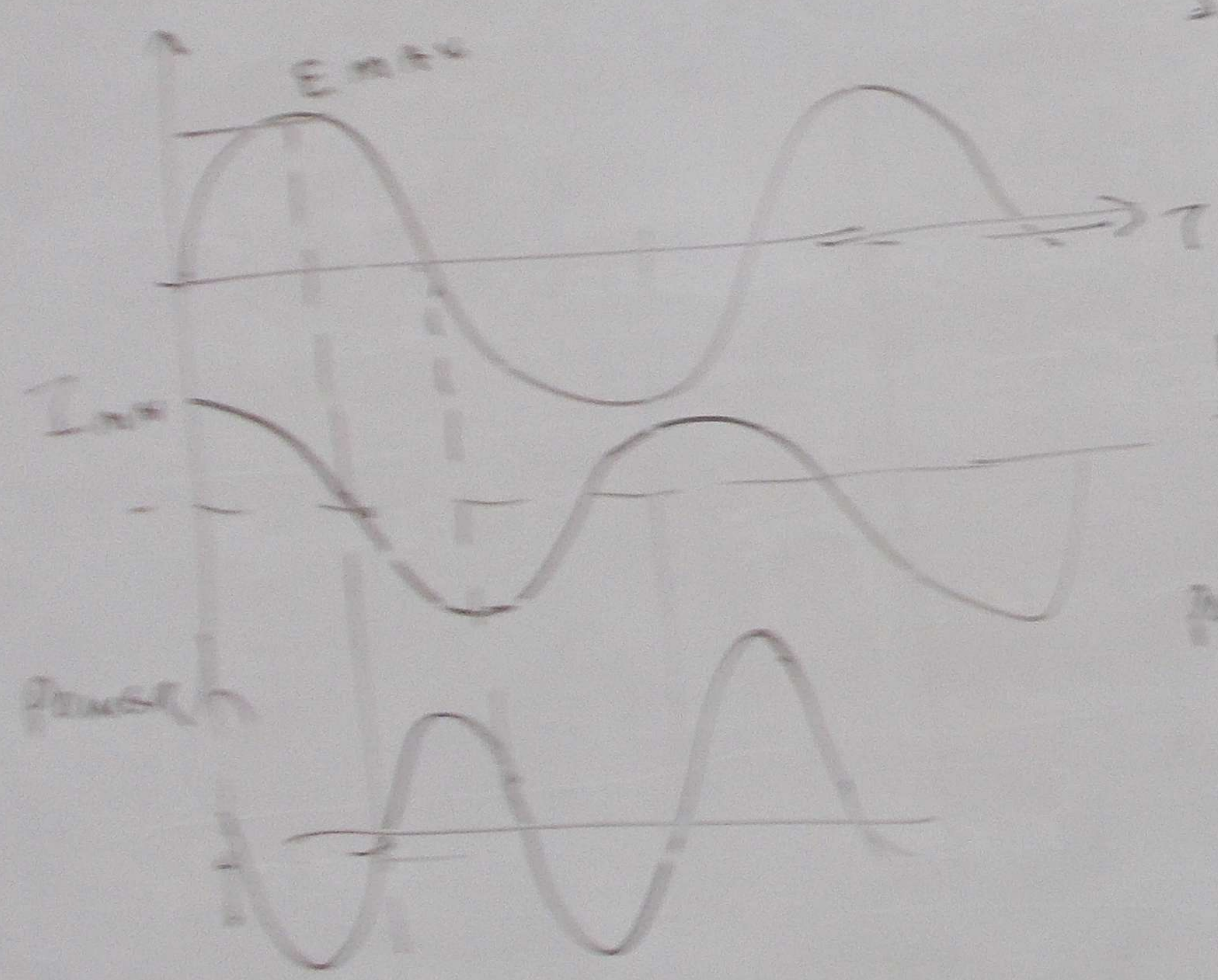
$$\text{Power} = +$$

$$\sin 2\theta = 2 \sin \theta \cos \theta$$

$$\sin 2\omega t = 2 \sin \omega t \cos \omega t$$

$$\sin \omega t \cos \omega t = \frac{\sin 2\omega t}{2}$$

$$Power = -\frac{1}{2} E_{max} I_{max} \sin 2\omega t$$



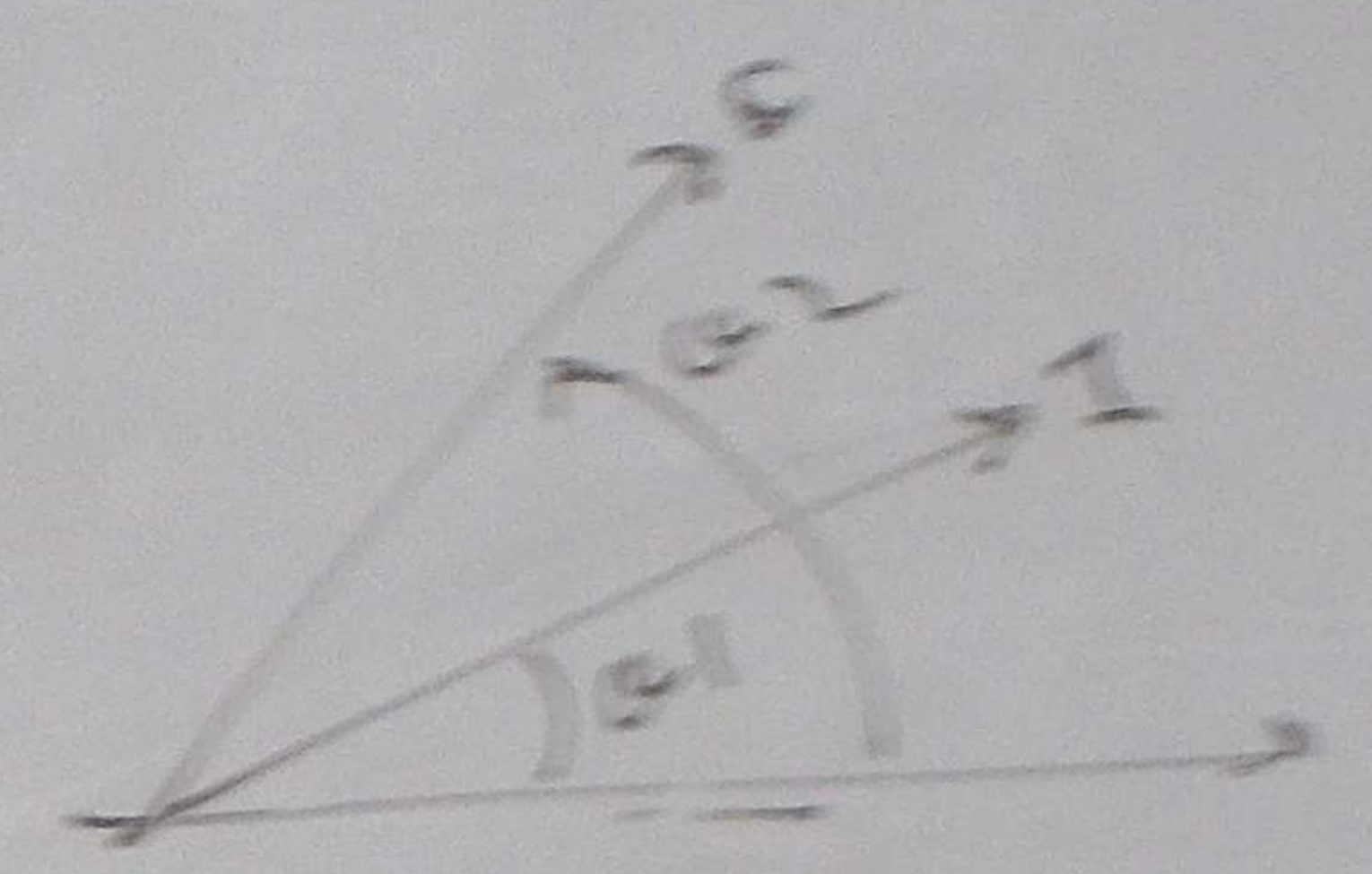
$E_{max} = +$
 $I_{max} = +$
 $Power = -$

$E_{max} = +$
 $I_{max} = -$

$Power = +!$

$$P = e I \cos \theta$$

$$P = \frac{E_{max} I_{max}}{2} \cos \theta$$



$$\theta_1 = \theta_2 - \theta_1$$

$$P = \frac{E_{max} I_{max}}{2} \cos (\theta_2 - \theta_1)$$

$$\theta = \frac{E_{max}}{I_{max}}$$

$$\theta = \frac{I_{max}}{E_{max}}$$

$$eI = \frac{E_{max} I_{max}}{2}$$

$$Power = -\frac{1}{2} E_{max} I_{max}$$

$$= -\frac{E_{max}}{2} \frac{I_{max}}{2}$$

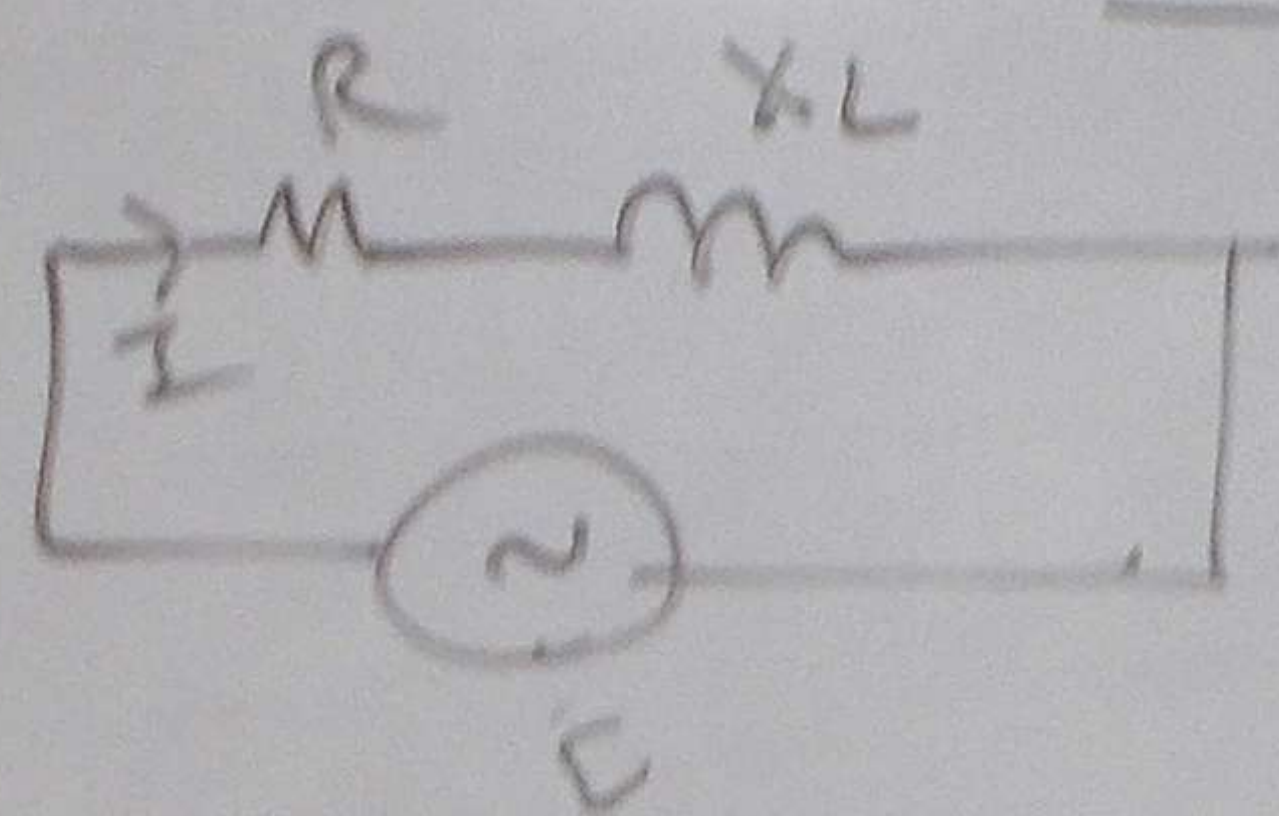
$$= -\frac{E_{max} I_{max}}{4}$$

Take only
 magnitude

POWER TRIANGLE

INDUCTIVE CIRCUIT

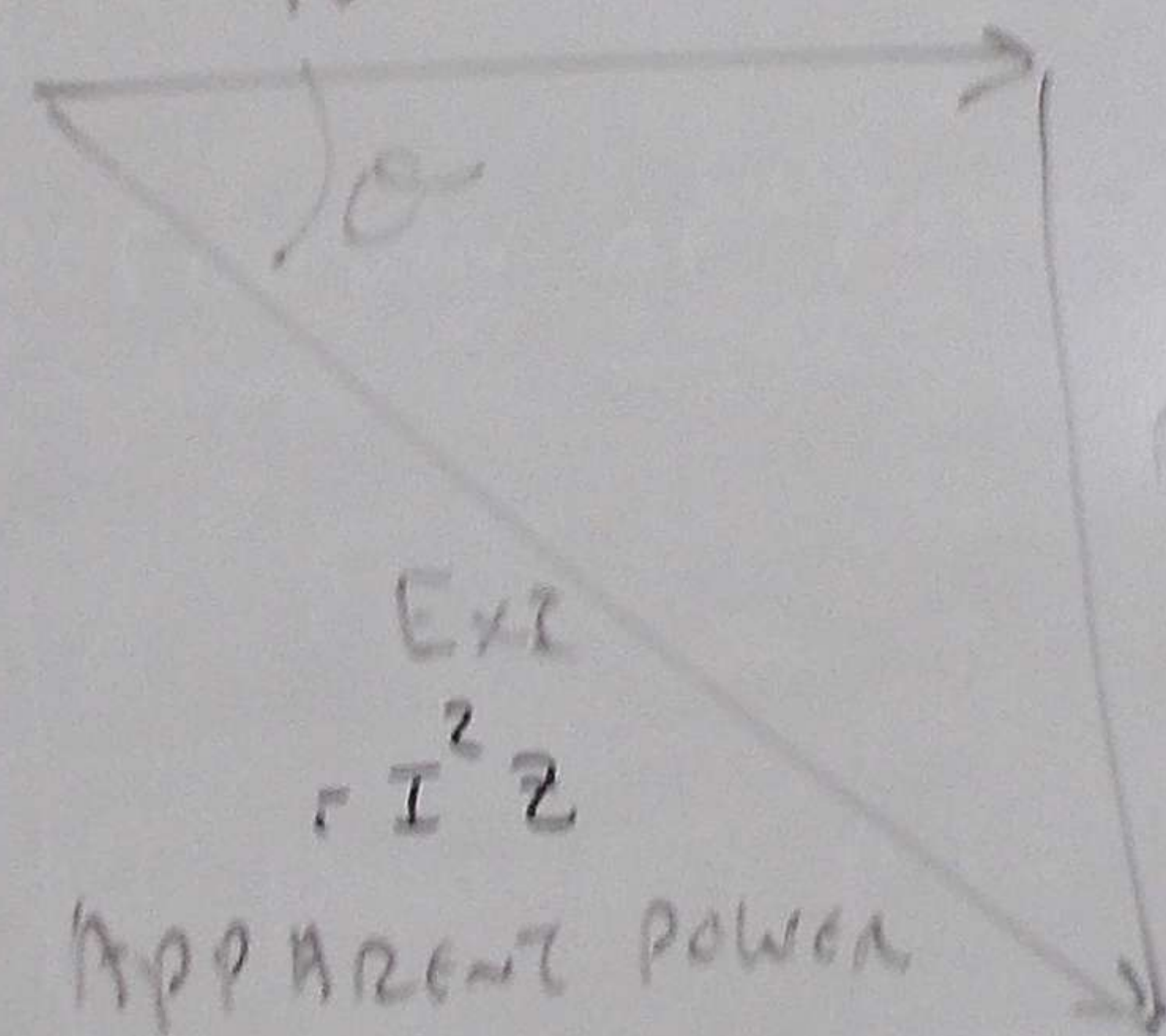
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$E \Rightarrow \text{RMS}$
 $I \Rightarrow \text{RMS}$

$$\text{REAL POWER} = (P) = E I \cos \phi \quad (\text{WATT})$$

$$= I^2 R$$



$$E \times I$$

$$= I^2 Z$$

APPARENT POWER

$$(S) = E I$$

(V.A)

$$\text{REACTIVE POWER} = E I \sin \phi$$

(Q) (VAR)

$$= I^2 X$$

$$\text{POWER FACTOR} = \cos \phi$$

LAGGING

R = RESISTANCE

$$X = \text{INDUCTIVE REACTANCE} = 2\pi f L$$

Z = IMPEDANCE

$$Z = \sqrt{R^2 + X^2}$$

$$P = \sqrt{3} E_L I_L \cos \phi = 3 I^2 R$$

$E_L = \text{LINE VOLTAGE}$

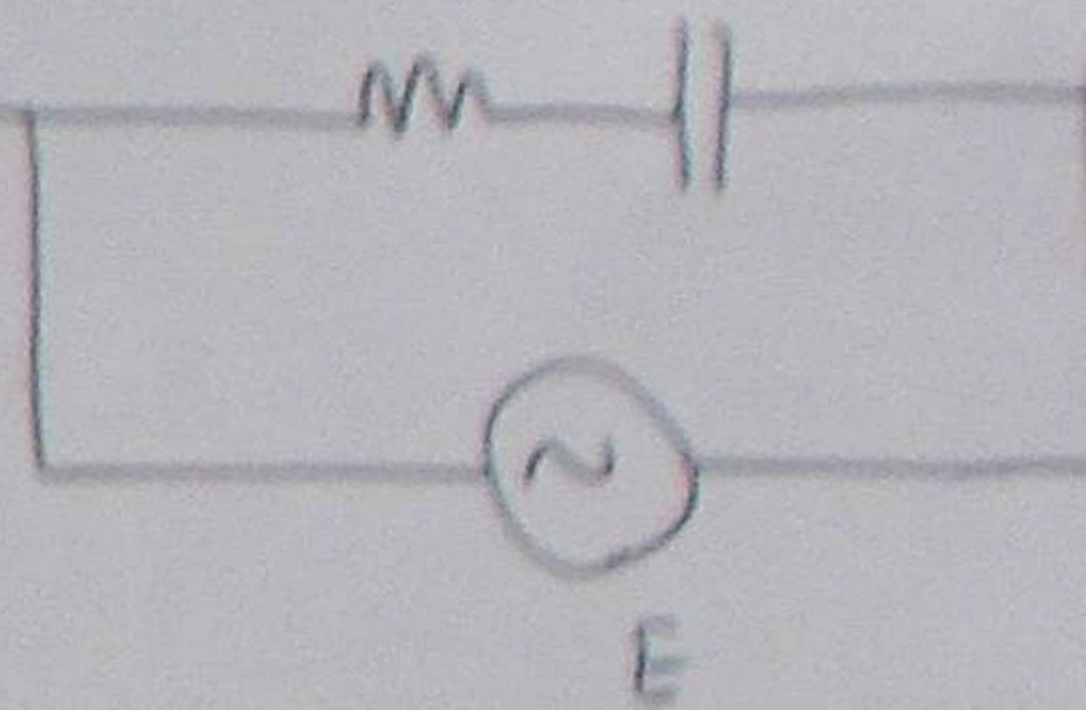
$I_L = \text{LINE CURRENT}$

$$S = \sqrt{3} E_L I_L = 3 I^2 Z$$

$$Q = \sqrt{3} E_L I_L \sin \phi$$

$$= 3 I^2 X$$

CAPACITIVE CIRCUIT



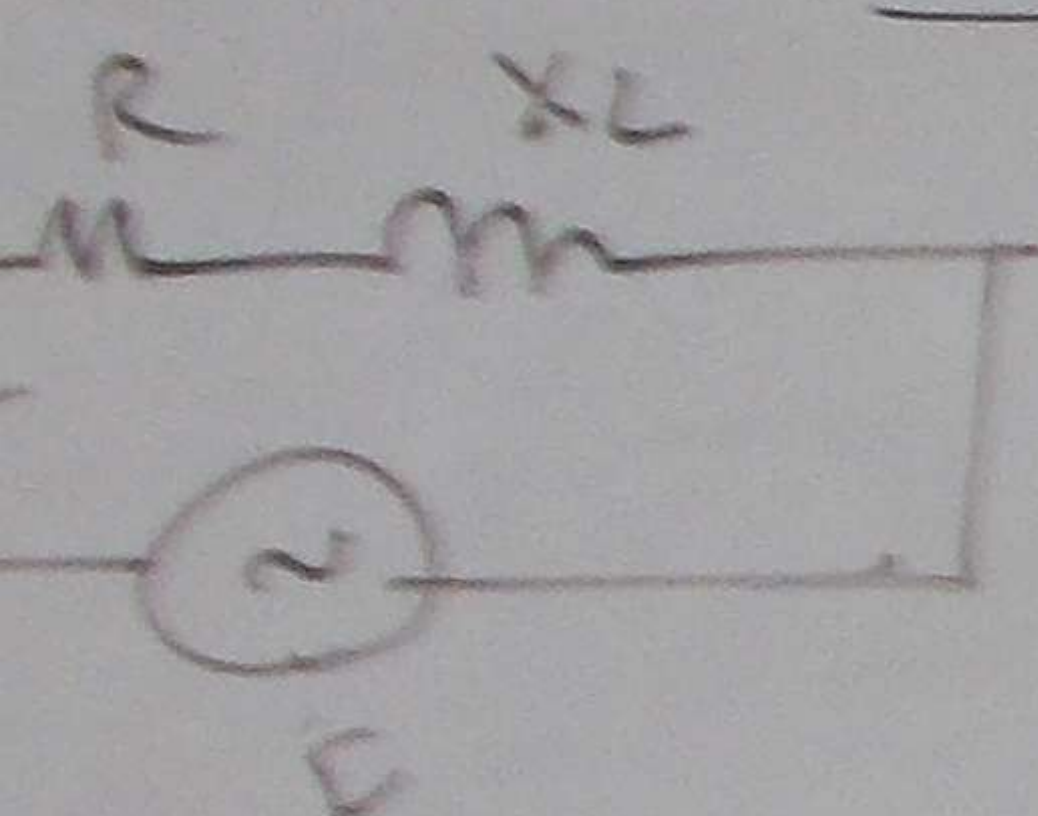
$$\text{APPARENT POWER (S)} = E I \cos \phi$$

