Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept

1 a) i) Cycle : " In a sinusoidal AC waveform each repetition consisting of one positive and one identical negative part is called as one cycle of the waveform." 1 mark

ii) Time period : " Time period is defined as time in seconds for waveform of an AC quantity to complete one cycle. 1 mark

1 b) Given expression is, $i = 10 \sin (100 \Pi t)$

Comparing it with, $I = I_m \sin (2 \Pi f_0 t)$

we get , $I_m = 10$, $2 \Pi f_0 = 100 \Pi$

i) To calculate frequency: $2 \Pi f_0 = 100 \Pi$

$\therefore 2 f_0 = 100$

$\therefore f_0 = 50$ Hz 1 mark

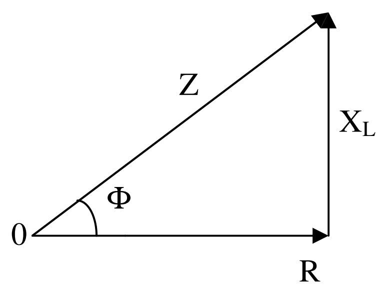
ii) To calculate I_{rms}: $I_{rms} = 0.707 I_m$

$\therefore I_{rms} = 0.707 \times 10 = 7.07$ A 1 mark

1 c) Definition: **Power factor** is defined as the ratio of true power and apparent power of an AC circuit. 1 mark

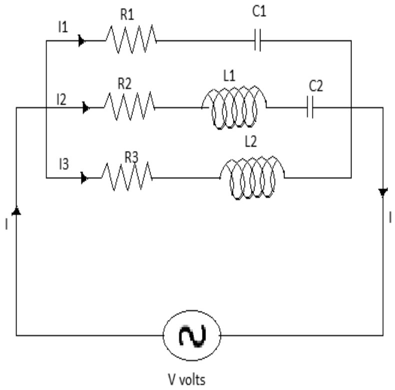
In case of R-L series circuit, power factor is lagging due to negative sign of Φ. 1 mark

1 d)



Labeled 2marks, unlabebed 1 mark

1 e) A parallel circuit has two or more series circuits connected parallel with each other across a common pair of nodes as shown in figure. The total current flowing into the parallel combination gets divided in inverse proportion to the impedance value. 1 mark



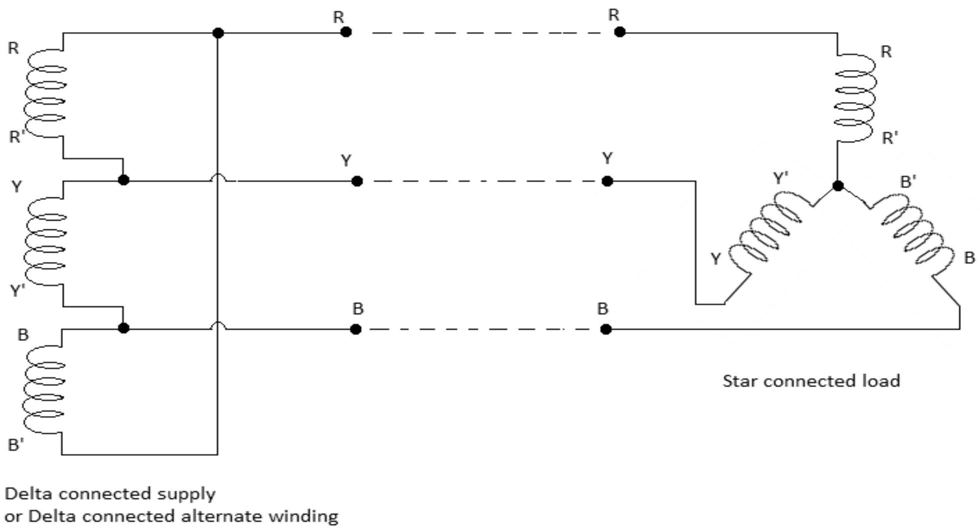
1 mark

1 f) There are two components of admittance:

i) Conductance(G): It is ratio of resistance(R) and squared impedance(Z^2) 1 mark

ii) Susceptance(B):): It is ratio of reactance(X) and squared impedance(Z^2) 1 mark

1 g)



Labeled 2 marks, unlabeled 1 mark

The delta connected windings of the supply side may belong to the sources or to the secondary of the transformer.

1 h) The mathematical equation for three phase voltages displaced by 120^0 is given by,

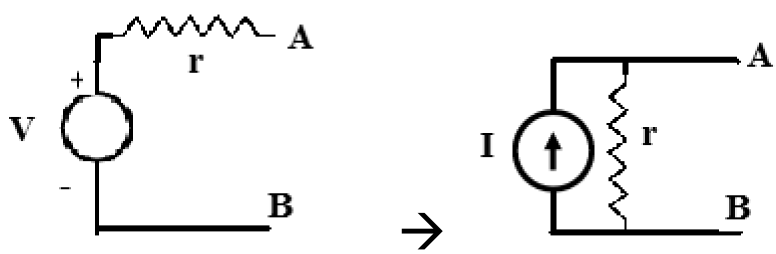
$V_R = V_m \sin \omega t$

$V_Y = V_m \sin (\omega t - 120^0)$ 1 mark

$V_B = V_m \sin (\omega t - 240^0)$ 1 mark

1 i) Steps to transform Voltage source to Current source:

1) Calculate equivalent current source as the short circuit current through the voltage source terminals: (I = V / r) 1 mark
2) The Shunt Resistance of current source: (R_{sh}= r)
3) Draw the equivalent source.