Real power (P)

POWER FACTOR

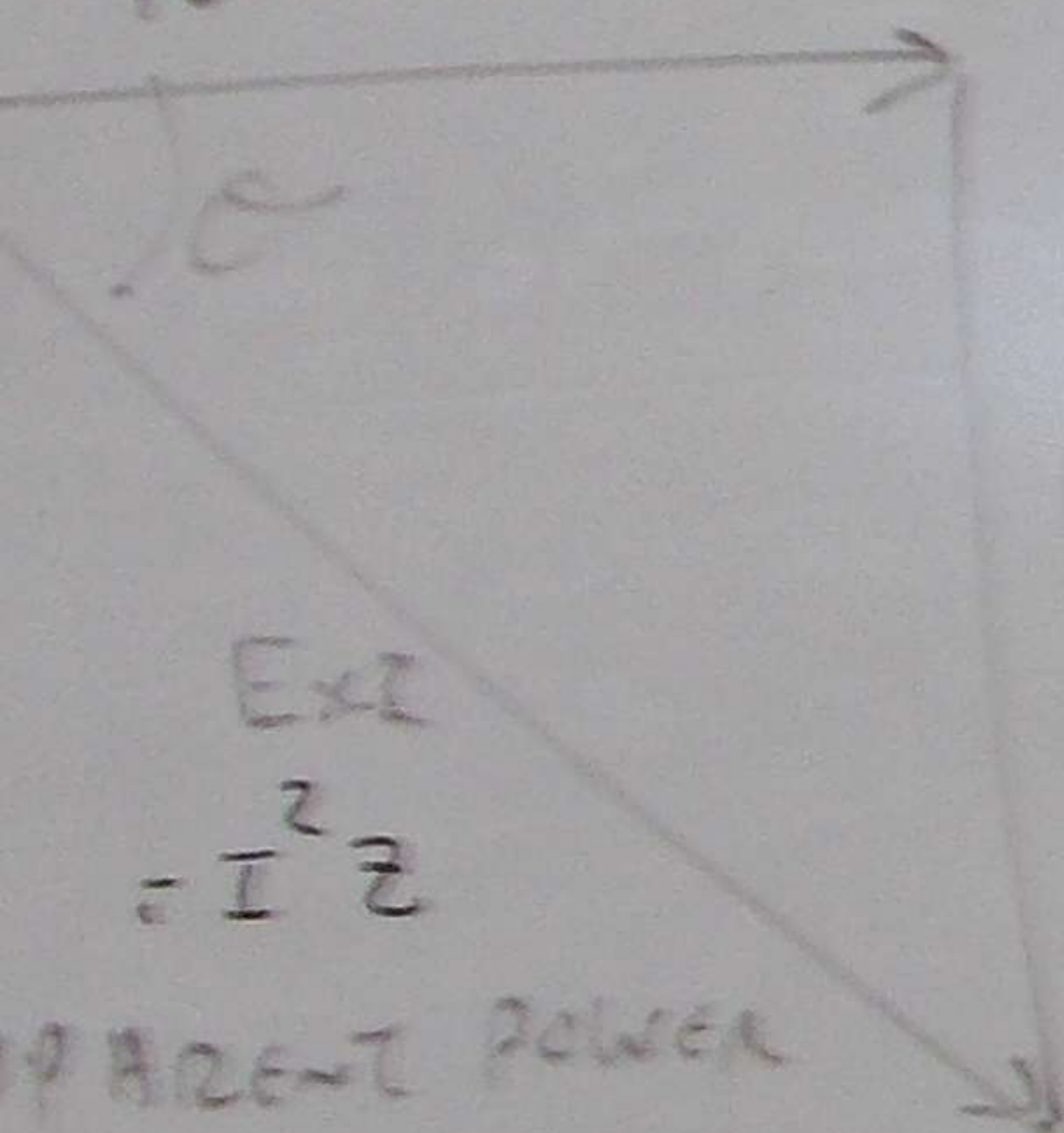
POWER TRIANGLES

INDUCTIVE CIRCUIT



$E \Rightarrow \text{RMS}$
 $I \Rightarrow \text{RMS}$

REAL POWER $(P) = EI \cos \phi$ (WATT)
 $= I^2 R$



REACTIVE POWER $(Q) = EI \sin \phi$ (VAR)
 $= I^2 X$

APPARENT POWER $(S) = EI$ (V.A)

POWER FACTOR $= \cos \phi$

LAGGING

$R = \text{RESISTANCE}$

$X = \text{INDUCTIVE REACTANCE} = 2\pi fL$

$Z = \text{IMPEDANCE}$

$$Z = \sqrt{R^2 + X^2}$$

$$P = \sqrt{3} E_L I_L \cos \phi = 3 I^2 R$$

$E_L = \text{LINE VOLTAGE}$

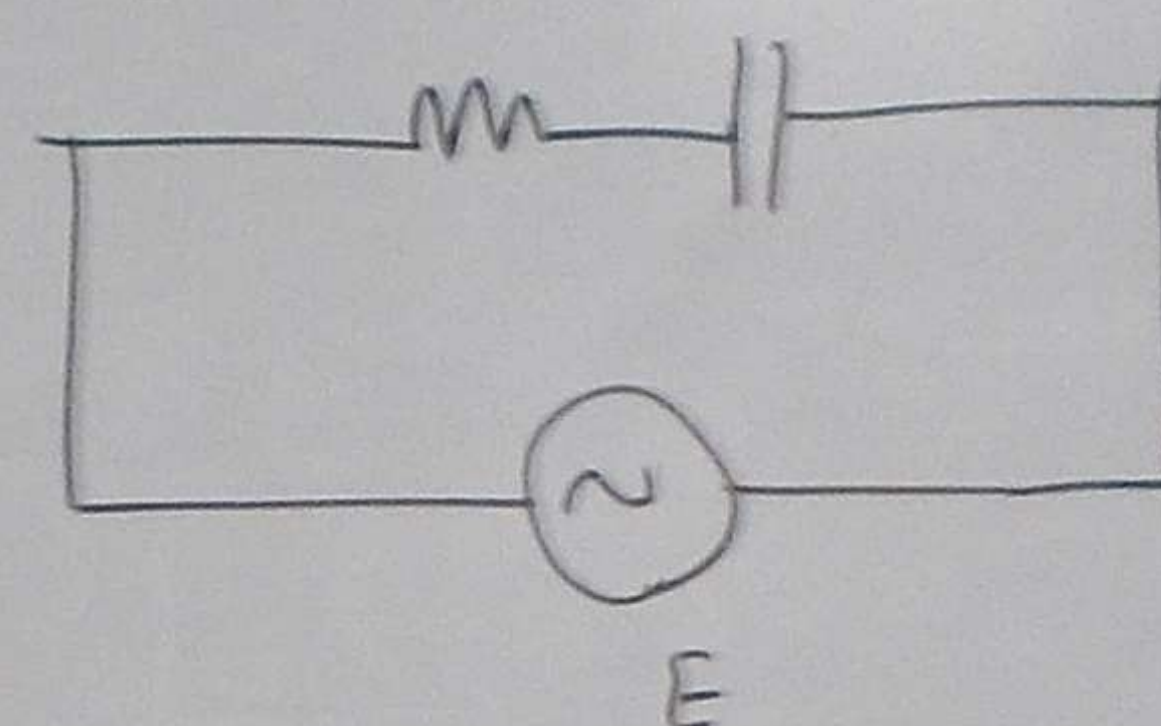
$I_L = \text{LINE CURRENT}$

$$S = \sqrt{3} E_L I_L = 3 I^2 Z$$

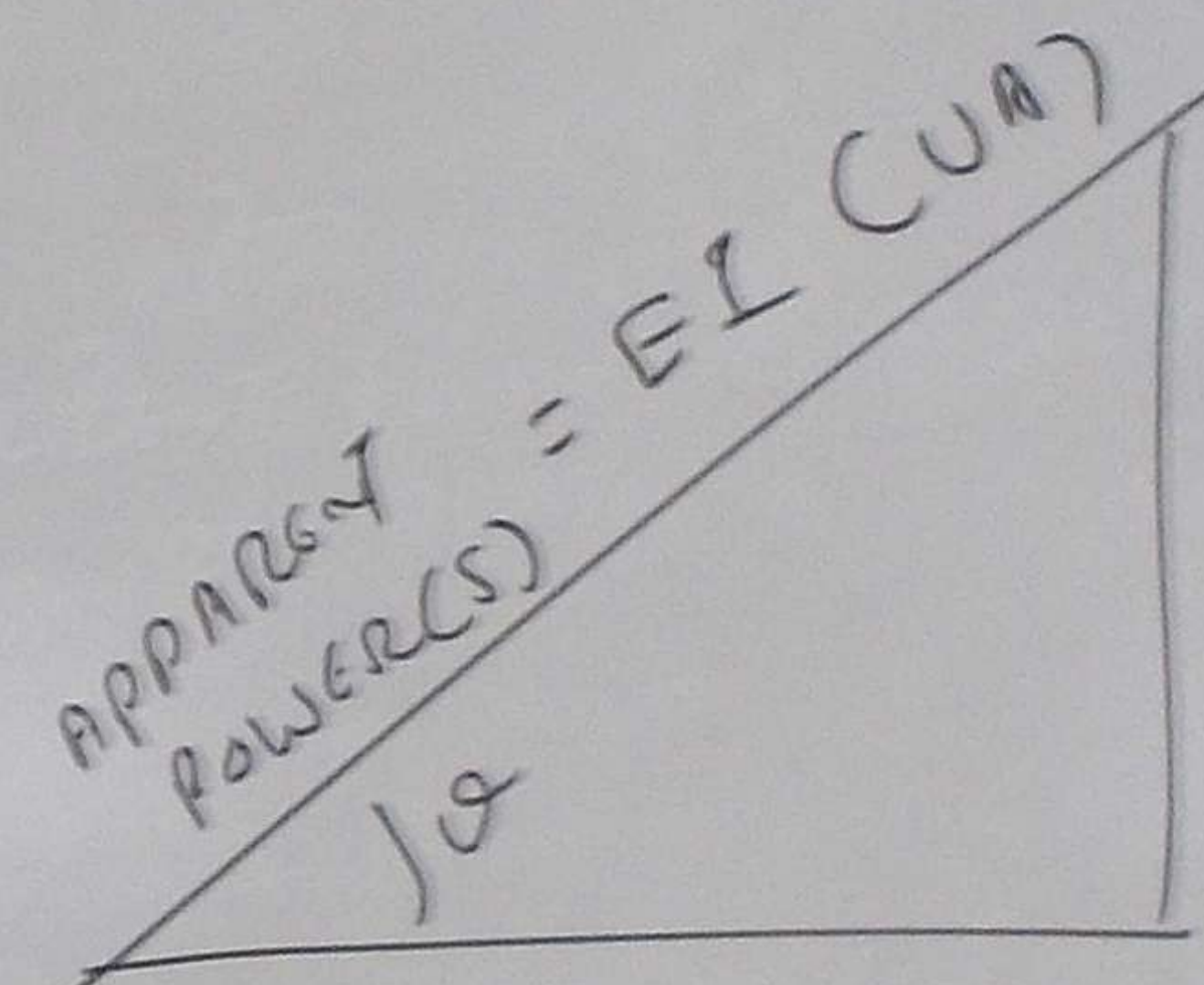
$$Q = \sqrt{3} E_L I_L \sin \phi = 3 I^2 X$$

$L = \text{INDUCTANCE}$ (H)

CAPACITIVE CIRCUIT



$E (\text{RMS})$
 $I (\text{RMS})$



REACTIVE POWER $(Q) = EI \sin \phi$ (VAR)

REAL POWER $(P) = EI \cos \phi$ (WATT)

POWER FACTOR $= \cos \phi = \text{LEADING}$

pb

A CIRCUIT CONSISTS OF A 60Ω

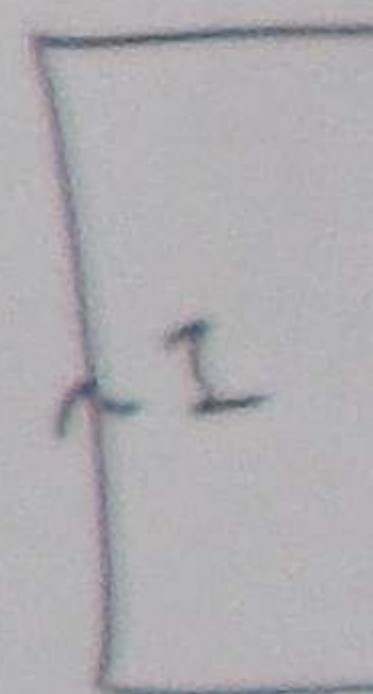
CALCULATE THE

(a) THE APPARENT

(b) THE TRUE

(c) THE REACTIVE

(d) THE POWER



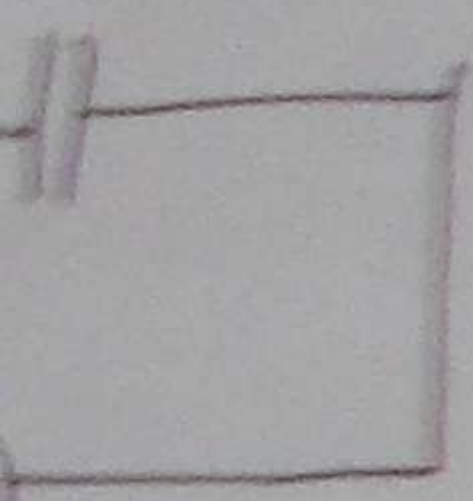
(a) APPARENT

(b) TRUE

(c) REACTIVE

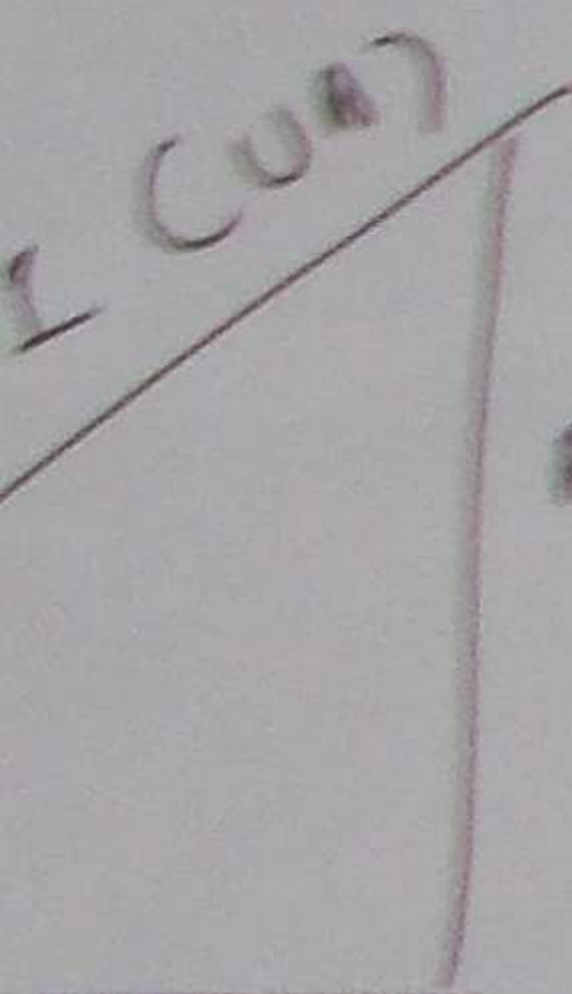
(d) POWER

REACTIVE CIRCUIT



E (RMS)

I (RMS)



REACTIVE POWER (Q) (VAR)

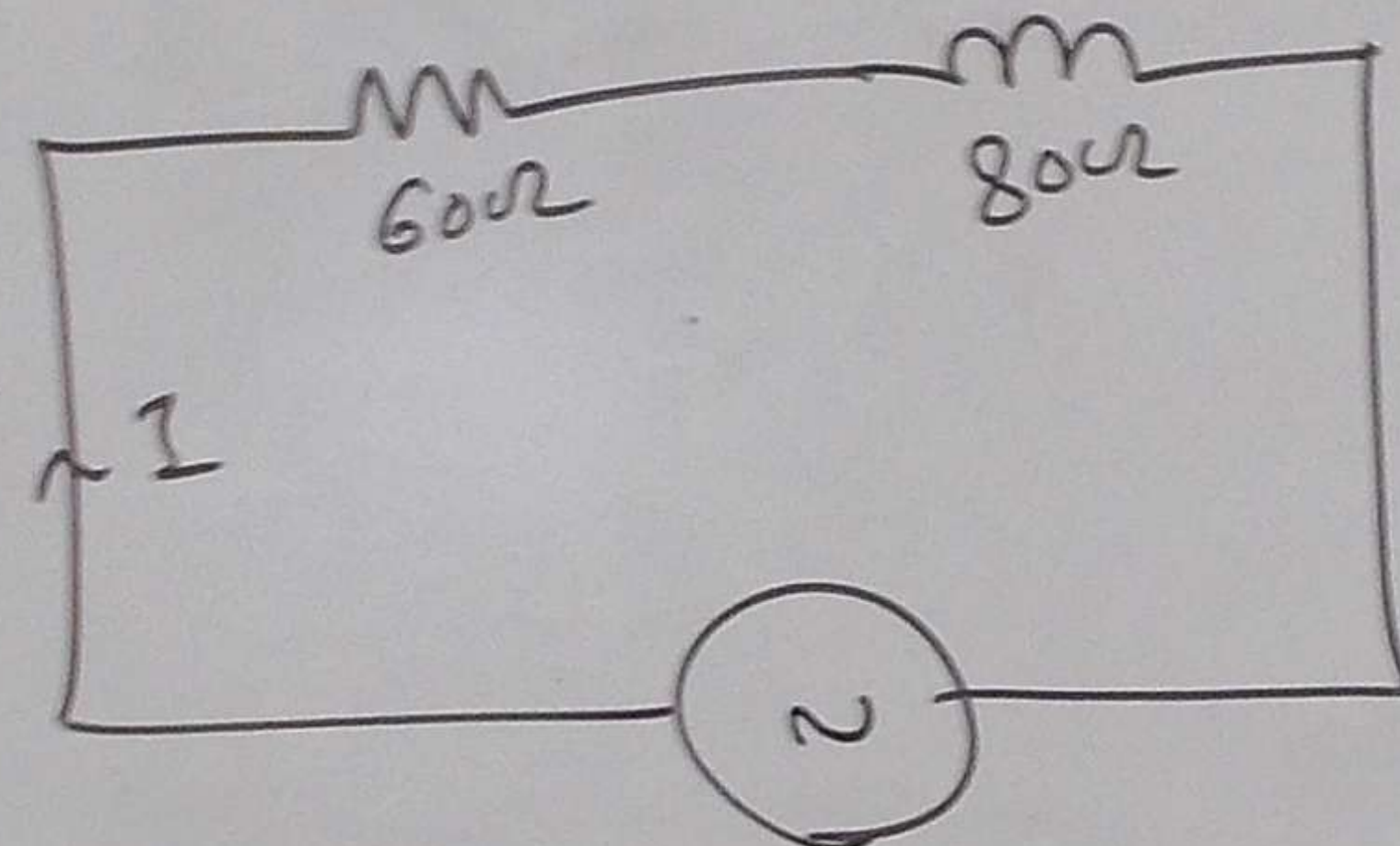
REAL POWER (P) (WATT)

POWER FACTOR = $\cos \theta$ = LEADING

PB

A CIRCUIT CONSISTS OF A 20V rms SOURCE CONNECTED TO A SERIES COMBINATION OF A 60Ω RESISTOR AND AN INDUCTOR WITH A REACTANCE OF 80Ω. CALCULATE THE CIRCUIT

- THE APPARENT POWER
- THE TRUE POWER (REAL POWER)
- THE REACTIVE POWER
- THE POWER FACTOR



20V (rms)

$$Z = 60 + j80$$

$$= \sqrt{60^2 + 80^2} \angle \tan^{-1} \frac{80}{60}$$

$$Z = 100 \angle 53.2^\circ \Omega$$

$$I = \frac{V}{Z} = \frac{20}{100 \angle 53.2^\circ} = 0.2 \angle -53.2^\circ \text{ Amp}$$

- APPARENT POWER = $E \times I = 20 \times 0.2 = 4 \text{ VA}$
- TRUE POWER: $E I \cos \theta = 20 \times 0.2 \cos 53.2^\circ = 4 \times 0.6 = 2.4 \text{ W}$
- REACTIVE POWER: $E I \sin \theta = 20 \times 0.2 \sin 53.2^\circ = 4 \times 0.8 = 3.2 \text{ VAR}$
- POWER FACTOR = $\cos \theta = \cos(-53.2^\circ) = 0.6 \text{ LAGGING}$

APPARENT POWER = $I^2 Z$
REAL POWER = $I^2 R$
REACTIVE POWER = $I^2 X_L$

EXERCISE

A CIRCUIT
CONNECTED
RESISTOR
CALCULATE

Source connected to a series combination
inductor with a reactance of 80Ω

$$Z = 60 + j80$$

$$= \sqrt{60^2 + 80^2} \angle \tan^{-1} \frac{80}{60}$$

$$Z = 100 \angle 53.2^\circ \Omega$$

$$\frac{10}{100 \angle 53.2^\circ} = 0.2 \angle -53.2^\circ \text{ Amp}$$

$$10 \times 0.2 = 4 \text{ VA}$$

$$10 \times 0.2 \cos 53.2^\circ = 4 \times 0.6 = 2.4 \text{ W}$$

$$10 \times 0.2 \sin 53.2^\circ = 4 \times 0.8 = 3.2 \text{ VAR}$$

$$(-53.2^\circ) = 0.6 \text{ LAGGING}$$

APPARENT power $= I^2 Z = (0.2)^2 \times 100 = 0.04 \times 100 = 4 \text{ VA}$
 REAL power $= I^2 R = (0.2)^2 \times 60 = 0.04 \times 60 = 2.4 \text{ WATT}$
 REACTIVE power $= I^2 X = (0.2)^2 \times 80 = 0.04 \times 80 = 3.2 \text{ VAR}$

EXERCISE

A circuit consists of 100 V rms source is connected to a series combination of 40Ω resistor in series with 30Ω inductor

- CALCULATE (a) APPARENT power
 (b) TRUE power
 (c) REACTIVE power
 (d) POWER factor

POWER IN PURE INDUCTOR

$$P = E_{\max} \sin \omega t$$

$$= \frac{E_{\max}}{\sqrt{2}} \frac{I_{\max}}{\sqrt{2}} \cos \phi$$

$$I = I_{\max} \sin \omega t$$

$$= \frac{I_{\max}}{\sqrt{2}}$$

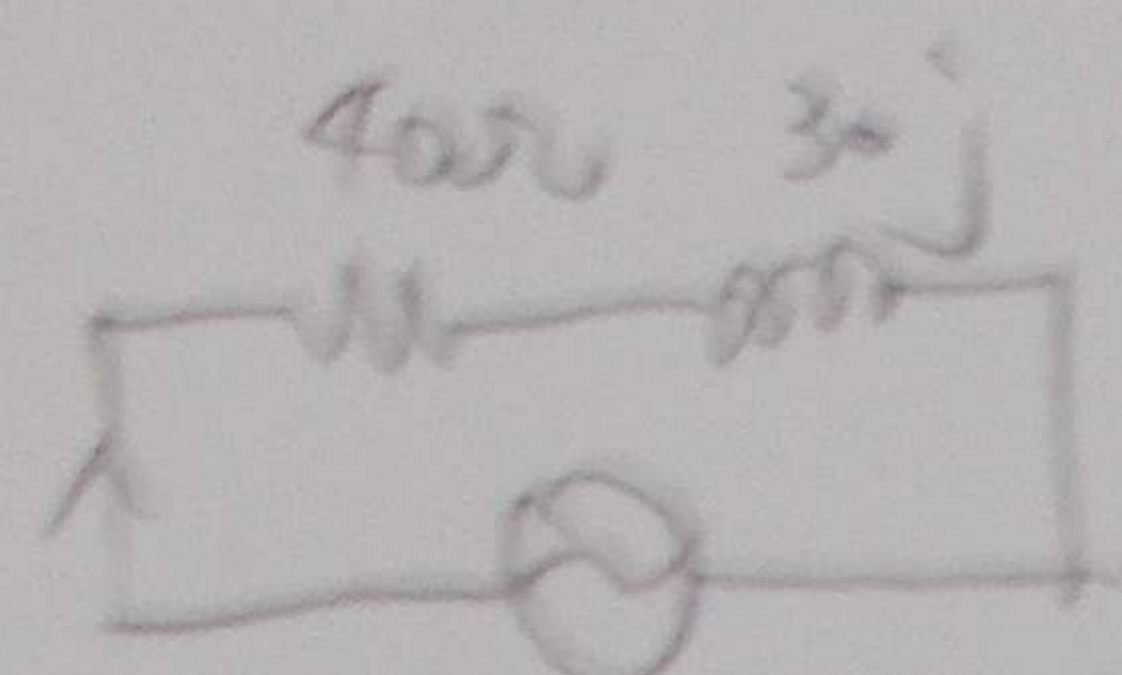
$$\text{Power} = E_{\max} \sin \omega t$$

$$= E_{\max} \sin \omega t$$

$$\sin(A-B) = \sin A \cos B - \cos A \sin B$$

$$\text{POWER} =$$

16/



100V RMS

$$V_{rms} = 100 \text{ V}$$

Order 100V

237 89045

$$Z = 50 \angle 37^\circ$$

$$I = \frac{100 \angle 0^\circ}{50 \angle 37^\circ} = 2 \angle -37^\circ$$

(a) Apparent $P = 200 \text{ VA}$

(b) $200 \times \cos(+37^\circ) = 160 \text{ W}$

(c) $200 \times \sin(+37^\circ) = 120 \text{ VAR}$

(d) $P_F = \cos 37^\circ = 0.8$



New Wun Ch
New Age - New Ch

$$Z = 40 + j30$$

$$= 50 \angle \tan^{-1} \frac{30}{40}$$

$$= 50 \angle 36.87$$

$$I = \frac{V}{Z} = \frac{100}{50 \angle 36.87}$$

$$= 2 \angle -36.87$$

a) $100 \times 2 = 200 \text{ W (apparent power)}$

b) $EI \cos \theta = 100 \times 2 \cos 36.87 = 160 \text{ W (T.P)}$

c) $EI \sin \theta = 100 \times 2 \sin(36.87) = 120 \text{ W (R.P)}$

d) $\cos \theta = \cos -36.87 = 0.8 \text{ Lagging (P.F)}$

Lag ϕ

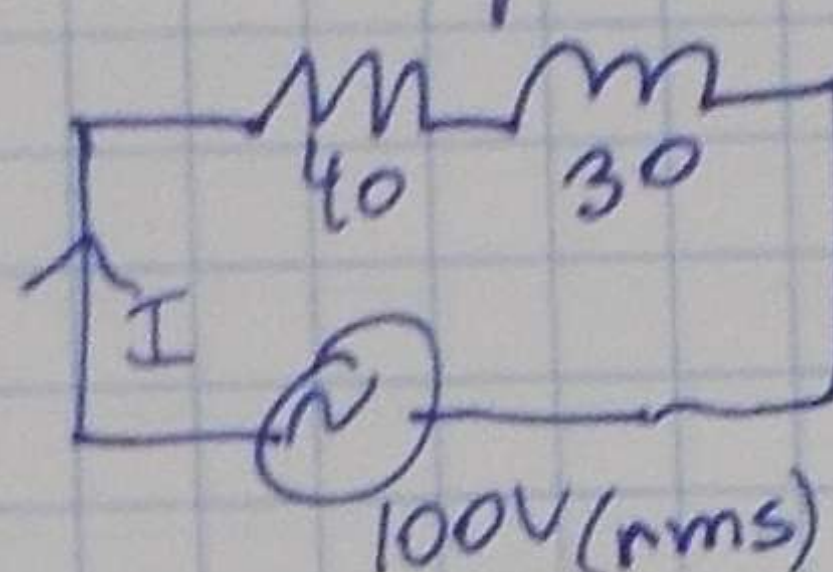
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Power Triangle

Exercise.

A circuit consist of a 100V rms source connected to a series combination of 40Ω resistors in series with 30Ω inductor. calculate a) apparent power b) true power c) reactive power d) power factor



$$a) E \times I = 100 \times 2 = AP = 200 \text{ VA}$$

$$b) EI \cos \theta = 100 \times 2 \times \cos -36.86 = 160 \text{ W}$$

$$c) EI \sin \theta = 100 \times 2 \times \sin -36.86 = 119.97 \text{ W}$$

$$d) \cos \theta = 0.8 \text{ lagging}$$

or

$$a) I^2 Z = (2)^2 \times 50 = 200 \text{ VA}$$

$$b) I^2 R = (2)^2 \times 40 = 160 \text{ W}$$

$$c) I^2 X = (2)^2 \times 30 = 119.97$$

MATEUS

803737657

$$Z = \sqrt{40^2 + 30^2} \quad \tan^{-1} \frac{30}{40} = 36.86$$

$$I = \frac{100}{50} = 2 \angle -36.86$$

ELECTRO MAGNETISM

ERICK MATIAS

$$T_{KT} = 30^{\circ}C, R_{KT} = 0.3\Omega, R_f = 0.4\Omega, T_f = 2$$

$$R_1 = \frac{234.5 + T_f}{234.5 + T_{KT}}$$

$$R_2 = \frac{234.5 + T_f}{234.5 + 30}$$

$$0.58 = (234.5 + T_f) / 0.7$$

$$0.58 = 70.35 + 0.7 T_f$$

$$T_f = \frac{35.45}{0.7}$$

$$= 118.16$$

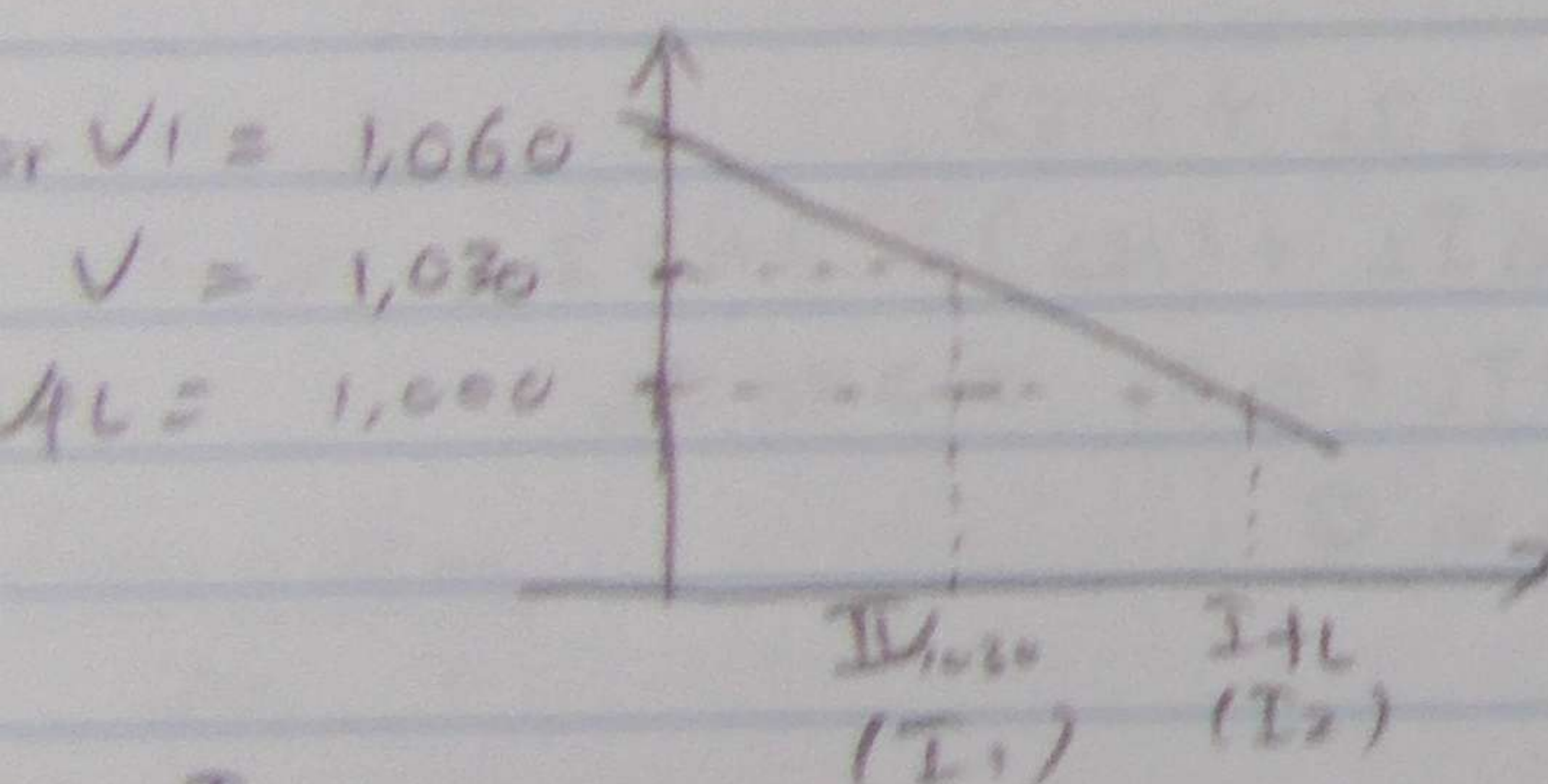
0 kW 1,000 V Generator

regulation = 6%

V open circuit (b) P output at terminal 1,030V assuming V₀ drops various uniformly between no load & full load current

$$E_g = \frac{V_t - V_L}{V_L} \times 100$$

$$E_g = \frac{1,000 - 1,030}{1,030} \times 100; E_g = 60 + 1,000 = 1,060V$$



$$I_2 = \frac{I_1}{I_0}$$

$$\frac{1,000}{1,030} = \frac{I_2}{I_1}$$

$$\frac{60}{30} = \frac{I_2}{I_1}$$

$$2 = \frac{I_2}{I_1}$$

all load

$\times 10^3$

100

$$2 = \frac{1,000}{I_1}$$

$$I_1 = 50A$$

$$P_{output} = V \times I$$

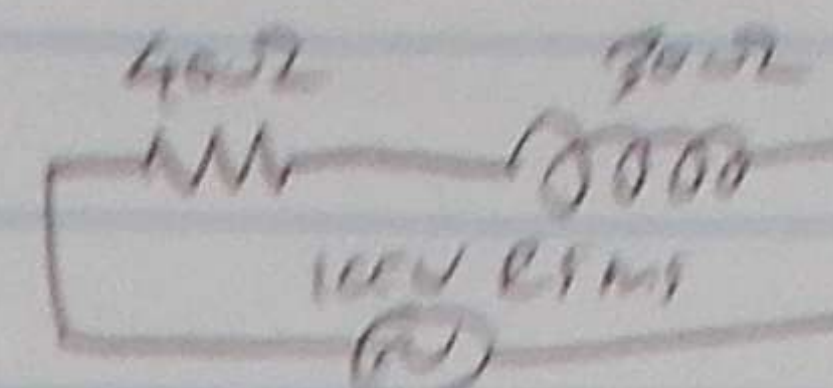
$$= 1,030 \times 50$$

$$= 51,500W$$

A.C

ERICK MATIAS 803737703

1)



(a) Apparent Power

(c) Reactive Power

(b) True Power

(d) Power factor

$$R = 40\Omega, X_L = 30\Omega / 90$$

$$Z = 40 + j30$$

$$= \sqrt{40^2 + 30^2} / \tan^{-1} \frac{30}{40}$$

$$= 50 / 36.87$$

$$I = \frac{E}{Z}$$

$$= \frac{100}{50} / 36.87$$

$$= 2 / -36.87 A$$

$$(a) S = E \cdot I = I^2 \cdot Z$$

$$= 100 \times 2 \text{ (or)} = 2^2 \times 50$$

$$= 200 VA \text{ (or)} = 200V.A$$

$$(b) P = E \cdot I \cos \theta \text{ or } I^2 \cdot R$$

$$= 100 \cdot 2 \times \cos 36.87 \text{ or } 2^2 \cdot 40$$

$$= 200 \times 0.79$$

$$\text{or } 160 \text{ watt}$$

$$= 159.99 \text{ watt}$$

$$(c) Q = E \cdot I \sin \theta \text{ or } I^2 \cdot X_L$$

$$= 100 \cdot 2 \times \sin 36.87 \text{ or } 2^2 \times 30$$

$$= 120 VAR$$

$$\text{or } 120 VAR$$

$$(d) \text{ Power factor} = \cos \theta$$

$$= \cos 36.87$$

$$= 0.79 \text{ Lagging}$$

Voltage $E_{rms} = 240 \angle 0^\circ$ V THE

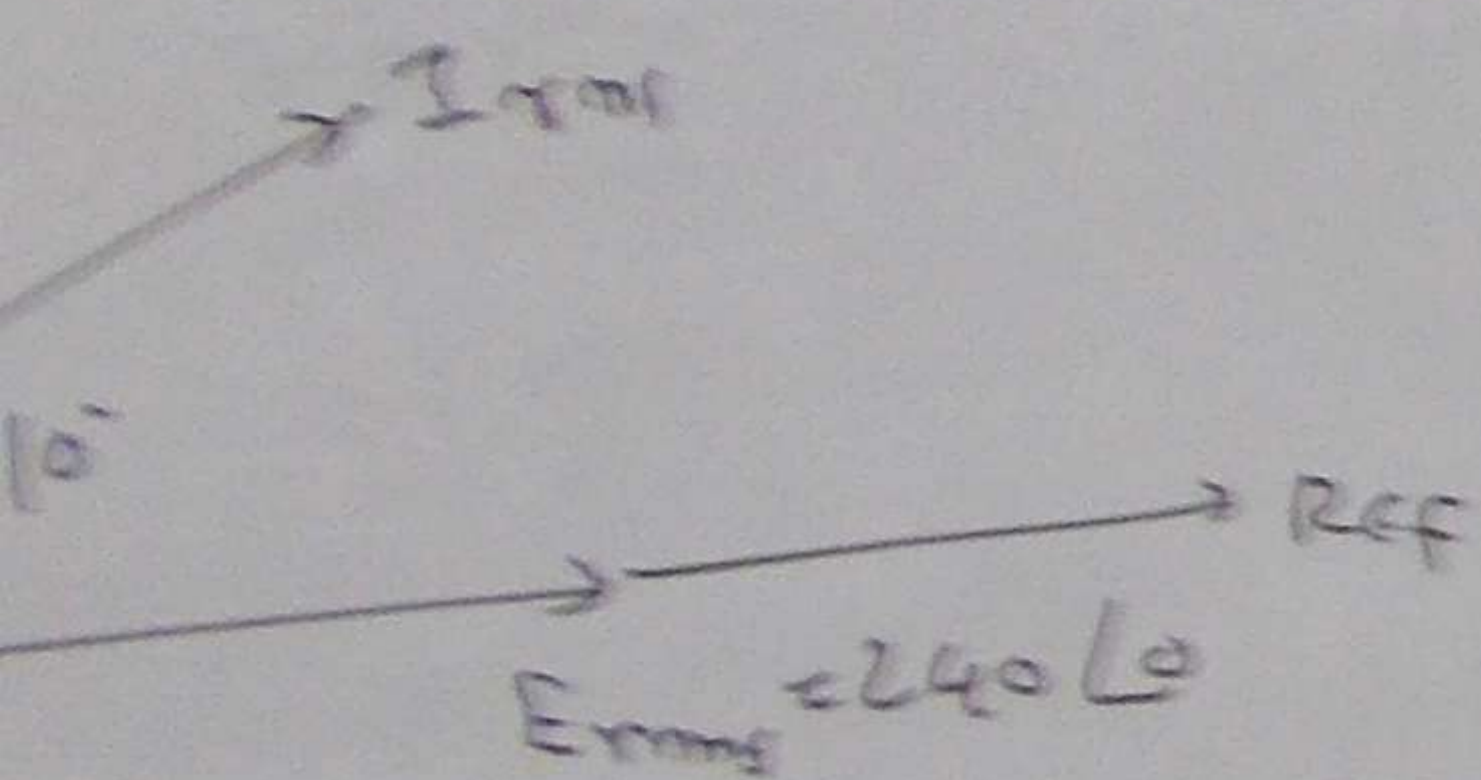
$I_{rms} = 10 \angle 10^\circ$ AMP

IN POLAR FORM

IN WATT

IN VAR (STATE WHETHER INDUCTIVE OR CAPACITIVE)

STATE WHETHER LEADING OR LAGGING



$$\begin{aligned} (a) \text{ APPARENT POWER (S)} &= E_{rms} I_{rms} \angle \theta_I \\ &= 240 \angle 10 - 0 \\ &= 2400 \angle 10 \\ &= 2400 \angle 10 \text{ VA} \end{aligned}$$

$$\begin{aligned} (b) \text{ REAL POWER (P)} &= VA \cos \theta_I \rightarrow (10 - 0) \\ &= 2400 \cos 10 \\ &= 2363 \text{ WATT} \end{aligned}$$

$$\begin{aligned} (c) \text{ REACTIVE POWER (Q)} &= VA \sin \theta \\ &= 2400 \sin 10 \\ &= 416.7 \text{ VAR} \end{aligned}$$

$$(d) \text{ POWER FACTOR} = \cos \theta = \cos 10 = 0.98 \text{ LEADING}$$

$$S = 2363 + j416.7 \text{ VAR}$$

EXERCISE

AN RC CIRCUIT $E_{rms} = 300 \angle 10^\circ$ V

$I_{rms} = 20 \angle 30^\circ$ AMP

FIND (a) S (b) P (c) Q

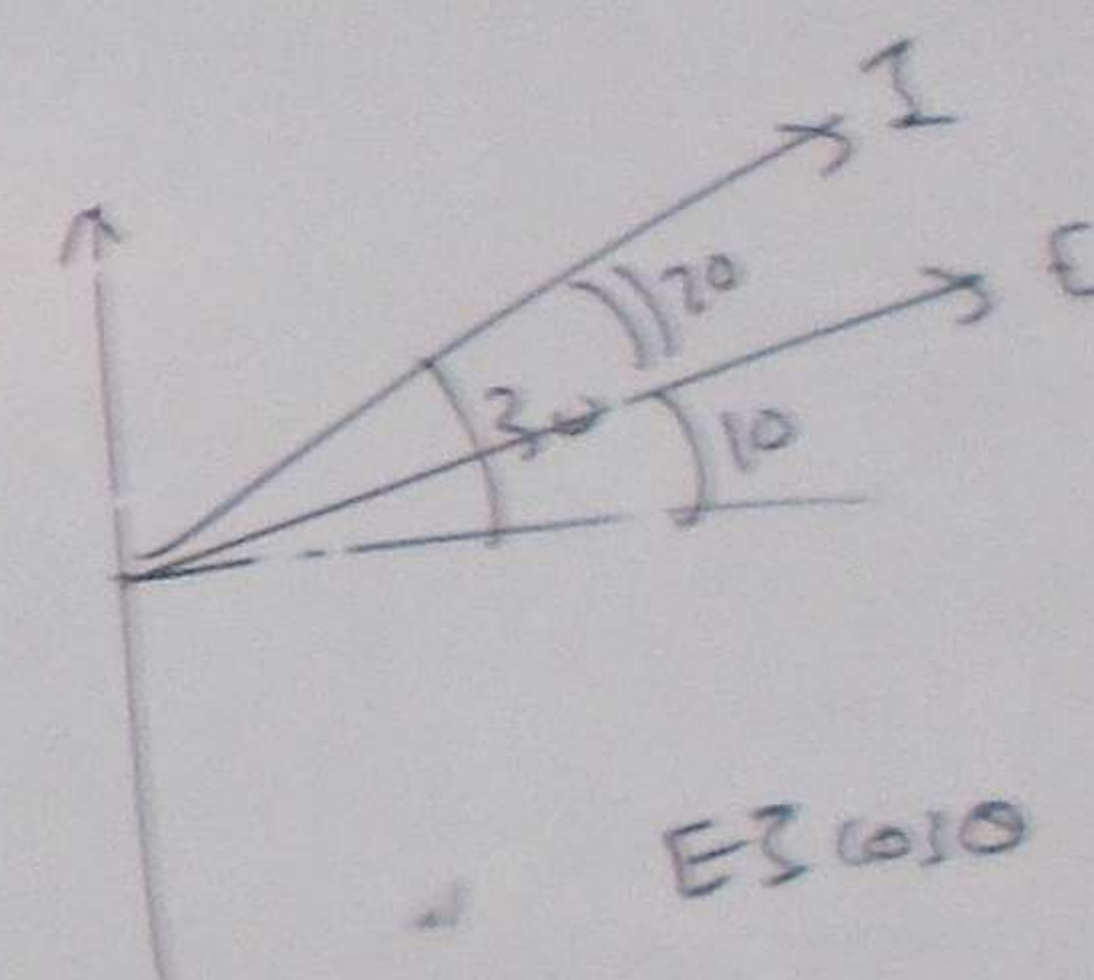
(d) P.F. LEADING OR LAGGING

$$E = 300 \angle 10$$

$$I = 20 \angle 30$$

$$EI \angle \theta_I$$

$$300 \times 20 \angle 30 - 10$$



$$\begin{aligned} &E I \cos \theta \\ &300 \times 20 \cos (30 - 10) \\ &= 300 \times 20 \cos (20) \\ &= 5638 \text{ WATT} \end{aligned}$$