1 mark

1 j) Statement of Maximum Power transfer Theorem (for DC circuits):

"It states that, the maximum amount of power is delivered to the load resistance when the load resistance is equal to the Thevenin's equivalent source resistance of the

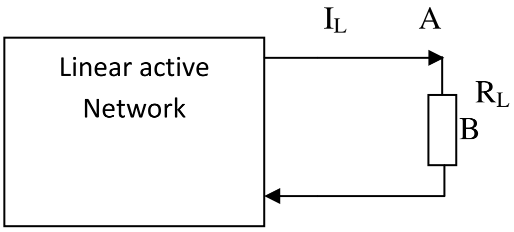
network supplying the power across the load terminals."
According to this theorem, condition for maximum power to be transferred is, $R_L = R_{TH}$, where R_{TH} = Thevenin's source resistance across R_L. 2 marks

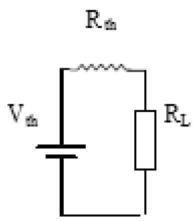
1 k) Statement of Thevenin's Theorem :
It states that current flowing through any resistance (referred as load resistance R_L) of an active, bilateral circuit can be calculated by Thevenin's theorem as

$$I_L = V_{th}/ (R_{th} + R_L)$$

1 mark

where,
V_{th} = the open circuit voltage measured across load terminals by removing the load resistance
R_{th} = the Thevenin's equivalent resistance measured across load terminals by removing the load resistance and replacing all sources by their internal resistances





1 mark

1 l) i) At the instant of switching (sudden or abrupt change in circuit condition), inductor (L) opposes the change in current in it and behaves as open circuit. 1 mark

ii) At the instant of switching (sudden or abrupt change in circuit condition), capacitor (C) opposes change in voltage across it and behaves as short circuit. 1 mark

2 a) Given equation is, e = 25 sin (314 t)

Comparing it with e = Vm sin(ωt)

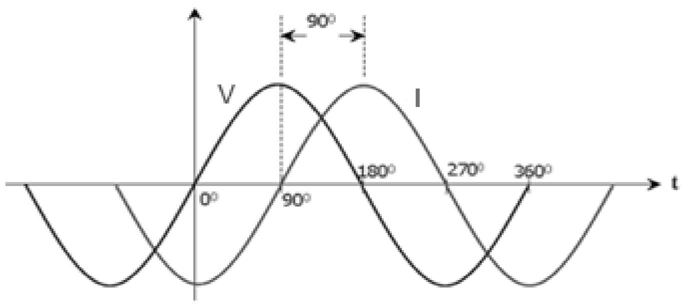
Amplitude $V_M = 25$ V 1 mark

RMS value = peak value/√2 = 25/√2 = 17.67 V. 1 mark

Frequency = ω/2π = 314/2π = 50 Hz. 1 mark

Time period = 1/frequency = 1/50 = 0.02 sec 1 mark

2 b)



1 mark

Fig. Waveform of voltage and current for purely inductive circuit.

Expression for supply voltage can be given by, $v = V_m \sin \omega t$

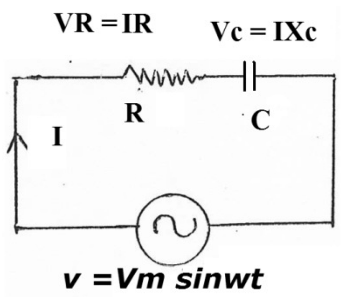
Now, Current in purely inductive circuit is, $I = (1/L) \int v dt$

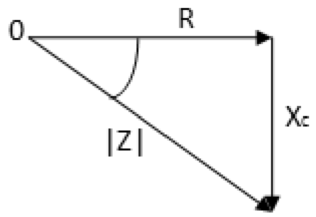
$\therefore\ I = (1/L)\ {}_0\int^{\Pi/2} V_m \sin(\omega t)dt$ 1 mark

$\therefore\ I = (V_m/\omega L) \sin (\omega t - \pi/2)$ 1 mark

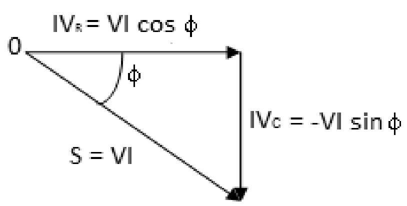
$\therefore\ I = I_m \sin (\omega t - \pi/2)$. 1 mark

2 c) R-C Series Circuit: Circuit 1 mark,





Impedance triangle 1 mark,



Power Triangle

Power triangle 2 marks.

2 d) Formula/Expression for:

1) Active power: $P = VI\cos\phi$. (W) — 1 mark

2) Reactive power: $Q = VI\sin\phi$. (VAR) — 1 mark

3) Apparent power: $S = V\ I$. (VA) — 1 mark

4)

$$\text{Power Factor} = \frac{\text{Active power (P)}}{\text{Apparent power (S)}}$$
— 1 mark

2 e) i) Given : $Z = 25 \angle -45^0 \Omega$

Let us convert it to rectangular form, $r = 25$ & $\theta = -45^0$

Its rectangular form is, $Z = 25\cos 45^0 - j\,25\sin 45^0$

$= (17.67 - j\,17.67)$ ohm

Comparing it with $Z = R + jX$

Resistance (R) = 17.67 Ω and X_C = 17.67 Ω — 1 mark

Taking f=50 Hz, $Xc = 1/(2\pi f C)$.