Leading

Archer CHIU 203789095

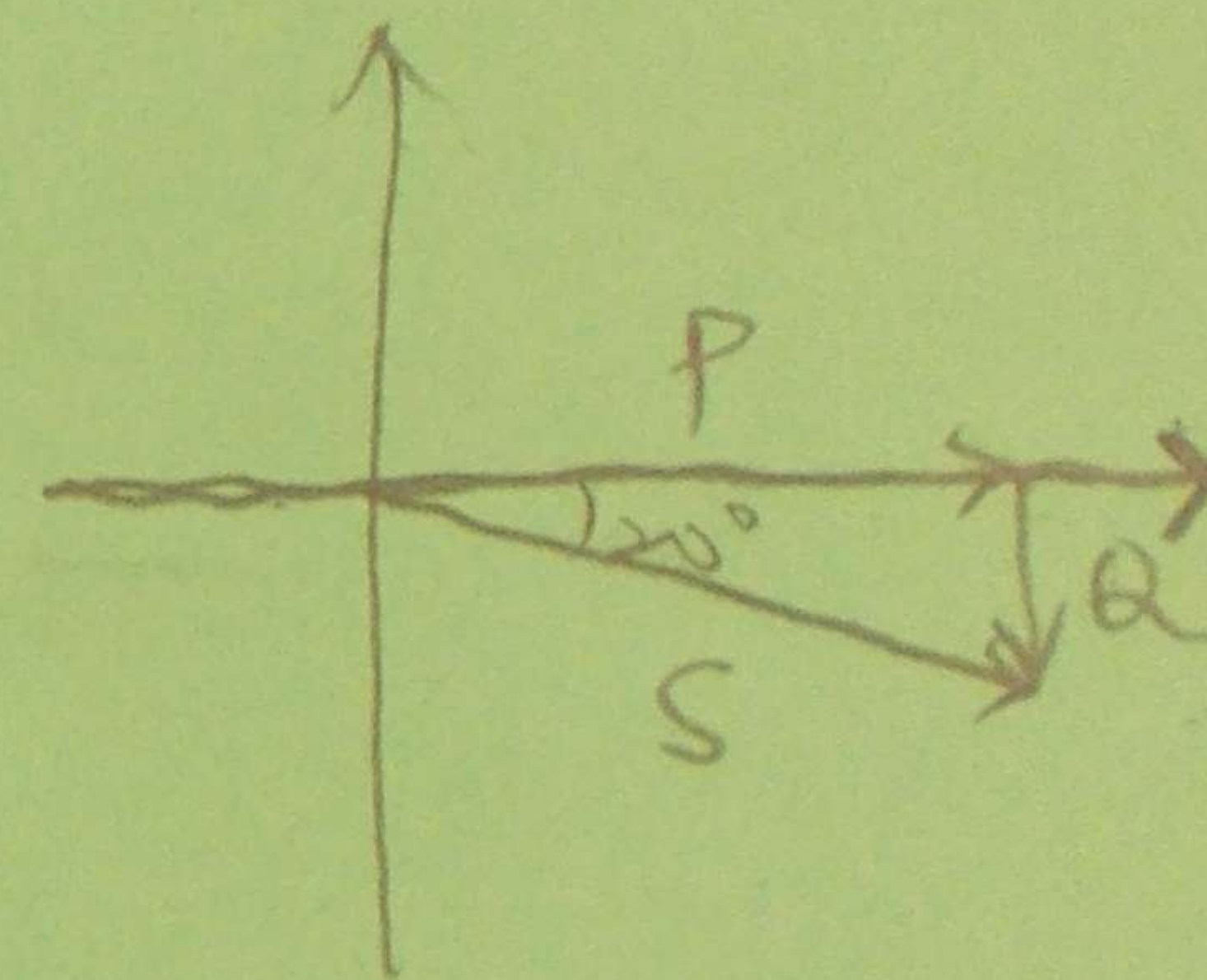
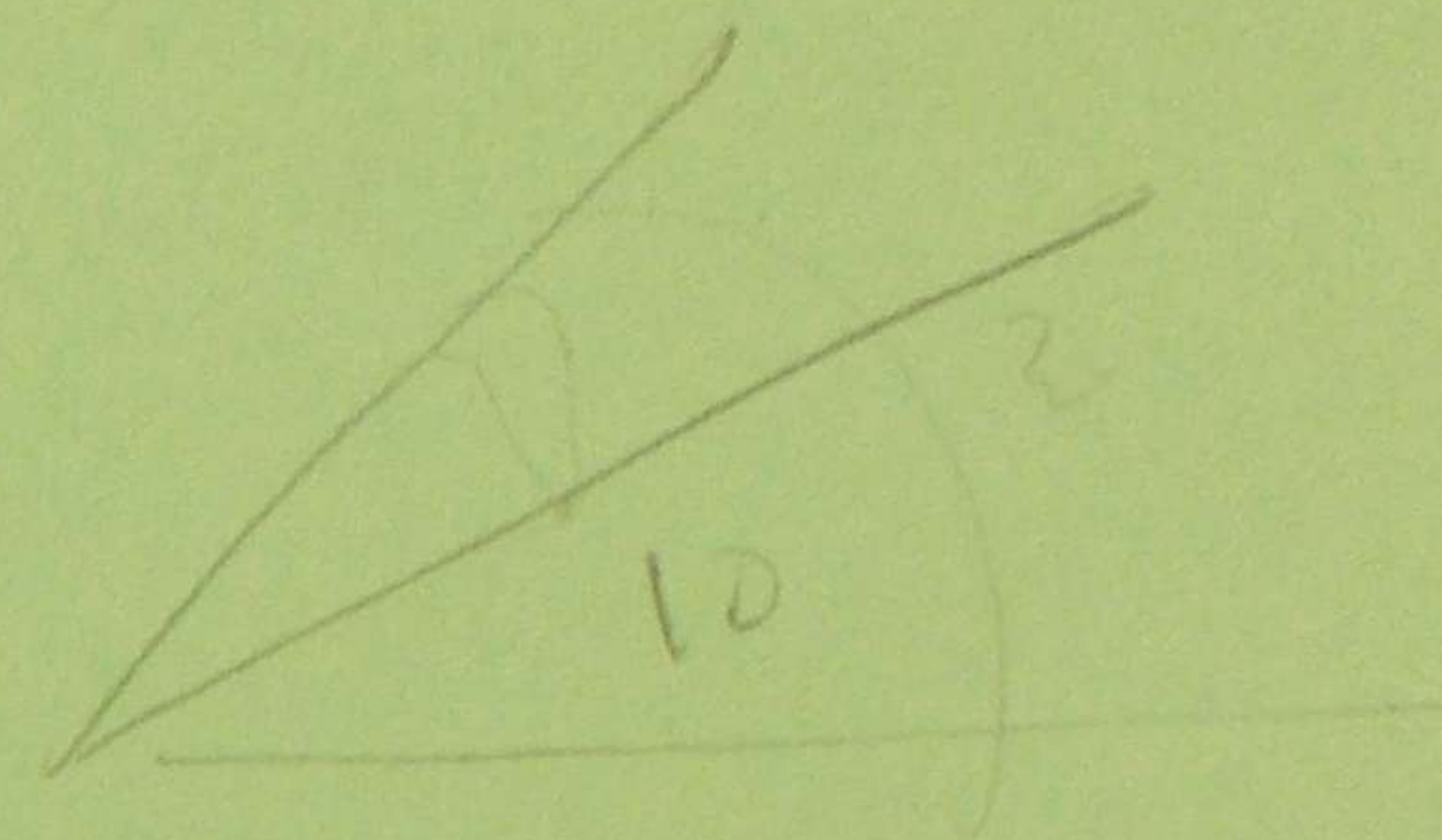
(a) RC circuit, $E_{rms} = 300 \angle 10^\circ V$
 $I_{rms} = 20 \angle 30^\circ A$

$$S = E \times I = 6000 \angle -20^\circ \text{ VA}$$

(b) $P = 6000 \times \cos(-20^\circ) = 5638.16 \text{ W}$

(c) $Q = 6000 \times \sin(-20^\circ) = -2052.12 \text{ VAR}$

(d) $P.F. = \cos(20^\circ) = 0.94 \text{ (Leading)}$



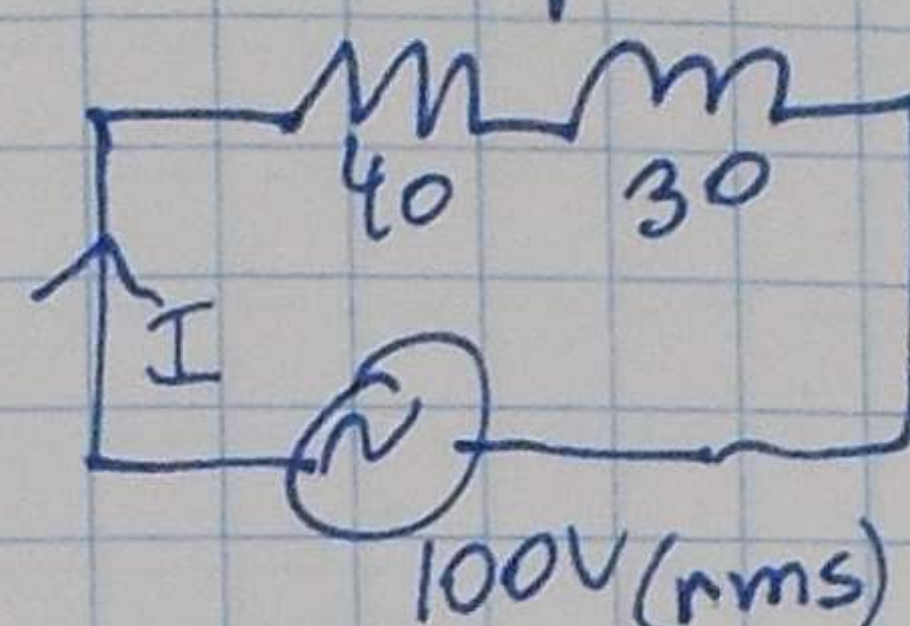
17/05/18

$$Z = \sqrt{40^2 + 30^2} \quad \tan^{-1} \frac{30}{40} = 36.86^\circ$$

Power Triangle

Exercise.

A circuit consists of a 100V rms source connected to a series combination of 40Ω resistors in series with 30Ω inductor. calculate a) apparent power b) true power c) reactive power d) power factor



a) $E \times I = 100 \times 2 = AP = 200 \text{ VA}$

b) $E I \cos \theta = 100 \times 2 \times \cos 36.86 = 160 \text{ W}$

c) $E I \sin \theta = 100 \times 2 \times \sin 36.86 = 119.97 \text{ W}$

d) $\cos \theta = 0.8$ lagging

or

a) $I^2 Z = (2)^2 \times 50 = 200 \text{ VA}$

b) $I^2 R = (2)^2 \times 40 = 160 \text{ W}$

c) $I^2 X = (2)^2 \times 30 = 119.97$

MATEUS

80373765+

An AC circuit $E_{RMS} = 300 \angle 10^\circ \text{ V}$, $I_{RMS} = 20 \angle 30^\circ \text{ A}$. find $\theta_I = \theta_L - \theta_E$

a) S b) P c) Q d) p.f leading or lagging

a) $S = E_{RMS} \times I_{RMS} = 300 \angle 10^\circ \times 20 \angle 30^\circ = 6000 \angle 20^\circ \text{ VA}$

b) $P = VA \cos \theta_I = 6000 \cos 20 = 5638.15 \text{ W}$

c) $Q = VA \sin \theta_I = 6000 \sin 20 = 2052.12 \text{ W}$

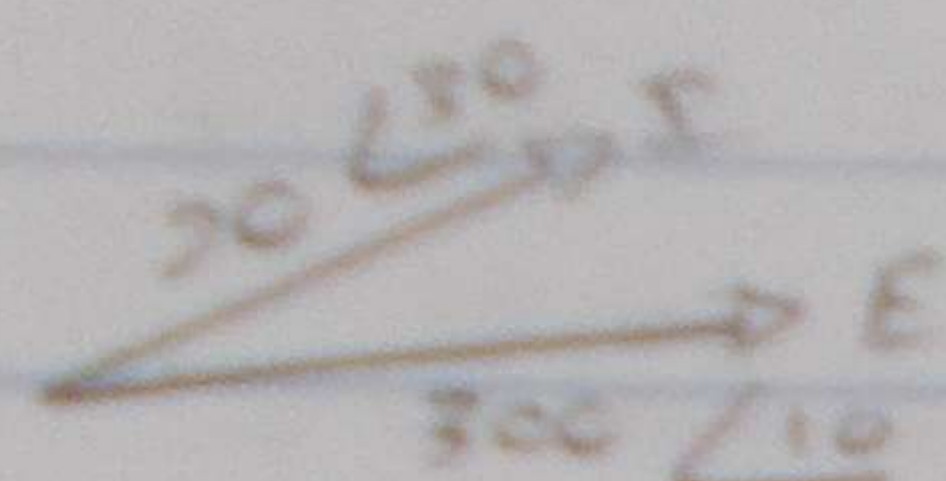
d) $PA \cos 20 = 0.93$ leading $5638.15 + j 2052.12$

A.C

ERICK MATIAS 803737703

2) RC circuit $E_{RMS} = 300 \angle 10^\circ V$, $I_{RMS} = 20 \angle 30^\circ A$

a) S b) P c) Q d) Power factor



$$\begin{aligned} \text{a) } S &= E_{RMS} \times I_{RMS} \angle \theta \\ &= 300 \times 20 \angle 10 - 30 \\ &= 6000 \angle -20 \text{ V.A} \end{aligned}$$

$$\begin{aligned} \text{b) } P &= E \times I \cos \theta \\ &= 6000 \cos -20 \\ &= 5638.1 \text{ watt} \end{aligned}$$

$$\begin{aligned} \text{c) } Q &= E \times I \sin \theta \\ &= 6000 \sin -20 \\ &= -2052.1 \text{ VAR} \end{aligned}$$

$$\begin{aligned} \text{d) Power factor} &= \cos \theta \\ &= \cos -20 \\ &= 0.94 \text{ Leading} \end{aligned}$$

$$a) E_{rms} = 300 \angle 10^\circ \quad I_{rms} = 20 \angle 30^\circ \text{ Amp}$$

$$(A.P) \quad 300 \angle 10^\circ \times 20 \angle 30^\circ$$

$$= 6000 \angle 30 + 10$$

$$= 6000 \angle 20$$

b) Real power

$$P = V_A \cos \theta$$

$$= 6000 \cos \angle 10 - 30$$

$$= 5638 \text{ W}$$

$$c) R.P = V_A \sin \theta$$

$$= 6000 \sin \angle -20$$

$$= -2052$$

$$d) P.F = \cos \theta = \cos -20 = 0.93$$

$$F = 5638 - 2052j \quad \text{Leading}$$

Lag L'

$$802093781$$

pb
AN IMPEDANCE

250V rms

CALCULATE (a)

(b)

(c)

(d)

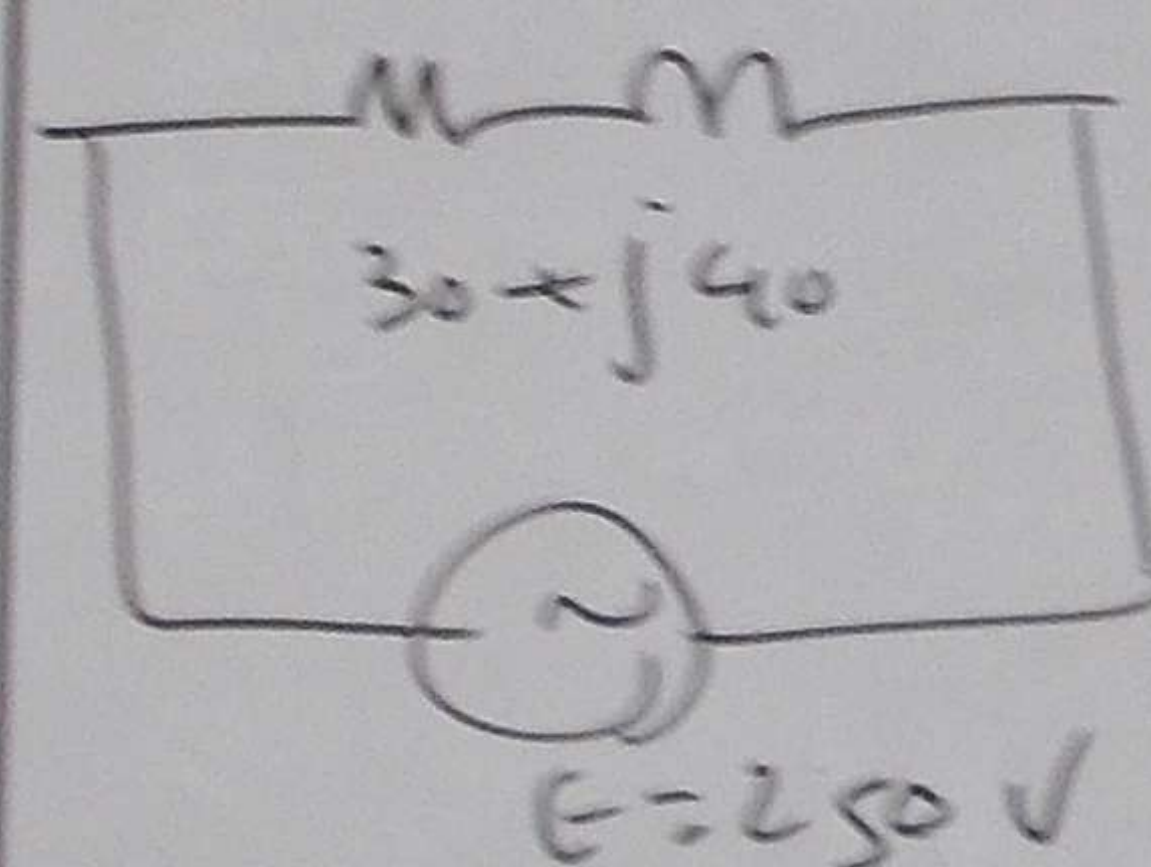
$Z = 30 + j40 \Omega$ IS CONNECTED TO
SUPPLY.

APPARENT POWER IN V.A

REAL POWER (WATT)

REACTIVE POWER (VAR)

CIRCUIT POWER FACTOR



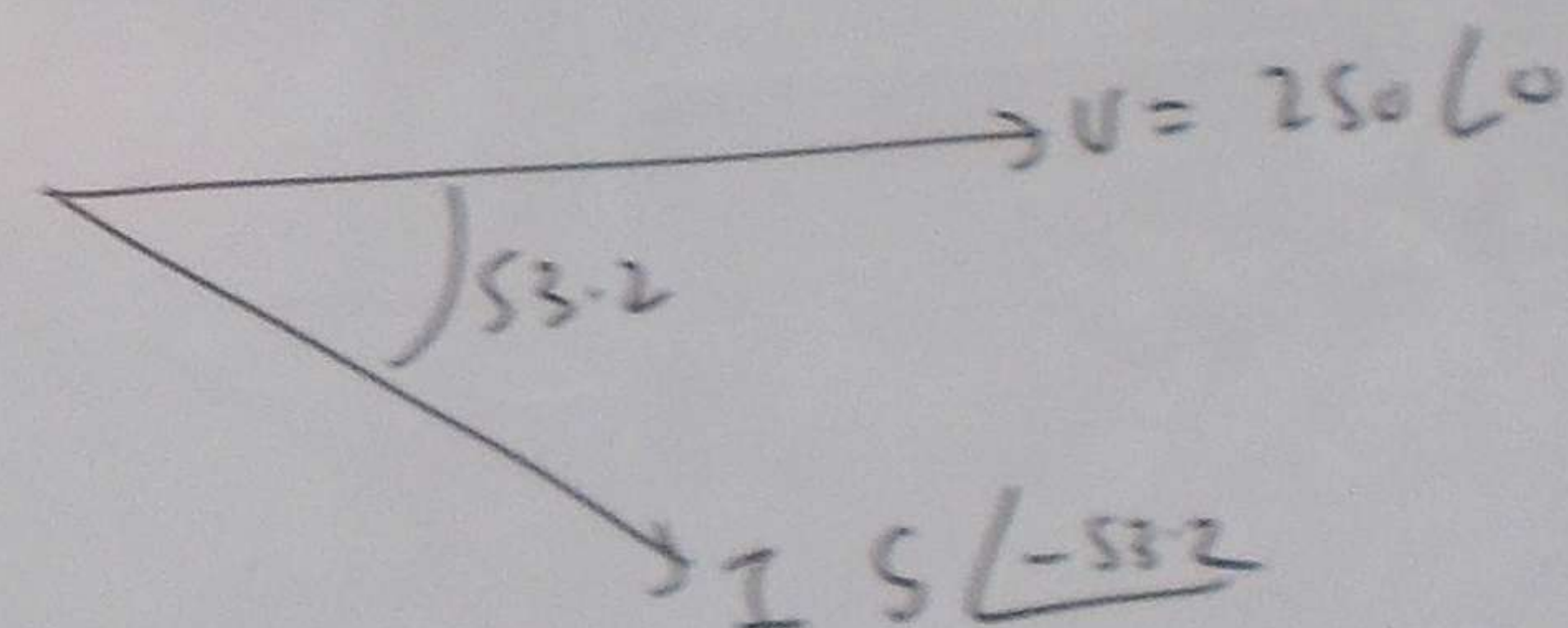
$$Z = \sqrt{30^2 + 40^2} \angle \tan^{-1} \frac{40}{30}$$

$$= 50 \angle 53.2^\circ \Omega$$

$$I = \frac{E}{Z}$$

$$= \frac{250 \angle 0^\circ}{50 \angle 53.2^\circ}$$

$$= 5 \angle -53.2^\circ \text{ — LAGGING}$$



$$(a) VA = E I \cos \theta$$

$$S = 250 \times 5 \cos 53.2^\circ$$

$$= 1250 \cos 53.2^\circ \text{ VA}$$

$$(b) P = S \cos \theta$$

$$= 1250 \cos 53.2^\circ$$

$$= 750$$

$$(c) Q = S \sin \theta$$

$$= 1250 \sin 53.2^\circ$$

$$= 1000$$

$$S = P + jQ$$

$$= 750 + j1000$$

$$(d) PF = \cos \theta$$

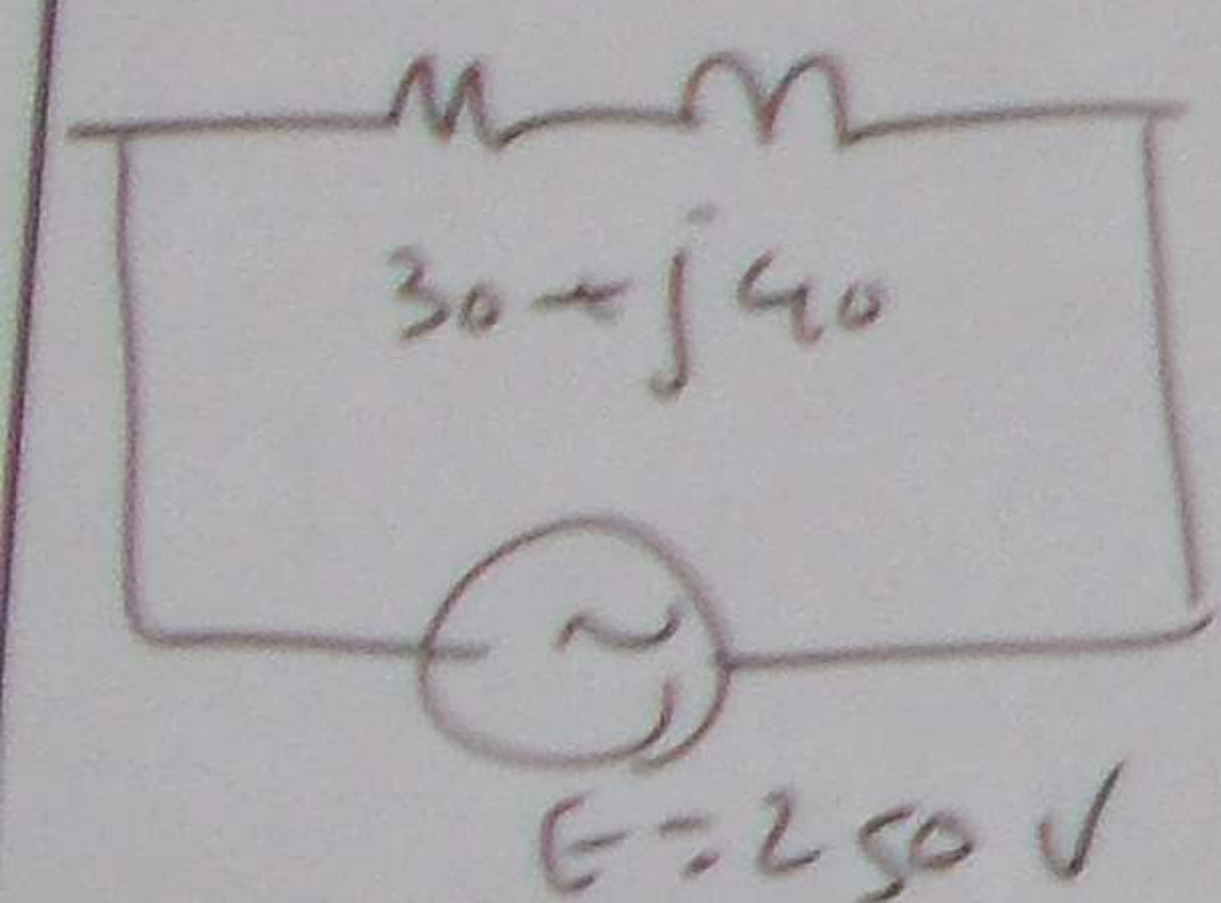
ce $Z = 30 + j40 \Omega$ IS CONNECTED TO SUPPLY.

APPARENT POWER IN V.A

REAL POWER (WATT)

REACTIVE POWER (VAR)

CIRCUIT POWER FACTOR



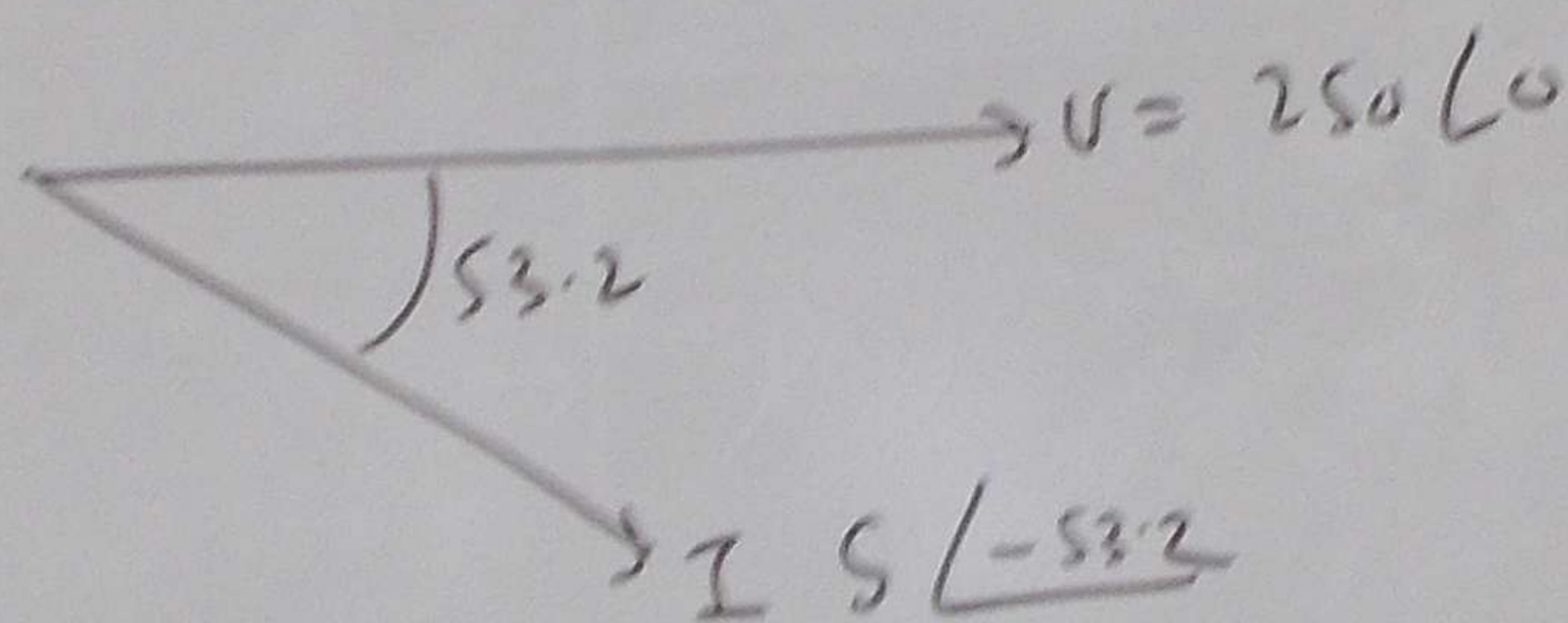
$$Z = \sqrt{30^2 + 40^2} \angle \tan^{-1} \frac{40}{30}$$

$$= 50 \angle 53.2^\circ \Omega$$

$$I = \frac{E}{Z}$$

$$= \frac{250 \angle 0}{50 \angle 53.2}$$

$$= 5 \angle -53.2^\circ \text{ — LAGGING}$$



$$(a) \text{ VA} = E I \cos \theta$$

$$S = 250 \times 5 \cos 53.2$$

$$= 1250 \cos 53.2 \text{ VA}$$

$$(b) P = S \cos \theta$$

$$= 1250 \cos 53.2$$

$$= 750$$

$$(c) Q = S \sin \theta$$

$$= 1250 \sin 53.2$$

$$= 1000$$

$$S = P \pm jQ \quad \begin{matrix} + \text{ LEADING} \\ - \text{ LAGGING} \end{matrix}$$

$$= 750 - j1000$$

$$(d) \text{ PF} = \cos \theta = \cos(-53.2)$$

$$= 0.6$$

LAGGING

Exercise
Impedance
Supply
Find (a)

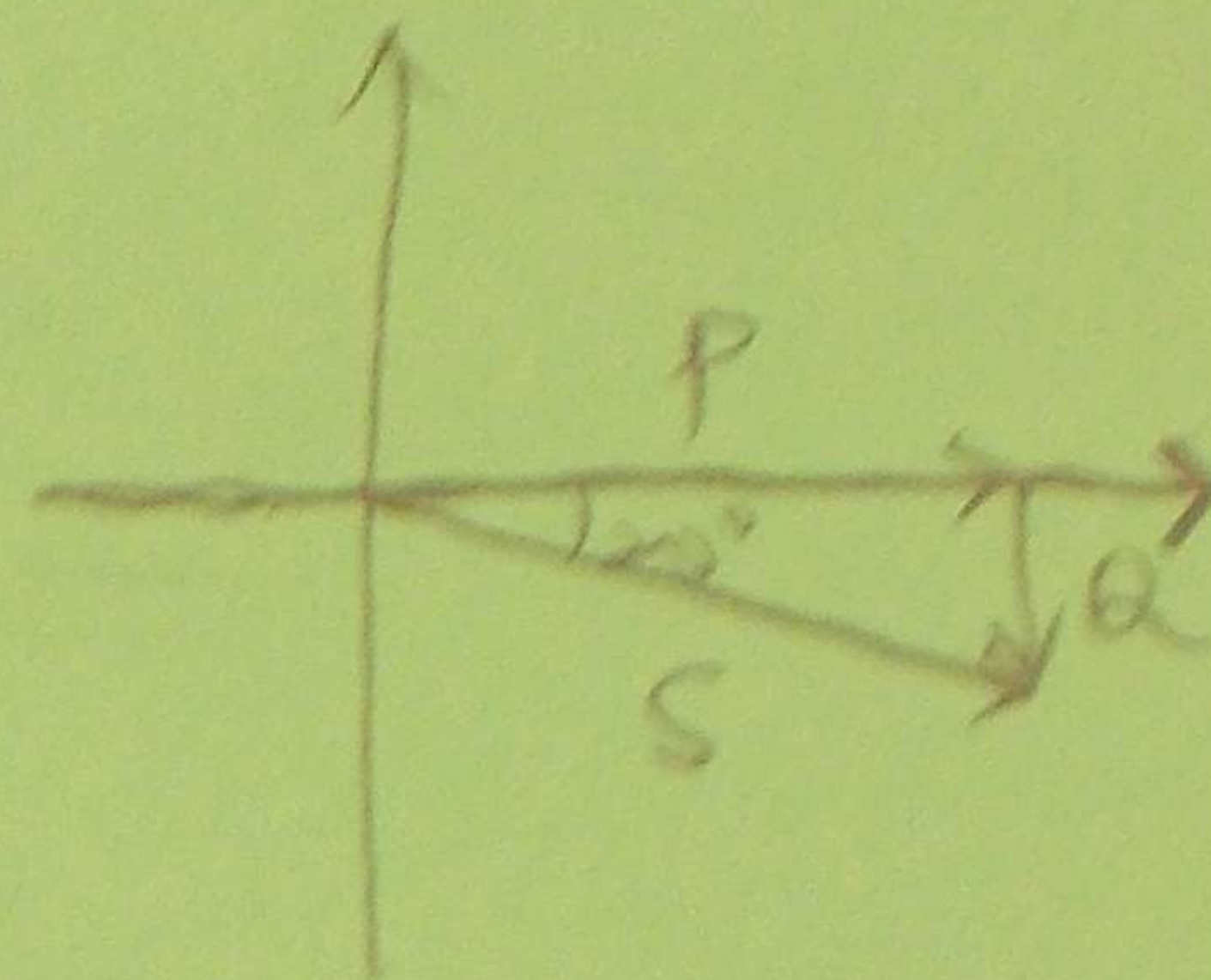
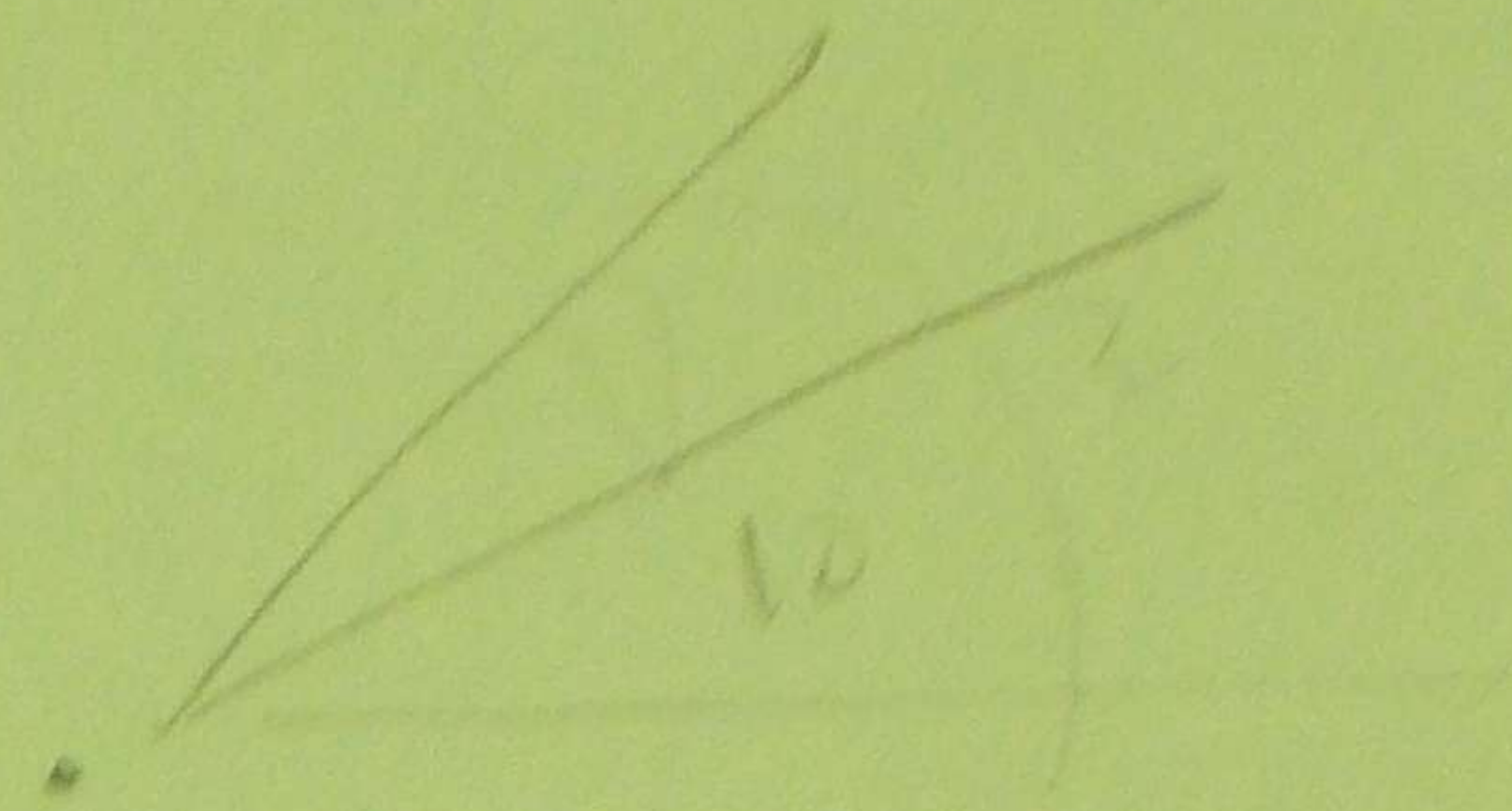
(a) RC circuit, $E_{rms} = 300 \angle 10^\circ V$
 $I_{rms} = 20 \angle 30^\circ A$

$S = E \cdot I = 6000 \angle -20^\circ \text{ VA}$

(b) $P = 6000 \times \cos(-20^\circ) = 5638.16 \text{ W}$

(c) $Q = 6000 \times \sin(-20^\circ) = -2052.12 \text{ Var}$

(d) P.F. $= \cos(-20^\circ) = 0.94$ (Leading)



$Z = 50 \angle 37^\circ$

$I = 20 \angle -37^\circ$

$V_{rms} = 1000 \angle 0^\circ V$

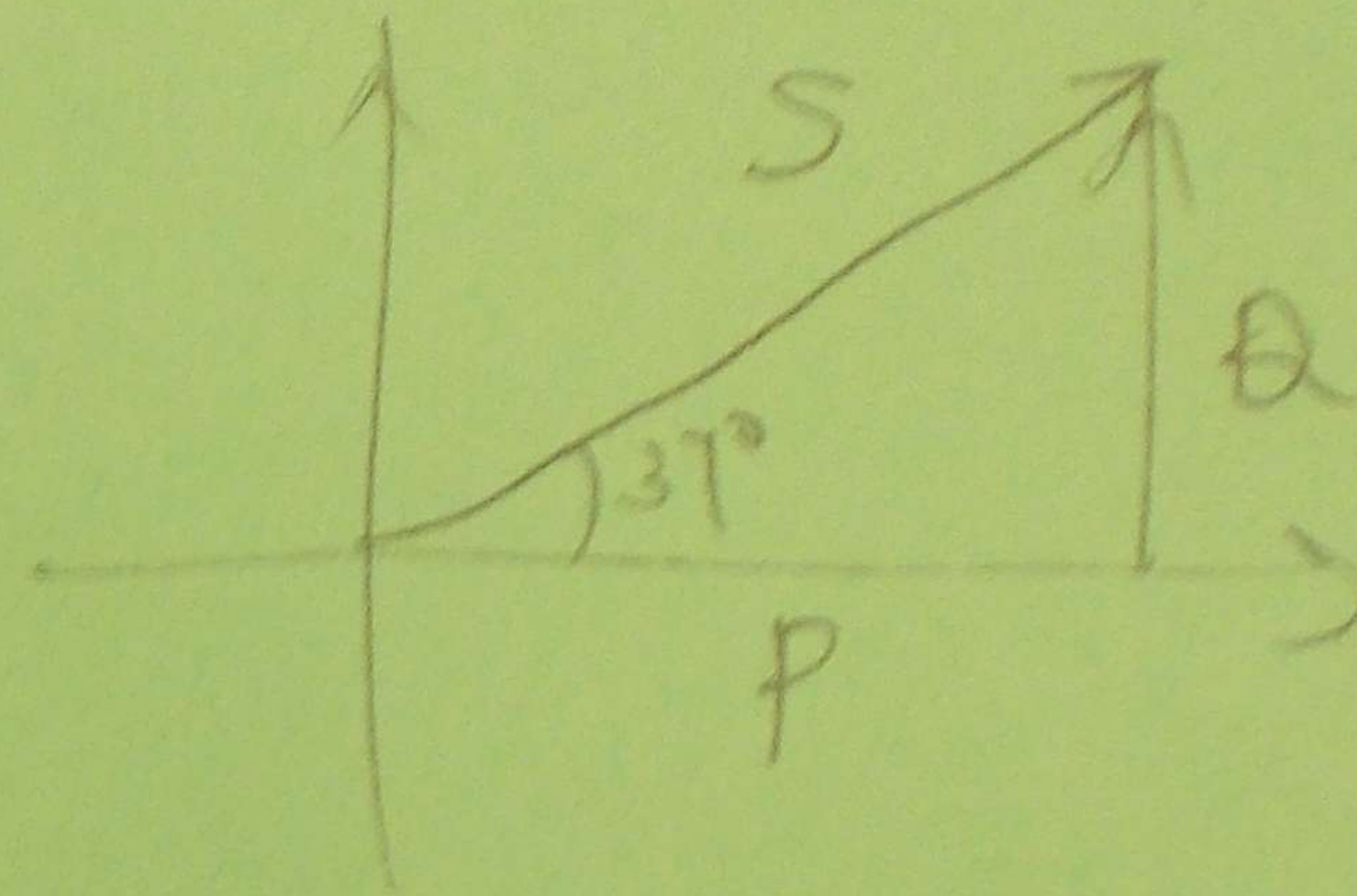
(a) $S = \vec{V} \cdot \vec{I} = 20 \angle 37^\circ \text{ (kVA)}$