$C = 1/(2\pi \times 50 \times) = 1.800 \times 10^{-4}$ F = 180 μF. — 1 Mark

ii) Given : $Z = 10 - j15\ \Omega$

∴ Resistance (R) = 10 Ω and X_C = 15Ω — 1 mark

$Xc = 1/(2\pi fC)$, $C = 1/(2\pi f\, Xc)$

$C = 1/(2\pi \times 50 \times 15) = 2.1231 \times 10^{-4}$ F = 212.31 μF. — 1 mark

2 f) Given: R = 75 Ω, C = 60 μF = 60×10^{-6} F , voltage = 230 V, f= 50 Hz

i) $X_C = 1 / (2\pi f C)$

$= 1 / (2 \times \pi \times 50 \times 60 \times 10^{-6})$

$= 53.05\ \Omega$ — 1 mark

ii) Now, $|Z| = \sqrt{(R^2 + X_C^{\ 2})}$

$= \sqrt{(75^2 + 53.05^2)}$

$= \sqrt{(5625 + 2814.3)}$

$= 91.87\ \Omega$

∴Current = Voltage / Impedance

= 230 / 91.87

= 2.5 A. — 1 Mark

iii) Power factor = $\cos\phi = R / |Z|$

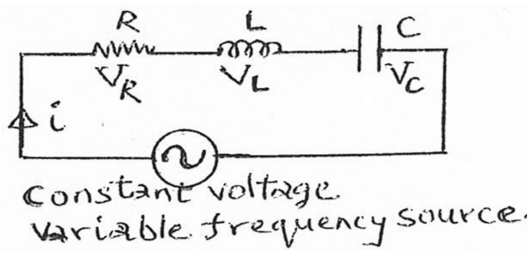
= 75 / 91.87

= 0.816 lead. — 1 mark

iv) Active power = $VI\cos\phi = 230 \times 2.5 \times 0.816$

= 469.2 Watt — 1 mark

3 a) Resonance in series RLC circuit:

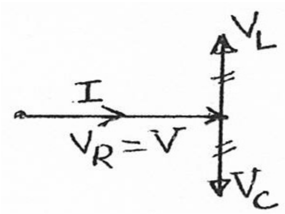


As the frequency is increased from zero towards higher values at a certain frequency f_O, $X_L = X_C$ and the net reactance of the circuit becomes zero. This is resonance condition. At resonance the voltages across the inductive reactance and capacitive reactance (X_L and X_C) are equal and opposite in phase.

$V_L = - V_C$ and hence $V_L + V_C = 0$, (phasor addition). 1 mark

Also $Z = \sqrt{[R^2+(X_L - X_C)^2]}$ and $V = \sqrt{[V_R^2+(V_L - V_C)^2]}$

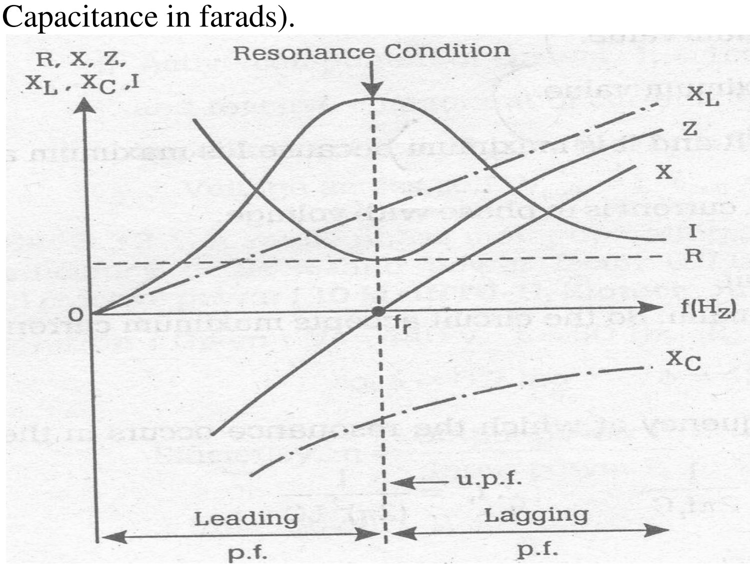
Give $V = V_R$.



1 mark

Hence the supply voltage applied is across the resistance R, $V = V_R$.
The impedance is minimum at resonance.
Current is max. = $I_O = V/R$. And is in phase with applied voltage.
As $X_L = X_C$, we have $2\pi f_O L = 1/(2\pi f_O C)$ which gives us

$f_O = 1/[2\pi\sqrt{(LC)}]$. (Where L = coefficient of inductance in henry, and C = Capacitance in farads). 1 mark



1 mark

3 b) Compare series and parallel resonant circuits: (any four points)

	Parameter	Series resonant circuit	Parallel resonant ckt
1	Impedance	minimum = R	maximum = L/(CR)
2	Current	maximum= V/R	minimum = V/(L/CR)
3	Resonant frequency	$f_r=1/[2\pi\sqrt{(LC)}]$	$f_r=(1/2\pi)\sqrt{\{[1/(LC)]-(R^2/L^2)\}}$
4	Power factor	Unity	unity
5	Magnification	Voltage	current
6	Q	$(1/R)[1/\sqrt{(LC)}]$	$(1/R)[1/\sqrt{(LC)}]$