(b) $P = 20 \cos 37^\circ = 16 \text{ (kW)}$

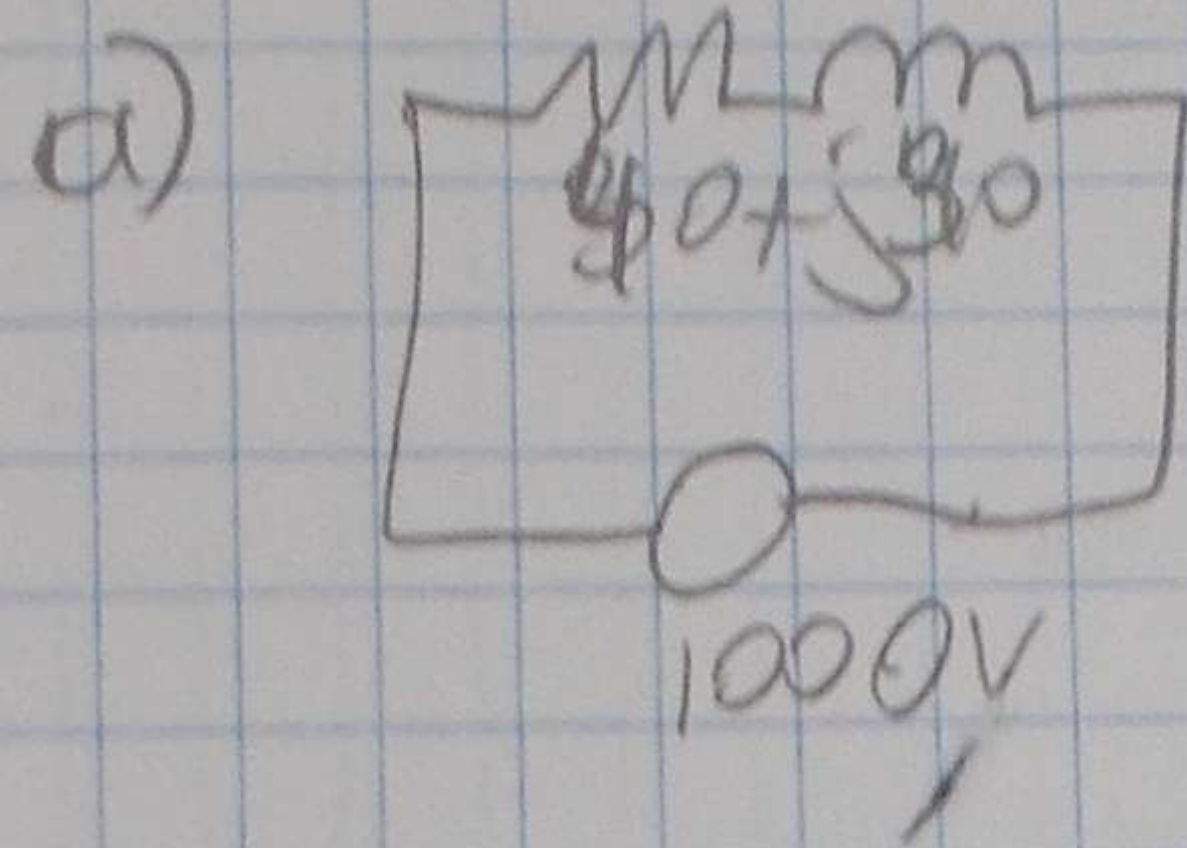
(c) $Q = 20 \sin 37^\circ = 12 \text{ (kvar)}$

(d) $\cos 37^\circ = 0.8$

P.F.:



Exercise impedance $Z = 40 + j30$ supply $V = 1000V$
 find a) S b) P c) Q d) Pf .



$$Z = \sqrt{30^2 + 40^2} \angle \tan^{-1} \frac{30}{40} = 50 \angle 36.86^\circ$$

$$I = \frac{1000}{50 \angle 36.86^\circ} = 20 \angle -36.86^\circ \text{ A (lagging)}$$

$$a) S = VI \angle \theta = 1000 \times 20 \angle 36.8^\circ = 20000 \angle 36.8^\circ \text{ VA}$$

$$b) P = S \cos \theta = 20000 \cos 36.8^\circ = 16014.6 \text{ W}$$

$$c) Q = S \sin \theta = 20000 \sin 36.8^\circ = 11980.4 \text{ W}$$

$$d) PF = \cos \theta = \cos 36.8^\circ = 0.8 \text{ lagging}$$

MARS

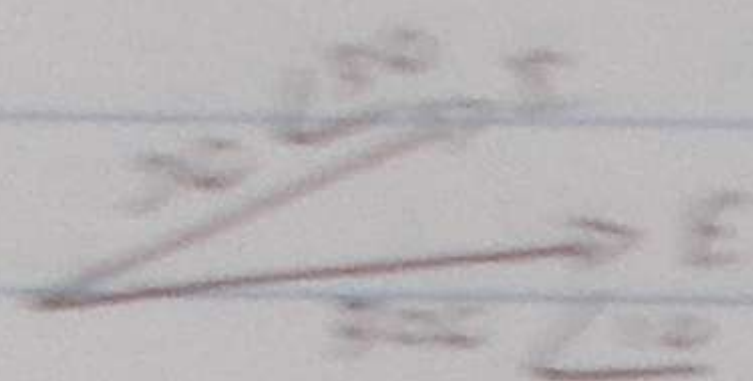
803737657

A.C

EDICK MINTAS 805737705

2) RC circuit $E_{rms} = 300 \angle 10^\circ V$, $I_{rms} = 20 \angle -20^\circ A$

Ⓐ S Ⓑ P Ⓒ Q Ⓓ power factor



$$\begin{aligned} \textcircled{A} S &= E_{rms} \times I_{rms} \angle \theta \\ &= 300 \times 20 \angle 10 - 20 \\ &= 6000 \angle -20 \text{ V.A} \end{aligned}$$

$$\begin{aligned} \textcircled{B} P &= E \times I \cos \theta \\ &= 600 \cos -20 \\ &= 563.81 \text{ watt} \end{aligned}$$

$$\begin{aligned} \textcircled{C} Q &= E \times I \sin \theta \\ &= 600 \sin -20 \\ &= -205.21 \text{ VAR} \end{aligned}$$

$$\begin{aligned} \textcircled{D} \text{Power factor} &= \cos \theta \\ &= \cos -20 \\ &= 0.94 \text{ Lagging} \end{aligned}$$

2) RC $Z = 40 + j30$ $E_{rms} = 1000 V$

$$Z = \sqrt{40^2 + 30^2} \angle \tan^{-1} \frac{30}{40} = 50 \angle 36.87^\circ$$

$$I = \frac{E}{Z} = \frac{1000}{50 \angle 36.87} = 20 \angle -36.87^\circ \rightarrow \text{Lagging}$$

$$\begin{aligned} \textcircled{A} S &= E \times I \angle \theta \\ &= 1000 \times 20 \angle 0 - (-36.87) \\ &= 20000 \angle 36.87 \text{ V.A} \end{aligned}$$

$$\begin{aligned} \textcircled{B} P &= E \cdot I \cos \theta \\ &= 20000 \cos 36.87 = 15999.97 \text{ watt} \end{aligned}$$

$$\begin{aligned} \textcircled{C} Q &= E \cdot I \sin \theta \\ &= 20000 \sin 36.87 = 12000 \text{ VAR} \end{aligned}$$

$$\begin{aligned} \textcircled{D} S &= P + jQ \\ &= 15999.97 - j12000 \end{aligned}$$

$$\cos \theta = \cos 36.87$$

$$Z = \sqrt{30^2 + 40^2} \angle \tan^{-1} \frac{30}{40}$$

$$= 50 \angle 36.87$$

$$I = \frac{E}{Z} = \frac{1000 \angle 0}{50 \angle 36.87}$$

$$= 20 \angle -36.87$$

Lagging

$$a) V_A = E I \angle \theta_I^E$$

$$S = 1000 \times 20 \angle 36.87$$

$$= 20000 \angle 36.87$$

$$b) P = 1000 \times 20 \cos 36.87$$

$$= 20000 \cos 36.87$$

$$= 16000 \text{ W}$$

$$c) \vartheta = S \cdot \sin \theta$$

$$= 20000 \sin 36.87$$

$$= 12000 \text{ W}$$

$$d) PF = \cos \theta$$

$$= \cos -36.87$$

$$= 0.8$$

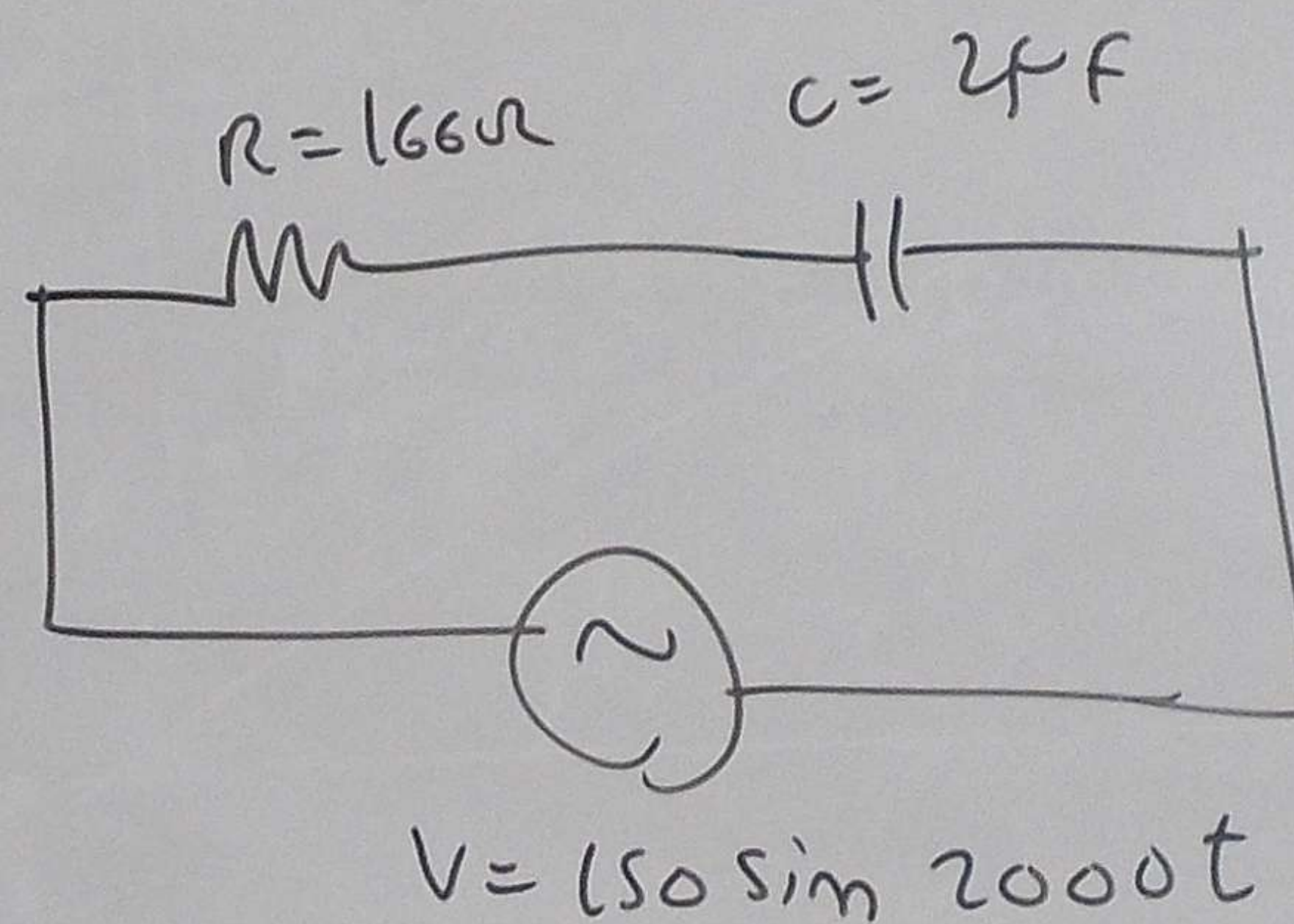
Long Li 802093781

pb

A VOLTAGE $V = 150 \sin 2000t$ IS APPLIED TO A RESISTANCE OF 166Ω IN SERIES WITH $2 \mu F$ CAPACITOR.

CALCULATE

- (a) APPARENT POWER IN U.A
- (b) REAL POWER IN WATT
- (c) REACTIVE POWER VAR
- (d) CIRCUIT POWER FACTOR
- (e) DRAW POWER TRIANGLE



$$V = 150 \sin 2000t$$

$$\omega = 2000$$

$$\omega = 2\pi f = 2000$$

$$V_{rms} = \frac{150}{\sqrt{2}} = 106 \angle 0^\circ \text{ V}$$

$$X_c = \frac{1}{2\pi f C}$$

$$= \frac{1}{2000 \times 2 \times 10^{-6}}$$

$$= 250 \Omega$$

$$Z = R - jX_c$$

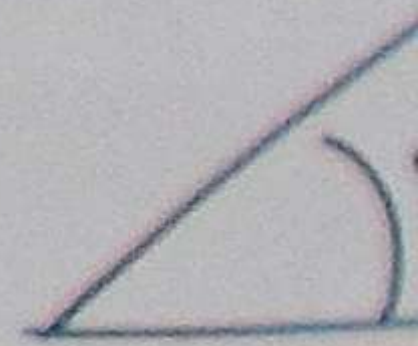
$$= 166 - j250$$

$$Z = \sqrt{166^2 + 250^2}$$

$$= 300 \Omega$$

$$I = \frac{V}{Z}$$

$$(a) S = V I$$



$$S =$$

RESISTANCE

150 sin 2000t

$$\omega = 2000$$

$$\omega = 2\pi f = 2000$$

$$I = \frac{150}{\sqrt{2}} = 106 \angle 0^\circ \text{ A}$$

$$\frac{1}{2\pi f C}$$

$$\frac{1}{2000 \times 2 \times 10^{-6}}$$

$$= 2500 \Omega$$

$$-jX_C$$

$$-j250$$

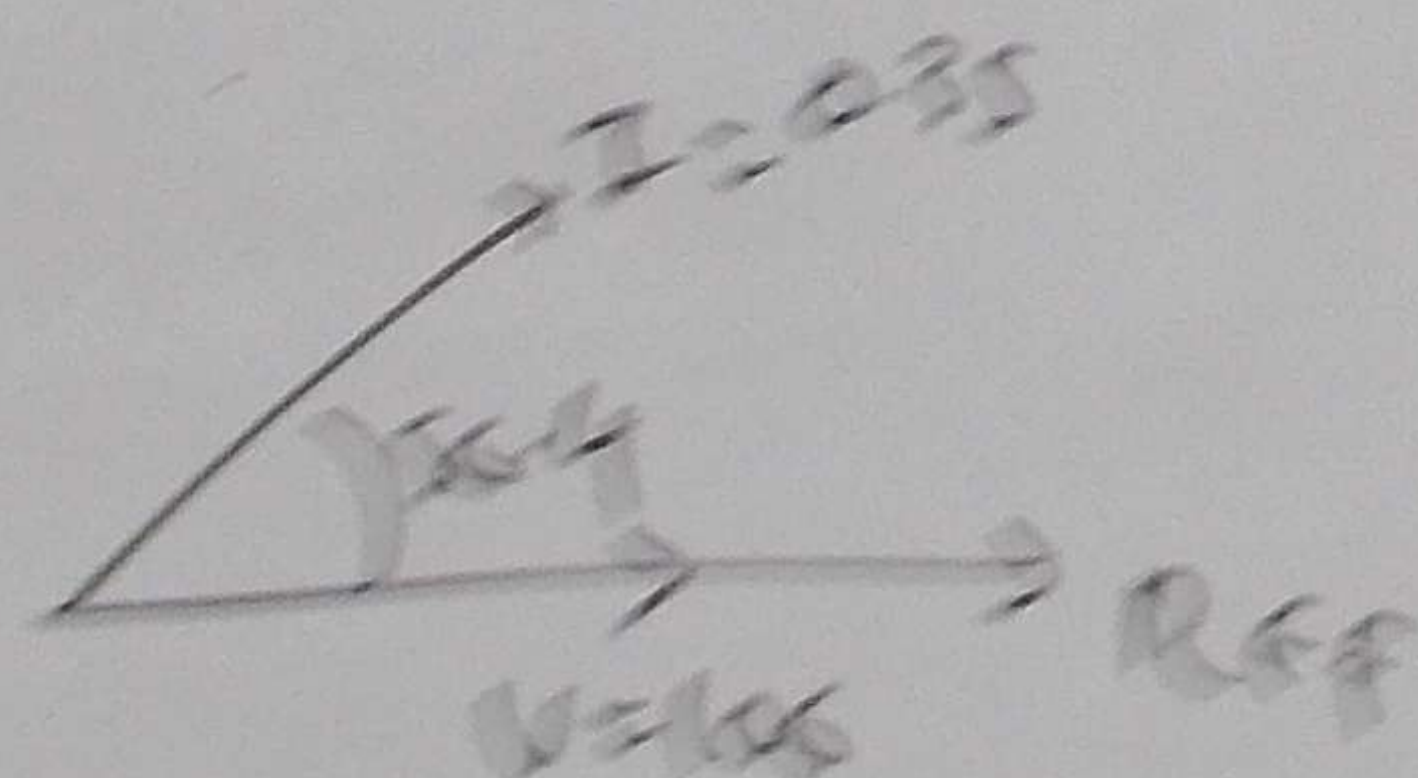
$$Z = \sqrt{150^2 + 250^2} \angle -\tan^{-1} \frac{250}{150}$$