1 mark each point any four = 4 marks

3 c) Impedance $Z_1= (8+j6)\ \Omega = 10 \angle 36.87^0$, Impedance $Z_2 = (4+j4)\ \Omega = 5.66\angle 45^0$

i) Branch Current $(i_1) = V/Z_1$

$= 200 \angle 0/ 10\angle 36.87$

$= 20 \angle -36.87^0 A$ 1 mark

ii) Branch Current $(i_2) = V/Z_2$

$=200\angle 0 / 5.66\angle 45^0$

$35.34 \angle -45^0 A$ 1 Mark

iii) Total Impedance $Z_T = (Z_1 * Z_2) / (Z_1+ Z_2)$

$= (10\angle 36.87 *5.66 * \angle 45^0) / ((8 + j6)+(4+j4))$

$= 56.6\angle 81.87 / 15.62 \angle 39.81$

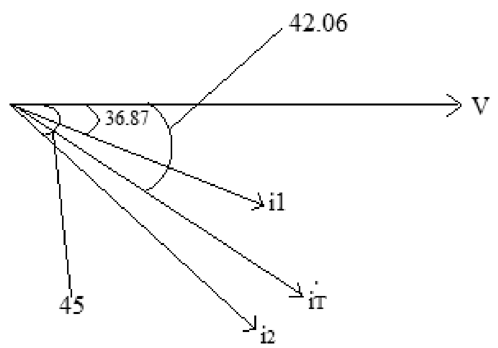
$= 3.62 \angle 42.06$. ohm

Total Current $i_T = V / Z_T$

$= 200\angle 0 / 3.62 \angle 42.06$

$= 55.25 \angle -42.06$ A 1 mark

Phasor Diagram



1 mark

3 d) Given : R = 100 Ω , L = 0.2 H , C = 150 μF , V = 230 V , f = 50 Hz.

Soln : $X_L = 2\pi fL$

$= 2\pi * 50 * 0.2$

$= 62.8\ \Omega$

$X_C = 1 / 2\pi fC$

$= 2\pi * 50 * 150 * 10^{-6}$

$= 1 / 47100 * 10^{-6}$

$= 21.23\ \Omega$

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

$= \sqrt{[100^2 + (62.8 - 21.23)^2]}$

$= \sqrt{[10000 + 1728.06]}$

$= 108.29\ \Omega$

Now, $I = V / Z$

$= 230 / 108.29$

$= 2.12$ A — 1 mark

Power factor $= \cos\Phi = R / Z$

$= 100 / 108.29$ — 1 Mark

$= 0.923$ (lag)

1 mark

Power factor is lagging because $X_L > X_C$

1 mark

Power consumed by ckt = $VI \cos\Phi = 230 * 2.12 * 0.923 = 450$ Watt

3 e) i) Taking i_2 as reference phasor,
i_3 is leading current — 1 mark
and i_1 is lagging current. — 1 mark

ii) i_1 lags behind i_3 by $(40+30) = 70^0$ — 2 marks

3 f) Given :

$V_L = 146.2$ volt, $V_R = 150$ volt, supply voltage V = 220 volt, f = 50Hz, I = 10A.

Sol^n: Total impedance of coil = Z = V/ I = 220 / 10 = 22 Ω

Series resistance $R = V_R / I = 150 / 10 = 15\ \Omega$

Now, total $|Z| = \sqrt{[(R + R_L)^2 + X_L^2]}$,

R_L & X_L = resistance & reactance of coil respectively,

$|Z|^2 = (R + R_L)^2 + X_L^2$

$\therefore 22^2 = (15 + R_L)^2 + X_L^2$

$\therefore 484 = 225 + 30 R_L + R_L^2 + X_L^2$

But, $R_L^2 + X_L^2 = Z_L^2$ where Z_L is impedance of coil

$\therefore 484 = 225 + 30R_L + Z_L^2$

$\therefore 259 = 30R_L + Z_L^2$

But, $Z_L = V_L / I$

$= 146.2 / 10$

$= 14.62\ \Omega$

$259 = 30R_L + (14.62)^2$

$30R_L = 45.2556$

i) $R_L = 1.51\ \Omega$ 1 Mark

Now, $X_L = \sqrt{(Z_L^2 - R_L^2])}$

$= \sqrt{[(14.62)^2 - (1.51)^2]}$

$= \sqrt{(213.74 - 2.28)}$

$= 14.54\ \Omega$

Now, $X_L = 2\pi f L$

ii) Inductance of coil, $L = X_L / (2\pi f) = 14.54 / (2\pi * 50)$.

$= 0.0463$ H 1 Mark

iii) Power consumed by coil, $P_L = I^2 * R_L$

$= 10^2 * 1.51$

$= 151$ watt 1 Mark

iv) P.F. of total circuit = R / Z

= 15 / 22

= 0.68 (lag) 1 Mark

4 a) Compare three phase system with single phase system (4 points)

Sr. No.	Parameter	Single Phase System	Three Phase System
1	Line Voltage	Low(230)	High(415V)
2	Transmission Efficiency	Low	High
3	Size of machine to produce same output	Larger	smaller
4	Cross sectional area of conductors (for equal power)	Larger	smaller
5	Application	Domestic, small power application	Industrial large power applications
6	No. of conductors	Two	Three or four

Any four points
1 Mark for each point

4 b) Given : $R = 15\Omega$, $L = 0.03$H, $V_L = 440$V, 50 Hz.

Soln : For delta connected load,

$V_{ph} = V_L = 440$ V

$Z_{ph} = R + jX_L$

$= 15 + j(2\pi * 50 * 0.03)$

$= 15 + j(9.42)$

$= 17.713 \angle 32.13^0$

i) Now, $I_{ph} = V_{ph} / Z_{ph}$

$= 440 / (17.713 \angle 32.13^0)$

$= 24.84 \angle -32.13^0$ 1 Mark

ii) $I_L = \sqrt{3} * I_{ph}$

$= \sqrt{3} * 24.8$

$= 42.95$ A 1 Mark

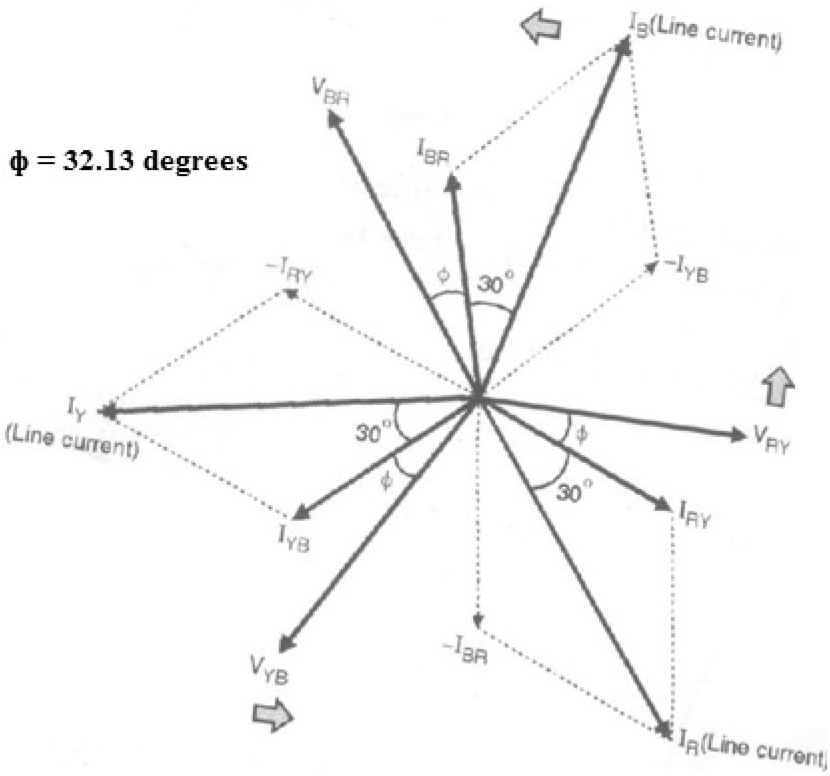
iii) Power consumed = $P = \sqrt{3}\ V_L\ I_L \cos\phi$

$= \sqrt{3} * 440 * 42.95 * \cos(32.13)$

$= 27722$ watt $= 27.722$ kW 1 Mark

iv)

ϕ = 32.13 degrees



Labeled phasor diagram

1 Mark

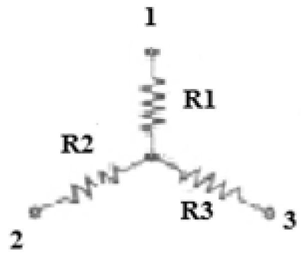
4 c) Given: Z_{ph}=(17.32+j10)Ω, 3Φ, f=50Hz, V_L=400V, Star connection.

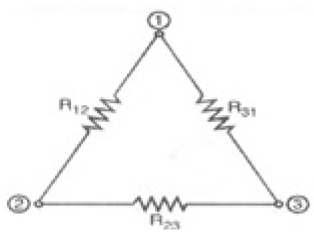
Solution:$Z_{ph}= \sqrt{(17.32^2 + 10^2)} = \sqrt{(299.98+100)} = 20\ \Omega$
$V_{ph} = V_L/\sqrt{3} = 400/\sqrt{3} = 230.94$ V
$I_{ph} = V_{ph} / Z_{ph} = 230.94/20 = 11.15$ A 1 Mark

Now, i) $\cos \Phi = R / |Z_{ph}| = 17.32/20 = 0.866$
ii) Power consumed = $3\ V_{ph}\ I_{ph} \cos \Phi$ = 3 * 230.94 * 11.55 * 0.866
= 6929.79 W 1 Mark

iii)For delta connection, $V_{ph} = V_L$ =400V
$I_{ph} = V_{ph} / Z_{ph}$ = 400/20 = 20A 1 mark
Power consumed = $3\ V_{ph}\ I_{ph} \cos \Phi$
= 3 * 400 * 20 * 0.866
= 20784 W 1 Mark

4 d)





We write expressions for equivalent resistances between corresponding terminals of the two networks and proceed.