$$= 300 \angle -56.4^\circ \Omega$$

$$I = \frac{V}{Z} = \frac{106}{300 \angle -56.4^\circ}$$

$$I = 0.35 \angle 56.4^\circ \text{ A}$$

$$(a) S = VI \angle \theta$$



$$S = 150 \times 0.35 \angle 56.4^\circ$$

$$= 37.45 \angle 56.4^\circ \text{ VA}$$

$$(b) P = S \cos \theta$$

$$= 37.45 \cos 56.4^\circ$$

$$= 20.7 \text{ WATT}$$

$$(c) Q = S \sin \theta$$

$$= 37.45 \sin 56.4^\circ$$

$$= 31.2 \text{ VAR}$$

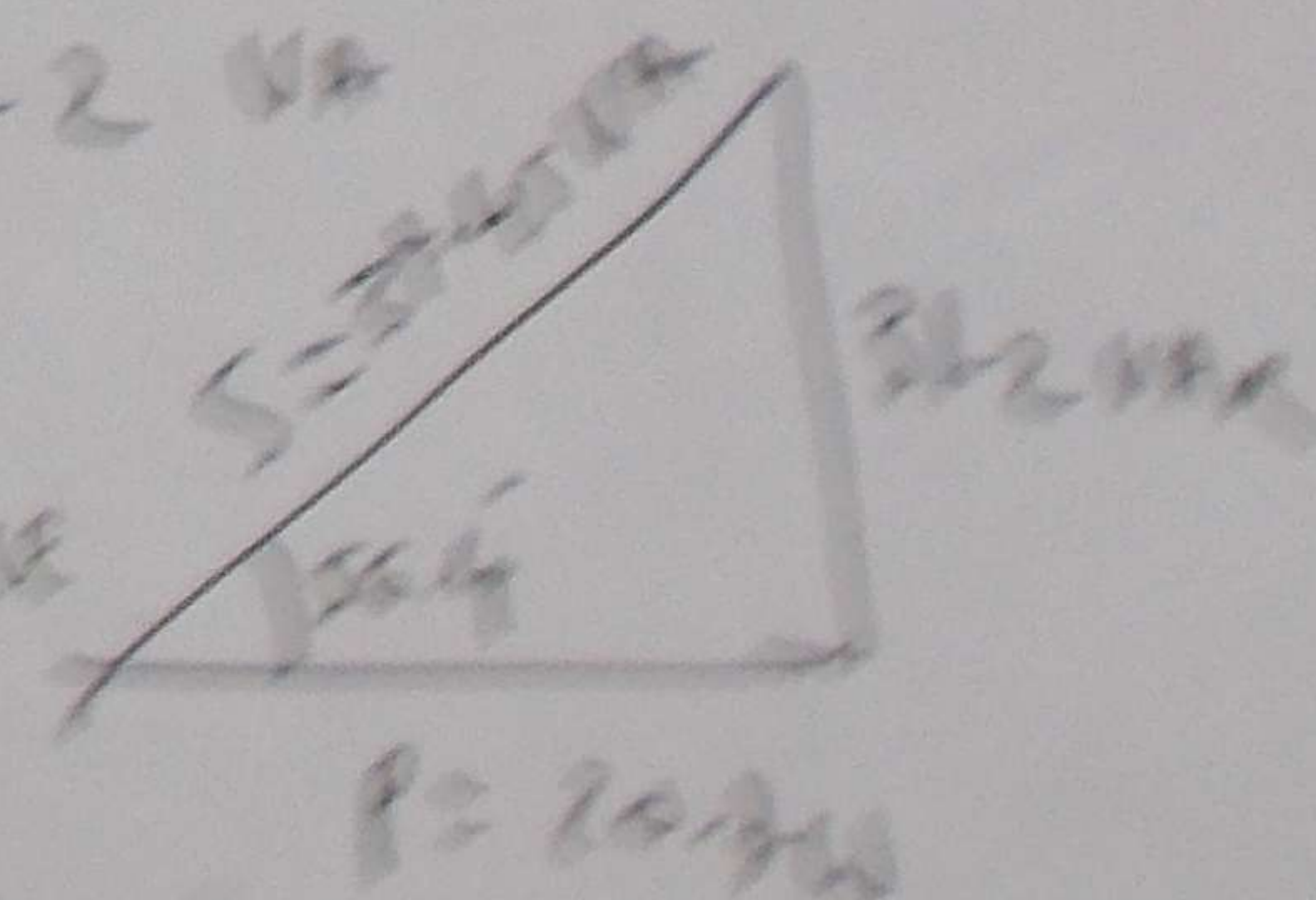
$$\text{PF LEADING} = \cos 56.4^\circ$$

$$= 0.55 \text{ LEADING}$$

$$S = P + jQ$$

$$= 20.7 + j31.2 \text{ VA}$$

POWER TRIANGLE



Ex 1.14

1. Calculate the

2. Calculate the

3. Calculate the

4. Calculate the

5. Calculate the

6. Calculate the

7. Calculate the

8. Calculate the

9. Calculate the

10. Calculate the

$$-\tan^{-1} \frac{250}{166}$$

$$.4 \Omega$$

$$106$$

$$300 \angle -56.4$$

$$0.35 \angle 56.4 \text{ A}$$

$$\frac{V}{I}$$

$$0.35$$

$$\rightarrow R_{eff}$$

$$0.35 \angle 56.4$$

$$.45 \angle 56.4 \text{ VA}$$

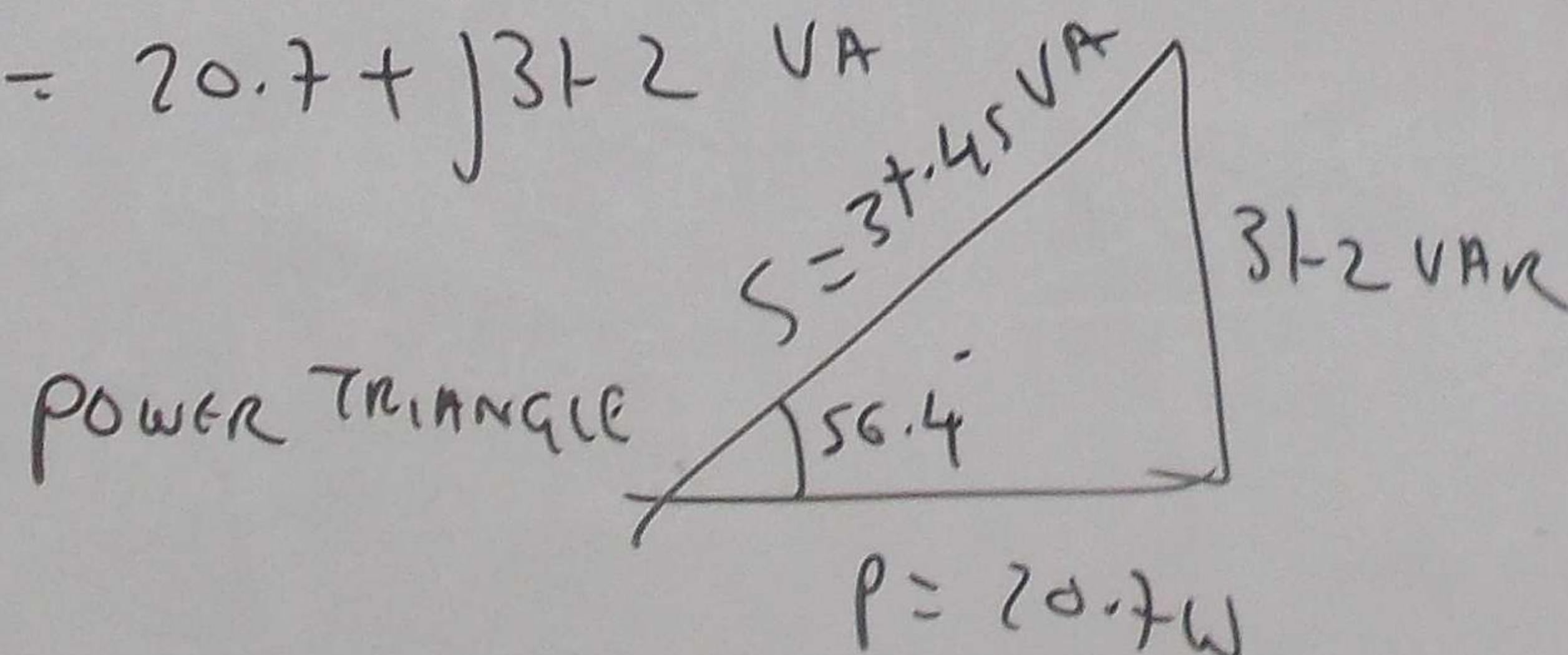
$$\begin{aligned} (b) P &= S \cos \alpha \\ &= 37.45 \cos 56.4 \\ &= 20.7 \text{ WATT} \end{aligned}$$

$$\begin{aligned} (c) Q &= S \sin \alpha \\ &= 37.45 \sin 56.4 \\ &= 31.2 \text{ VAR} \end{aligned}$$

$$\begin{aligned} \text{PF LEADING} &= \cos 56.4 \\ &= 0.55 \text{ LEADING} \end{aligned}$$

$$S = P + jQ$$

$$= 20.7 + j31.2 \text{ VA}$$



EXERCISE

A VOLTAGE $V = 270 \sin(3000t)$

IS APPLIED TO CIRCUIT

RESISTANCE = 200Ω

CAPACITANCE = $6 \mu\text{F}$

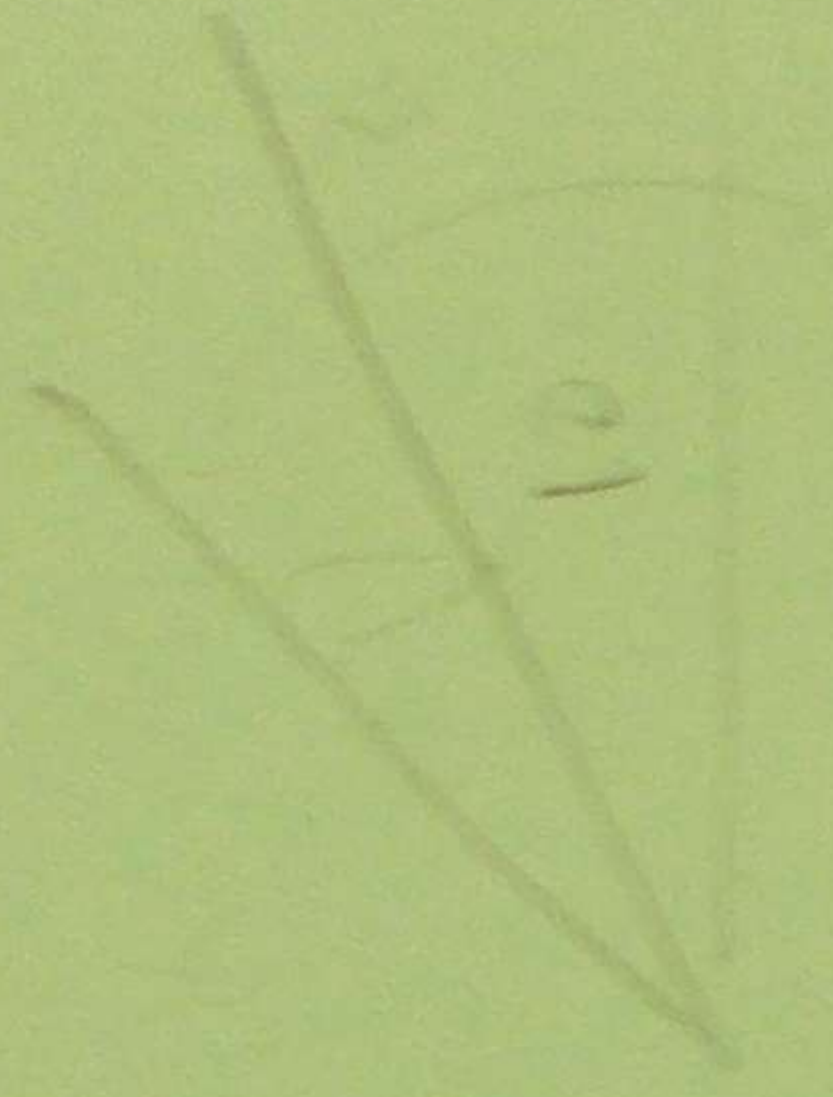
CALCULATE

(a) S (b) P (c) Q

(d) P.F (e) POWER TRIANGLE

Archer CHU 003789095

(a) RC circuit, $E_{rms} = 300 \angle 10^\circ V$
 $I_{rms} = 20 \angle 30^\circ A$

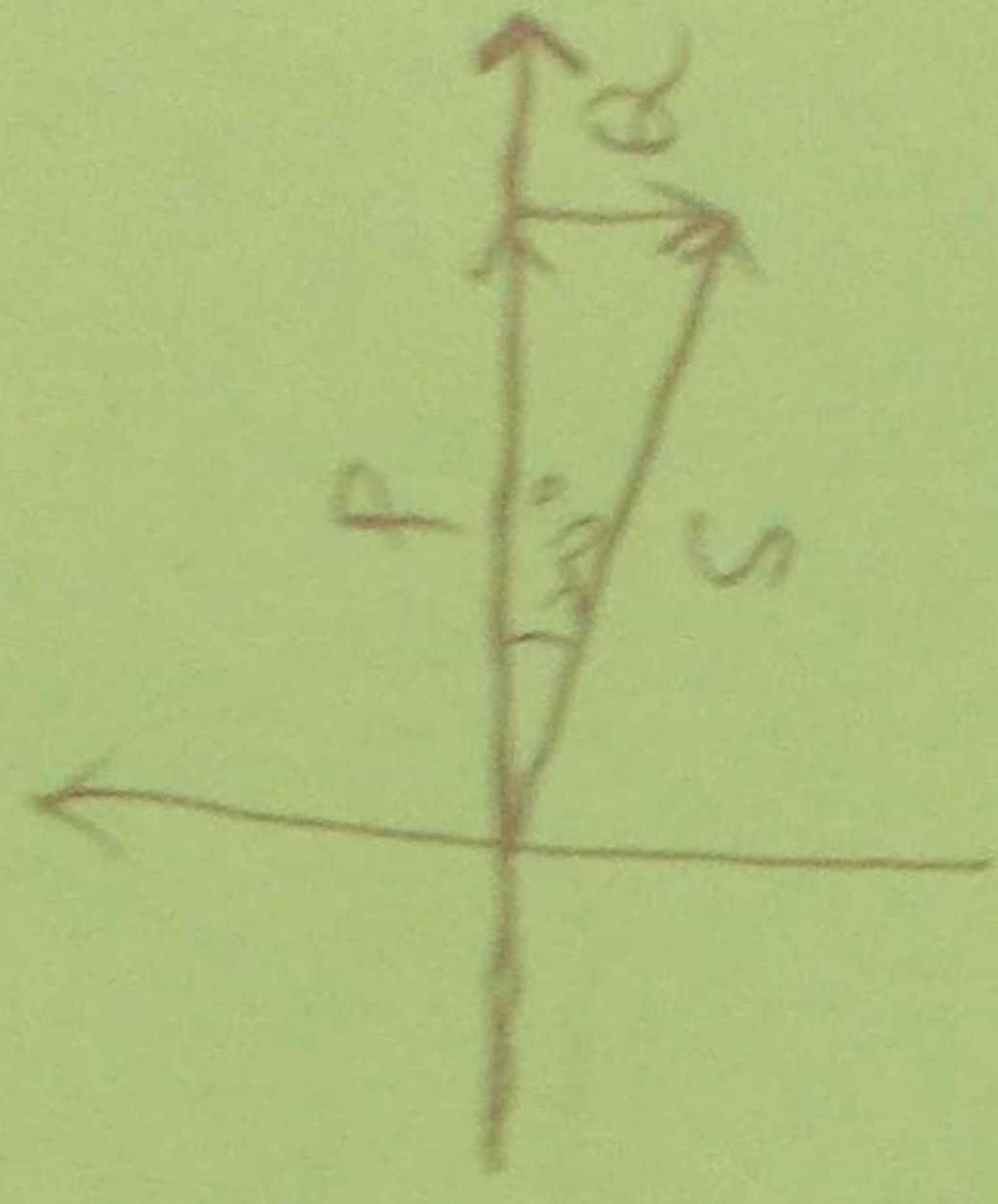


$$S = EI = 6000 \angle -20^\circ \text{ (VA)}$$

(b) $P = 6000 \times \cos(-20^\circ) = 5638.16 \text{ (W)}$

(c) $Q = 6000 \times \sin(-20^\circ) = -2052.12 \text{ (Var)}$

(d) $P.F. = \cos(20^\circ) = 0.94 \text{ (Leading)}$



$$Z = 50 \angle 37^\circ$$

$$V_{rms} = 1000 \angle 0^\circ V$$

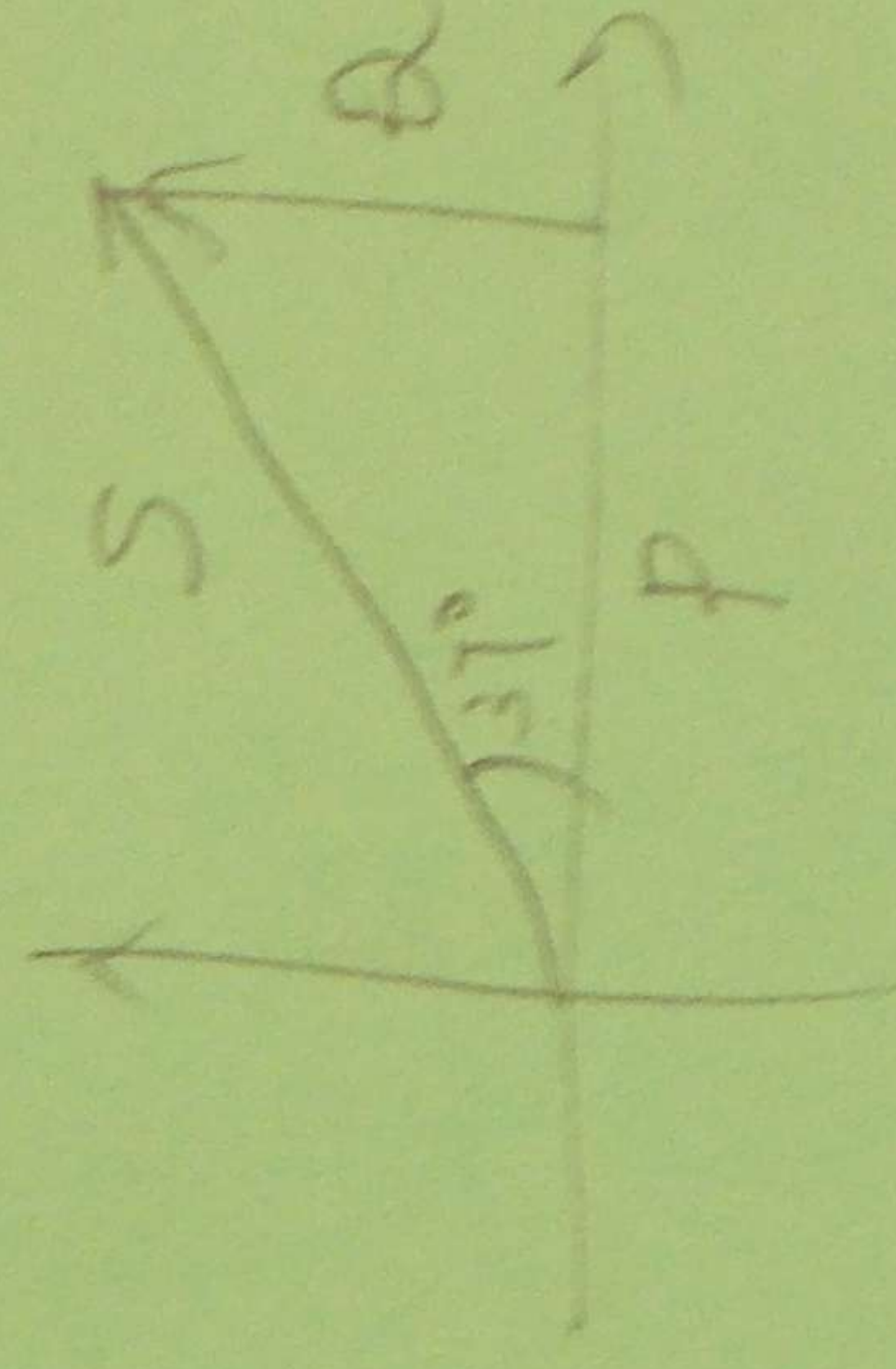
$$I = 20 \angle -37^\circ$$

(a) $S = \vec{V} \vec{I}^* = 20 \angle 37^\circ \text{ (kVA)}$

(b) $P = 20 \cos 37^\circ = 16 \text{ (kW)}$

(c) $Q = 20 \sin 37^\circ = 12 \text{ (kVar)}$

(d) $\cos 37^\circ = 0.8 \text{ (Lagging)}$
 P.F.:



$$V = 270 \sin(3000t)$$

$$R = 200 \Omega, C = 6 \mu F$$

(a) $\omega = 2\pi f = 3000 \text{ (rad/s)}$

$$V_{rms} = \frac{270}{\sqrt{2}} = 190.92 \angle 0^\circ \text{ (V)}$$

$$X_C = \frac{1}{\omega C} = \frac{1}{(3000 \times 6 \times 10^{-6})} = 55.56 \text{ (}\Omega\text{)}$$

$$Z = 200 - j55.56$$

$$= 207.6 \angle -15.5^\circ$$

$$I = \frac{190.92 \angle 0^\circ}{207.6 \angle -15.5^\circ}$$

$$= 0.92 \angle 15.5^\circ$$

(a) $S = VI = (190.92) \times (0.92)$

$$= 175.6 \angle -15.5^\circ \text{ (VA)}$$

(b) $P = S \cos(-15.5^\circ)$

$$= 169.3 \text{ (W)}$$

(c) $Q = S \sin(-15.5^\circ)$

$$= -47 \text{ (Var)}$$

(d) $P.F. = \cos(-15.5^\circ)$

$$= 0.964 \text{ (Leading)}$$

A.C

ERICK MATIAS 803737703

23) P.C. circuit $E_{rms} = 200 \angle 10^\circ V$, $I_{rms} = 20 \angle 30^\circ A$

a) S b) P c) Q d) Power factor



$$\begin{aligned} \text{a) } S &= E_{rms} \times I_{rms} \angle \theta \\ &= 200 \times 20 \angle 10-30 \\ &= 4000 \angle -20 \text{ V.A} \end{aligned}$$

$$\begin{aligned} \text{b) } P &= S \cos \theta \\ &= 4000 \cos -20 \\ &= 3759.1 \text{ Watts} \end{aligned}$$

$$\begin{aligned} \text{c) } Q &= E \times I \sin \theta \\ &= 4000 \sin -20 \\ &= -1369.21 \text{ VAR} \end{aligned}$$

$$\begin{aligned} \text{d) Power factor} &= \cos \theta \\ &= \cos -20 \\ &= 0.94 \text{ Leading} \end{aligned}$$

$$\begin{aligned} R &= 20 \angle 45^\circ + j30 \quad E_{rms} = 1000 V \\ Z &= \sqrt{R^2 + X^2} \angle \theta = 40 \angle 36.87^\circ \\ I &= \frac{E}{Z} = \frac{1000}{40} \angle 10-36.87 = 25 \angle -26.87^\circ \text{ Leading} \end{aligned}$$

$$\begin{aligned} S &= E \times I \angle \theta \\ &= 1000 \times 25 \angle 10-(-26.87) \\ &= 25000 \angle 36.87 \text{ V.A} \end{aligned}$$

$$\begin{aligned} P &= S \cos \theta \\ &= 25000 \cos 36.87 = 19999.92 \text{ Watts} \end{aligned}$$

$$\begin{aligned} Q &= S \sin \theta \\ &= 25000 \sin 36.87 = 15000 \text{ VAR} \end{aligned}$$

$$\begin{aligned} S &= P + jQ \\ &= 19999.92 + j15000 \end{aligned}$$

$$\begin{aligned} \text{Power factor} &= \cos \theta \\ &= \cos 36.87 \\ &= 0.8 \text{ Leading} \end{aligned}$$

A.C

ERICK MATIAS 803737703

1) $V = 270 \sin(3000t)$ $R = 200 \Omega$, $C = 6 \mu F$

a) S b) P c) Q d) P.f e) power triangle

a) $S = E \times I \angle \theta$

$$E = \frac{270}{\sqrt{2}} = 190.92 \angle 0$$

$$X_C = \frac{1}{\omega C} = \frac{1}{3000 \times 6 \times 10^{-6}} = \frac{10^3}{18} = 55.56 \Omega$$

$$\begin{aligned} Z &= 200 - j55.56 \\ &= \sqrt{200^2 + 55.56^2} \angle -15.52^\circ = 207.57 \angle -15.52^\circ \end{aligned}$$

$$\begin{aligned} I &= \frac{E}{Z} \\ &= \frac{190.92 \angle 0}{207.57 \angle -15.52} = 0.91 \angle 15.52^\circ \text{ Leading} \end{aligned}$$

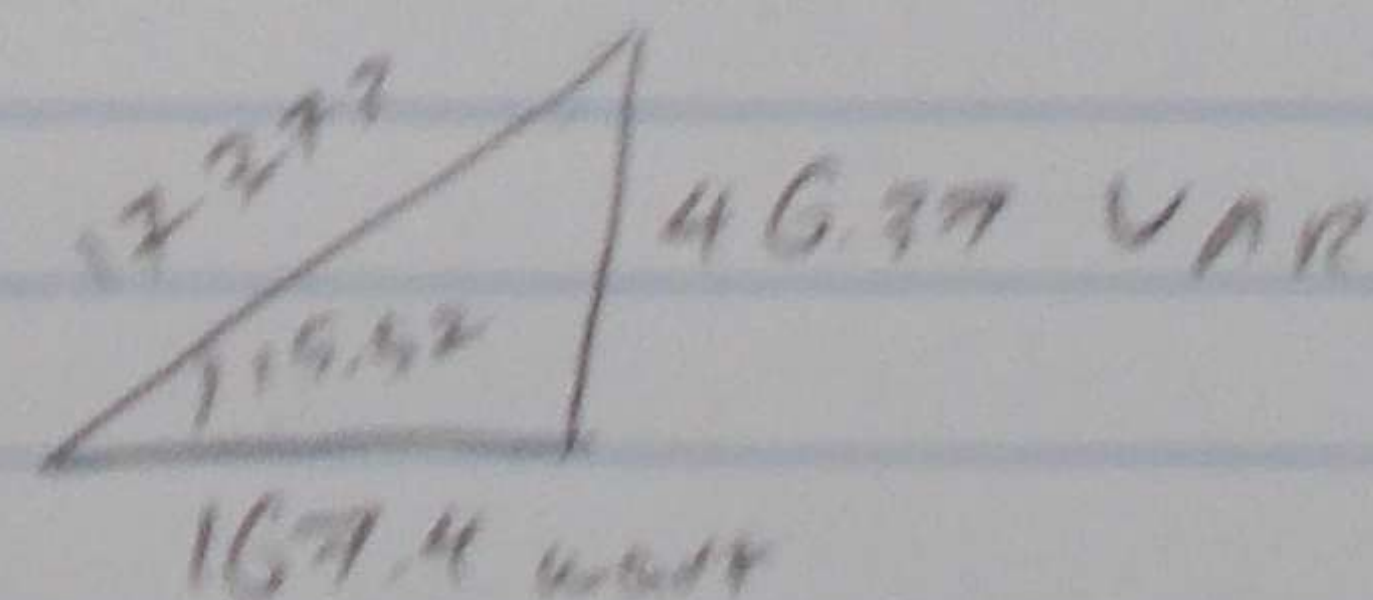
$$\begin{aligned} \text{a) } S &= 190.92 \times 0.91 \\ &= 173.73 \angle 15.52^\circ \text{ V.A} \end{aligned}$$

$$\begin{aligned} \text{b) } P &= S \cos \theta \\ &= 173.73 \cos 15.52^\circ \\ &= 167.4 \text{ Watts} \end{aligned}$$

$$\begin{aligned} \text{c) } Q &= S \sin \theta \\ &= 173.73 \sin 15.52^\circ \\ &= 46.37 \text{ VAR} \end{aligned}$$

$$\begin{aligned} \text{d) } P.f &= \cos \theta \\ &= \cos 15.52^\circ = 0.96 \text{ Leading} \end{aligned}$$

e) Power triangle



$$V = 270 \sin(3000t)$$

$$R = 200 \Omega$$

$$C = 6 \mu F$$

$$\omega = 2\pi f = 3000$$

$$V_{rms} = \frac{270}{\sqrt{2}} = 190.9$$

$$X_c = \frac{1}{\omega C}$$

$$= \frac{1}{3000 \times 6 \times 10^{-6}}$$

$$= 55.6 \Omega$$

$$Z = 200 - 55.6j$$

$$= \sqrt{200^2 + 55.6^2} \angle \tan^{-1} \frac{55.6}{200}$$

$$= 207.58 \angle -15.5$$

$$I = \frac{190.9}{207.58 \angle -15.5} = 0.92 \angle 15.5$$

$$a) S = VI \angle \theta_v$$

$$S = 190.9 \times 0.92 \angle 15.5$$

$$= 175.6 \angle 15.5$$

$$b) S_{avg}$$

$$= 175.6 \cos 15.5 = 169.2$$

$$c) S \sin \theta$$

$$= 175.6 \sin 15.5$$

$$= 46.9$$

$$\text{Leading} = \cos 15.5$$

$$= 0.96$$

$$d) S = P + jQ$$

$$= 169.2 + j46.9$$

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EXERCISE

A VOLTAGE $V = 270 \sin(3000t)$

IS APPLIED TO CIRCUIT

RESISTANCE = 200Ω

CAPACITANCE = $6 \mu F$

CALCULATE

(a) S (b) P (c) Q

(d) P.F (e) POWER TRIANGLE

Prob

A $50V$ RMS VOLTAGE SUPPLIES A SERIES CIRCUIT WHICH CONSISTS OF A 3Ω RESISTOR, 6Ω INDUCTOR AND 2Ω CAPACITOR.