Resistance between 1 and 2

for star = $R_1 + R_2$ = (for delta) = $\frac{R_{12}\,(R_{23} + R_{31})}{(R_{12} + R_{23} + R_{31})}$ ------(1)

Resistance between 2 and 3

for star = $R_2 + R_3$ = (for delta) = $\frac{R_{23}\,(R_{12} + R_{31})}{(R_{12} + R_{23} + R_{31})}$ ------(2)

Resistance between 3 and 1

1 mark

for star = $R_3 + R_1$ = (for delta) = $\frac{R_{31}\,(R_{12} + R_{23})}{(R_{12} + R_{23} + R_{31})}$ ------(3)

Subtracting (2) from (3) we get,

$R_1 - R_2 = \dfrac{R_{12}(R_{31} - R_{23})}{(R_{12}+R_{23}+R_{31})}$ ---------------------------(4)

Adding (1) and (4) and simplifying we get

$2R_1 = \dfrac{2R_{12}R_{31}}{(R_{12}+R_{23}+R_{31})}$, hence $R_1 = \dfrac{R_{12}R_{31}}{(R_{12}+R_{23}+R_{31})}$, 1 mark

Similarly $R_2 = \dfrac{R23\ R12}{R12+R23+R31}$ $R_3 = \dfrac{R31\ R23}{R12+R23+R31}$ --------------------(5)

From above expressions

$\dfrac{R_1}{R_2} = \dfrac{R_{31}}{R_{23}}$, $\dfrac{R_2}{R_3} = \dfrac{R_{12}}{R_{31}}$ and $\dfrac{R_3}{R_1} = \dfrac{R_{23}}{R_{12}}$ ----------------------(6) 1 mark

From (5) $R_{12} = [R_1(R_{12} + R_{23} + R_{31})/R_{31}]$

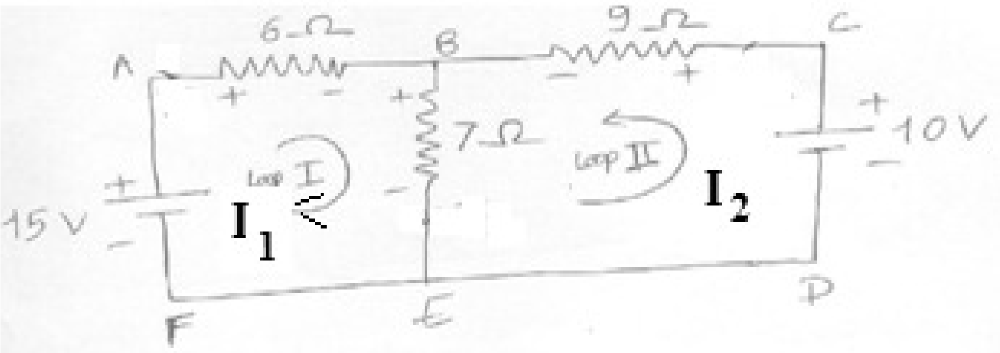
$= R_1(\dfrac{R_{12}}{R_{31}} + \dfrac{R_{23}}{R_{31}} + 1)$ 1 mark

Using (6) $R_{12} = R_1(\dfrac{R_2}{R_3} + \dfrac{R_2}{R_1} + 1) = (\dfrac{R_1R_2}{R_3} + R_2 + R_1)$.

Similarly we can write,

$R_{23} = (\dfrac{R_3R_2}{R_1} + R_2 + R_3)$ and $R_{31} = (\dfrac{R_3R_1}{R_2} + R_3 + R_1)$

4 e) Given circuit is



In loop ABEFA by KVL,

$13I_1+7I_2 = 15$ ……………….(1) Equations

In loop CBEDC by KVL, 1 and 2 =

$7I_1+16I_2= 10$ ………………. (2) 1 Mark,

Solving equations (1) & (2) we get

$I_2= 0.157$ A

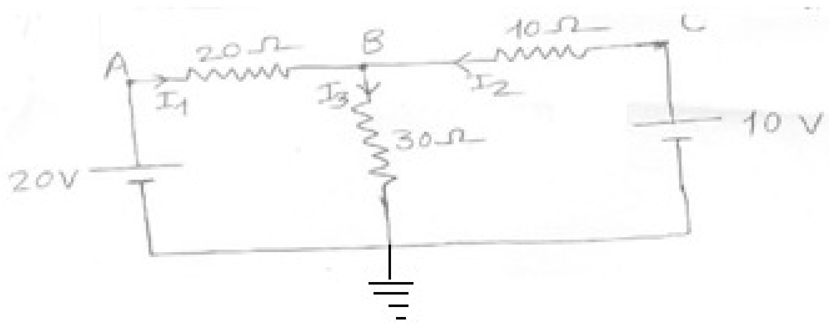
$I_1 = 1.07$ A 1 mark

$\therefore$ current through 7Ω resistance is $I_1 + I_2 = 1.227$ A. 1 Mark

1 mark

4 f) Given Circuit is

Students may determine current in any one of the three resistances to which marks will be awarded as given



Apply KCL at node B, $I_3 = I_1 + I_2$

But, $I_1 = (V_A - V_B) / 20$, $I_2 = (V_C - V_B) / 10$ & $I_3 = V_B / 30$

$V_B / 30 = [(20 - V_B) / 20] + [(VC - V_B) / 10]$

But, $V_A = 20V$ and $V_C = 10V$ 1 Mark

$V_B / 30 = [(20 - V_B) / 20] + [(10 - V_B) / 10]$

$2V_B = 3(20 - V_B) + 6 (10 - V_B)$

$2V_B = 60 – 3V_B + 60 – 6V_B$

$11V_B = 120$

$V_B = 10.91$ V 1 Mark

- Current in 10Ω resistance is,

$I_2 = (V_C - V_B) / 10$

$= (10 – 10.91) / 10$

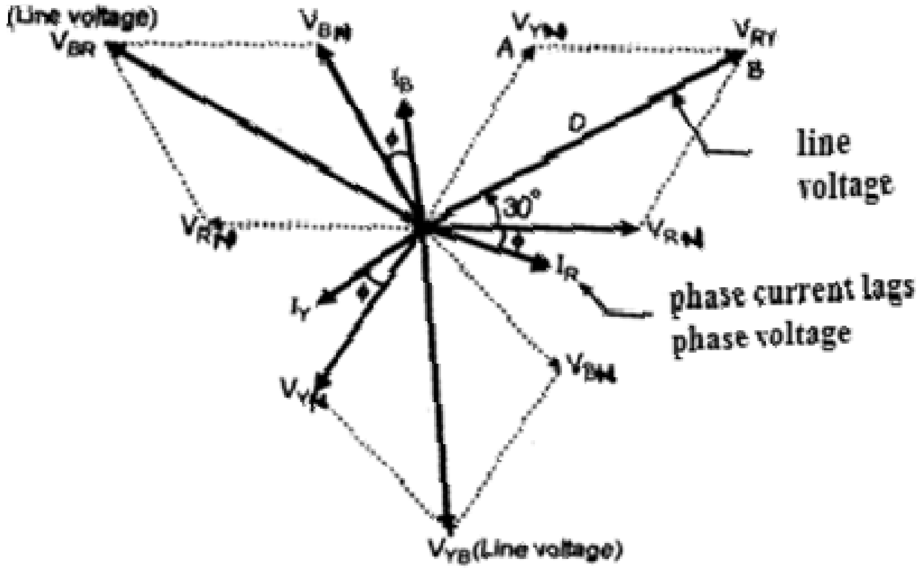
$= -0.091A$ 2 Marks

Negative sign indicates that the actual direction of this current is opposite to that we assumed. OR

- Current in 30 ohm = $I_3 = V_B/30 = 10.91/30 = 0.3636$ A. OR — 2 marks
- Current in 20 ohm = $I_1 = (20-10.91)/20 = 0.4545$ A. — 2 marks

5 Attempt any two — 16 marks

5 a)



Labeled phasor diagram 2 Marks

Let $V_R = V_{m(ph)} \sin\omega t$

Where $V_{m(ph)}$ denotes the peak phase voltage.

Hence $V_Y = V_{m(ph)} \sin(\omega t - 120^0)$ — 1 Mark

Convert V_R and V_Y into their rectangular form to get,

$V_R = V_m + j0$

And $V_Y = (V_m \cos 120^0 - j V_m \sin 120^0)$

$= -0.5 V_m - j0.866 V_m$ — 1 Mark

$V_{RY} = V_m + j0 - (-0.5 V_m - j0.866 V_m)$

$= (1.5 V_m + j0.866 V_m)$ volts — 1 Mark

Converting into polar form we get.

$\mathbf{V_{RY} = \sqrt{3}\ V_{m(ph)} \angle 30^0}$ **volts** — 1 Mark

The current passing through any branch of the star connected load is called as the phase current. The current passing through any line R, Y, B is called as the line current. — 1 Mark

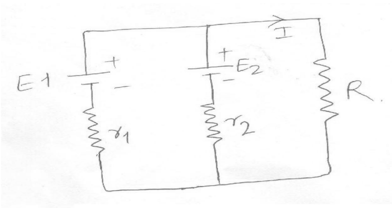
As current flowing through each line is equal to the current flowing through the corresponding branch, the line current is equal to the phase current.

∴ For Star Connected Load $I_L = I_{ph}$ 1 Mark

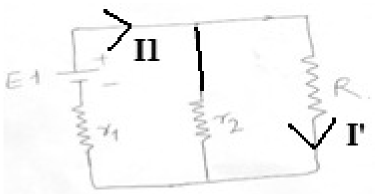
5 b) Statement of superposition theorem :

The superposition theorem states that, in any linear network containing two or more sources, the response (current) in any element is equal to the algebraic sum of currents caused by individual source acting alone, while other sources are removed with only their internal resistances in place. 3 Marks

Procedural steps to find current in given circuit :



Step 1: Remove E_2 and keep only its internal resistance r_2 in circuit.

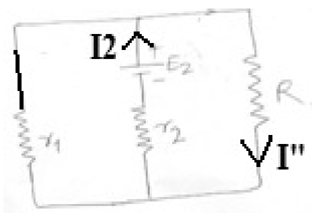


Using any relevant method determine I’ as follows;

$I_1 = E_1/[r_1 + r_2R/(r_2 + R)]$ and 1 mark

$I' = I_1\, r_2/[r_2 + R]$. 1 mark

Step 2: Remove E_1 and keep only its internal resistance r_1 in circuit.



Using any relevant method determine I” as follows;

$I_2 = E_2/[r_2 + r_1R/(r_1 + R)]$ and 1 mark

$I'' = I_2\, r_1/[r_1 + R]$. 1 mark

Step 3: Add algebraically the branch currents obtained due to individual sources to obtain combined effect of the both sources I = I' + I''.

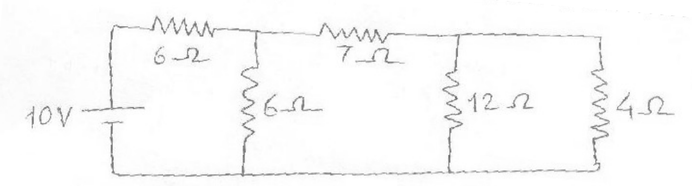
1 mark

5 c) Statement of Norton's theorem :
It states that, any linear, active, resistive network containing one or more voltage and/or current source can be replaced by any equivalent circuit containing a single current source and equivalent conductance (resistance across the current source). 1 mark

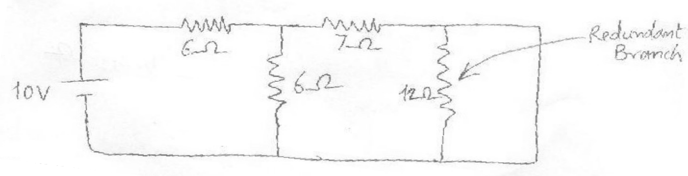
The equivalent current source (Norton's source) I_N = the short curcuit current through the terminals of the load.
The equivalent conductance G_N (or R_N) is the conductance (or resistance) seen between the load terminals with the load removed and sources replaced by their internal reistances.
If R_L is load resistance then current through it is $I_L = I_N R_N/(R_N + R_L)$.