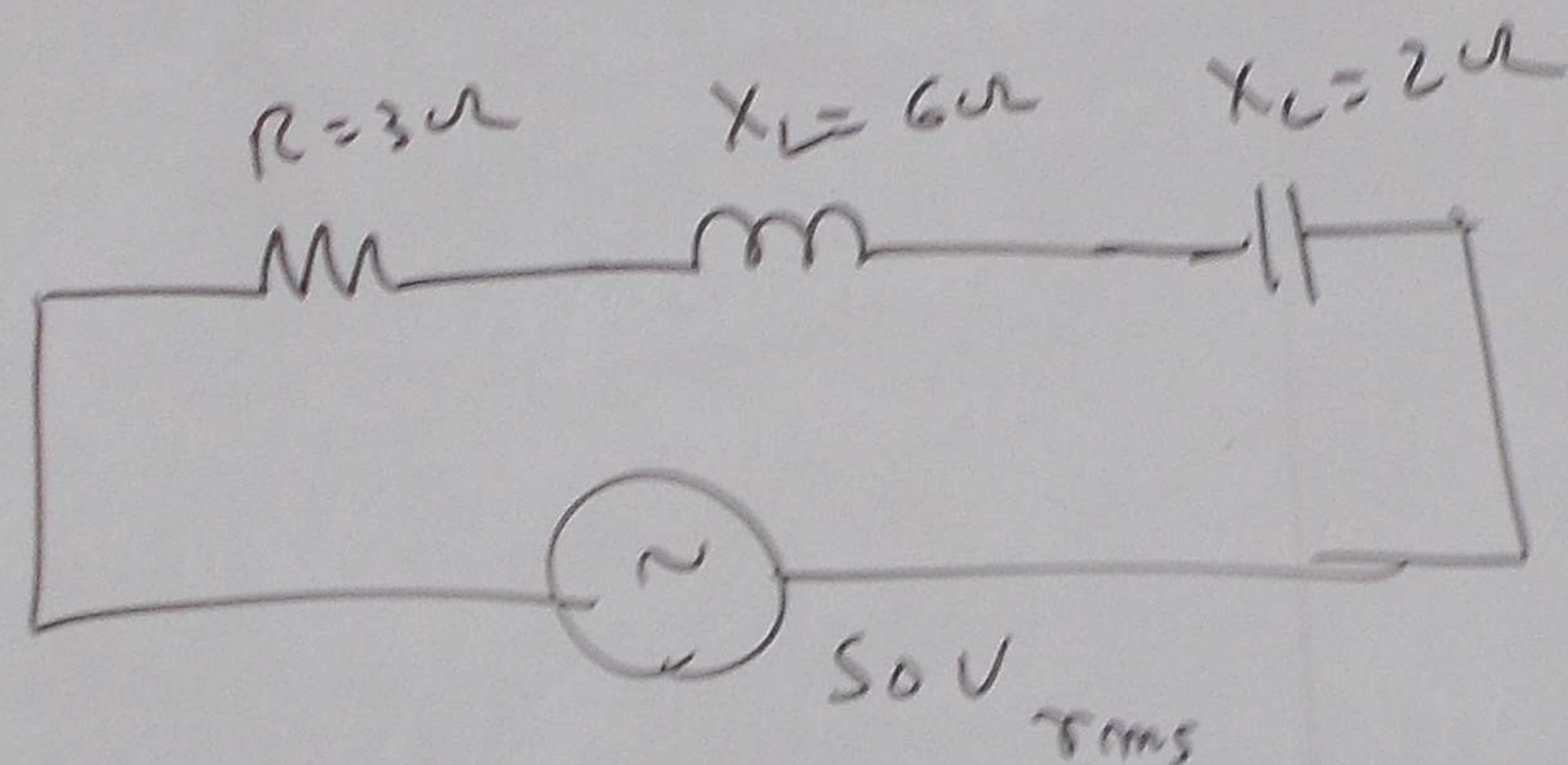
CALCULATE

(a) APPARENT POWER (V.A)

(b) REAL POWER (WATT)

(c) REACTIVE POWER (VAR)

(d) CIRCUIT POWER FACTOR.

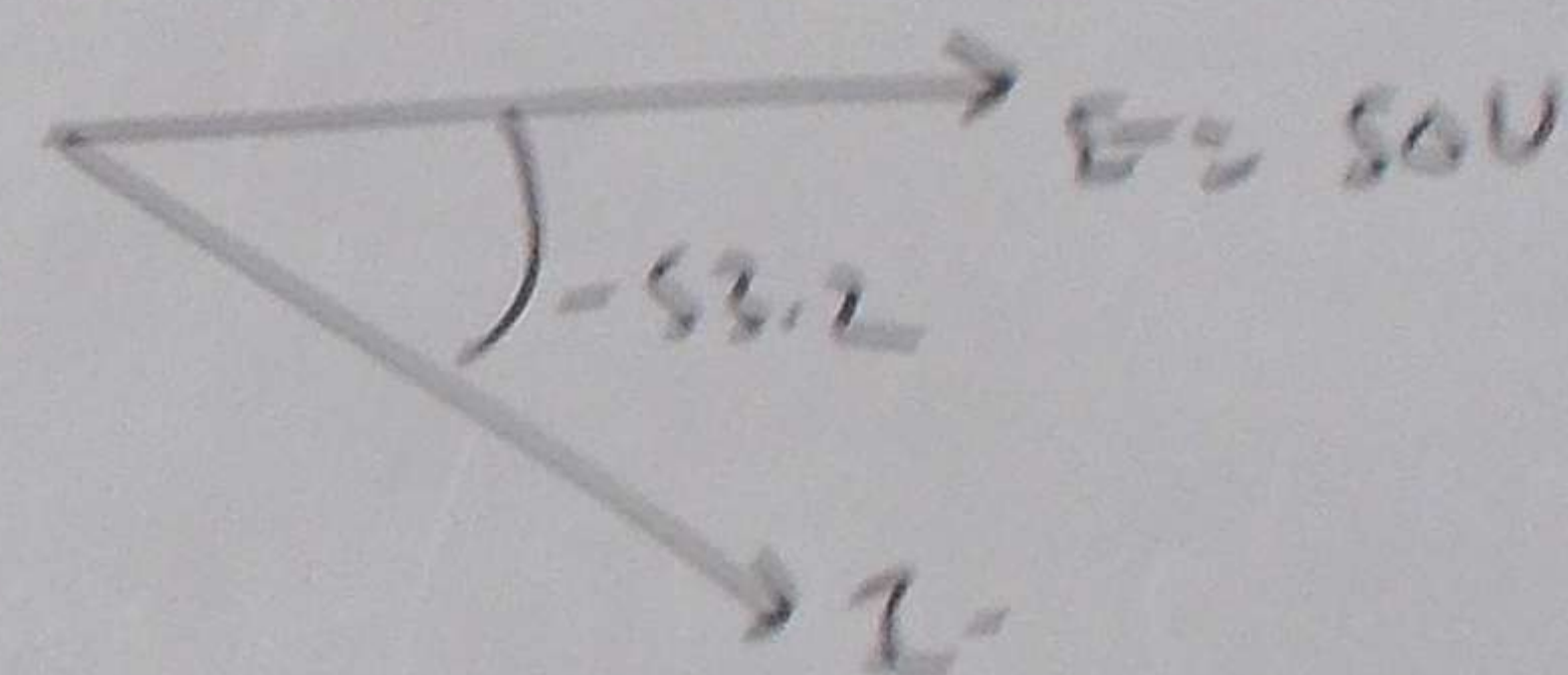


$$\begin{aligned} Z &= R + j(X_L - X_C) \\ &= 3 + j(6 - 2) \\ &= 3 + j4 \end{aligned} \quad \left| \quad \begin{aligned} Z &= \sqrt{3^2 + 4^2} \angle \tan^{-1} \frac{4}{3} \\ &= 5 \angle 53.2^\circ \Omega \end{aligned} \right.$$

$$\begin{aligned} I &= \frac{E}{Z} \\ &= \frac{50 \angle 0^\circ}{5 \angle 53.2^\circ} \end{aligned}$$

$$= 10 \angle -53.2^\circ A$$

$$\begin{aligned} (a) S &= V I \angle \theta \\ &= 50 \times 10 \angle -53.2^\circ \end{aligned}$$



$$S = 500 \angle -53.2^\circ VA$$

$$\frac{L_0}{S_{3.2}}$$

$$\frac{-53.2^\circ}{V}$$

$$E = 50V$$

$$S = 500 \angle -53.2^\circ VA$$

$$P = VI \cos \theta$$

$$= 500 \cos(53.2)$$

$$= 300 \text{ WATT}$$

$$Q = VI \sin \theta$$

$$= 500 \sin(-53.2)$$

$$= -400 \text{ VAR}$$

$$S = P + jQ$$

$$= 300 - j400 \text{ VA}$$

$$PF = \cos(-53.2)$$

$$= 0.6 \text{ LAGGING}$$

EXERCISE

100 V rms RESISTANCE = 5Ω

INDUCTOR 8Ω CAPACITOR 3Ω

Find (a) S (b) P (c) Q (d) PF

Archer CH10

$$\vec{V}_{ba} = 100 \angle 0^\circ \text{ V}$$

$$\begin{cases} R = 5 \Omega \\ X_L = 8 \Omega \\ X_C = 3 \Omega \end{cases}$$

$$Z = 5 + 8j - 3j$$

$$= 5 + 5j = 5\sqrt{2} \angle 45^\circ$$

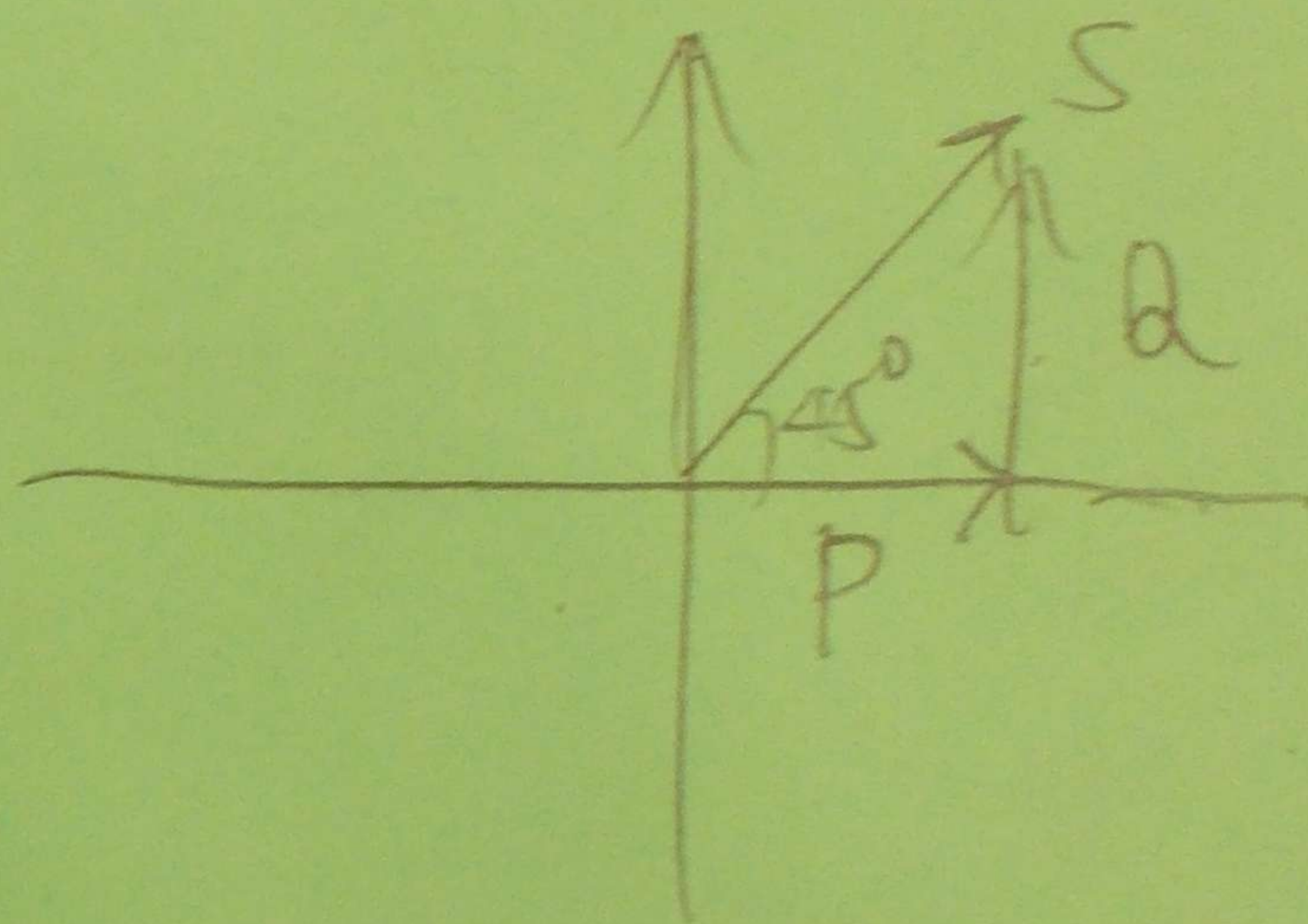
$$I = \frac{V}{Z} = 14.14 \angle -45^\circ$$

$$(a) S = VI = \underline{1.414} \angle 45^\circ \text{ (kVA)}$$

$$(b) P = 1 \text{ (kW)}$$

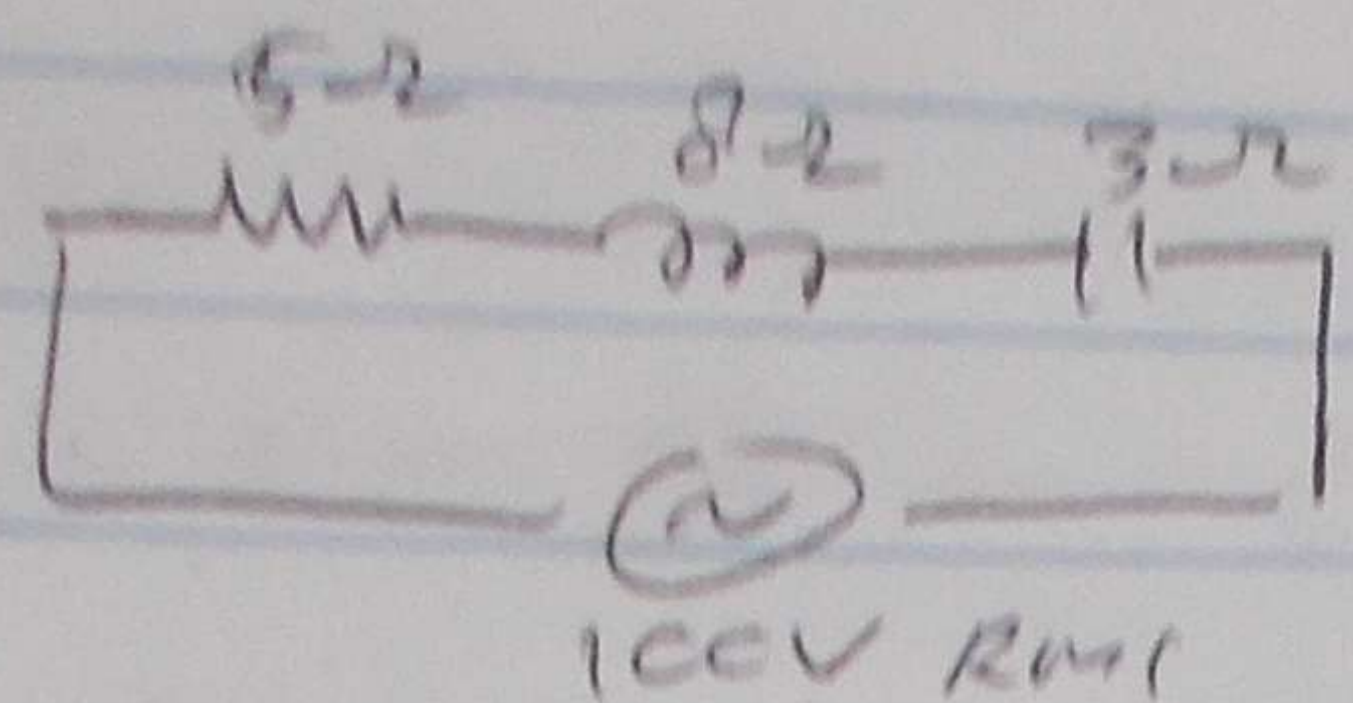
$$(c) Q = 1 \text{ (kvar)}$$

$$(d) \text{PF} = \frac{P}{S} = 0.707 \text{ (Lagging)}$$



A.C

ERICK MATIAS 803737703



(a) S (b) P

(c) Q (d) Pf

$$Z = 5 + j8 - j3$$

$$= 5 + j5 = \sqrt{5^2 + 5^2} \angle \tan^{-1} \frac{5}{5} = 7.07 \angle 45^\circ$$

$$I = \frac{100 \angle 0}{7.07 \angle 45} = 14.14 \angle -45 \text{ A}$$

(a) $S = E \cdot I$

$$= 7.07 \cdot 14.14 \angle -45$$

$$= 99.96 \angle -45 \text{ VA}$$

(b) $P = S \cdot \cos \theta$

$$= 99.96 \cos -45 = 7.04 \text{ watt}$$

(c) $Q = S \cdot \sin \theta$

$$= 99.96 \sin -45$$

$$= -70.68 \text{ VAR}$$

$$S = 7.04 - j 70.68$$

(d) $Pf = \cos \theta$

$$= \cos -45$$

$$= 0.7 \text{ Lagging}$$

$$Z = R + j(X_L - X_C)$$

$$= 5 + j(8 - 3)$$

$$= 5 + 5j$$

$$Z = 7.07 \angle 45^\circ$$

$$I = \frac{E}{Z} = \frac{100}{7.07 \angle 45^\circ} = 14.14 \angle -45^\circ$$

$$\begin{aligned} a) S &= VI \angle \theta_z^\circ \\ &= 100 \times 14.14 \angle -45^\circ \\ &= 1414 \angle -45^\circ \end{aligned}$$

$$\begin{aligned} P &= VI \cos \theta \\ &= 1414 \cos(-45^\circ) \\ &= 999.8 \end{aligned}$$

$$\begin{aligned} Q &= VI \sin \theta \\ &= 1414 \sin(-45^\circ) \\ &= -999.8 \text{ VAR} \end{aligned}$$

$$\begin{aligned} S &= P + jQ \\ &= 999.8 - 999.8j \end{aligned}$$

$$\begin{aligned} PF &= \cos -45^\circ \\ &= 0.707 \text{ Lagging} \end{aligned}$$

$$\begin{aligned} c) S \sin \theta \\ &= 175.6 \sin 15.5^\circ \\ &= 46.9 \end{aligned}$$

$$\cos \theta = \cos 15.5^\circ$$

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