1 mark

Given circuit is,

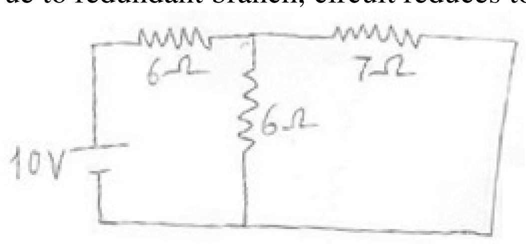


Part I) to obtain value of $I_N = I_{sc}$:
Let us short circuit the 4Ω resistance.



1 Mark

Due to redundant branch, circuit reduces to,

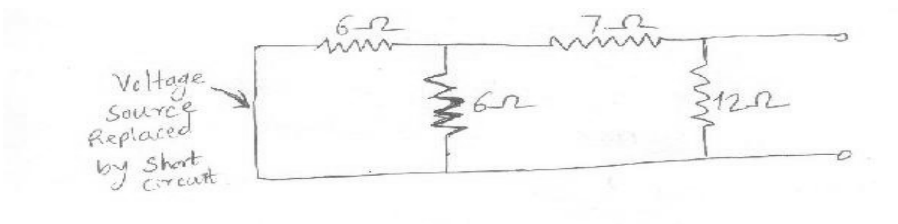


$R_T = [(6*7) / (6+7)] + 6$

$\therefore R_T = 9.23\Omega$

.'. $I_T = 10 / 9.23$
$= 1.0834$ A
.'. $I_N = I_{sc} = (6 / (6+7)) * 1.0834$ 1 Mark
$= 0.5$ A

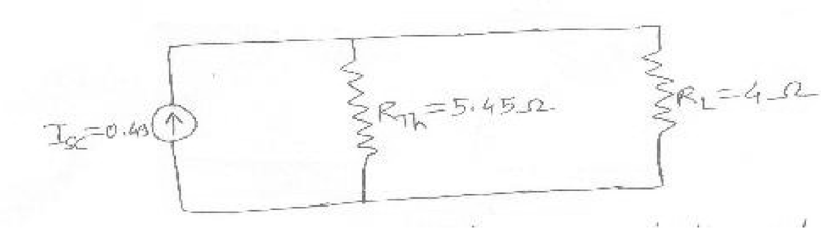
Part II) To obtain value of R_N or R_{TH}



1 Mark

Two 6Ω resistance are in parallel,
Their equivalent is $R_1 = (6 * 6) / (6 + 6)$
$= 3\Omega$
7Ω resistance is in series with R_1
.'. their equivalent is, 1 Mark
$R_{Th} = (10 * 12) / (10 + 12)$
$= 5.45\Omega$

Part III) Norton's equivalent circuit can be drawn as,



1 Mark

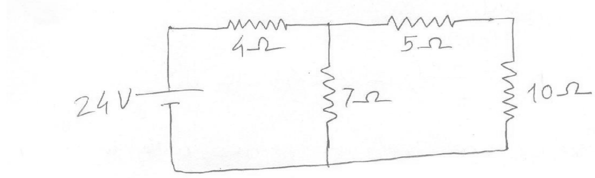
By current division rule, current through 4Ω resistance is given

1 Mark

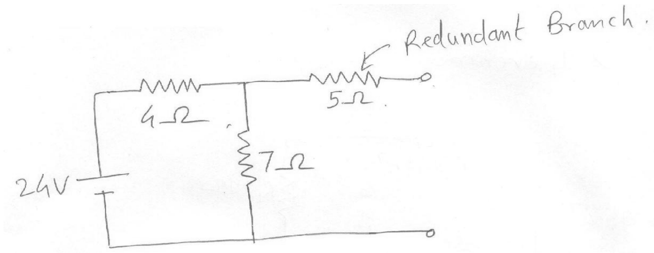
$I_L = [5.45 / (5.45 + 4)] * 0.5$
$= 0.288$ A

6 Attempt any four. 16 marks

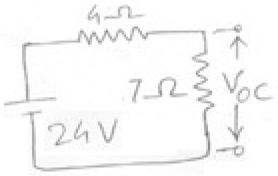
6 a) Given circuit is,



Part 1) Find V_{OC}:



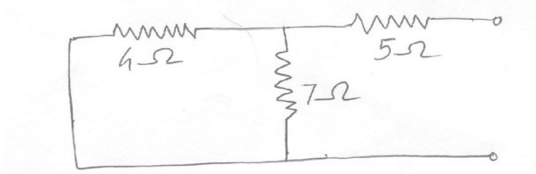
∴ circuit reduces to,



. ' . By voltage division rule,

$V_{OC} = V_{TH} = 24 \times 7 / (7+4)$ 1 Mark
$= 15.27$ V

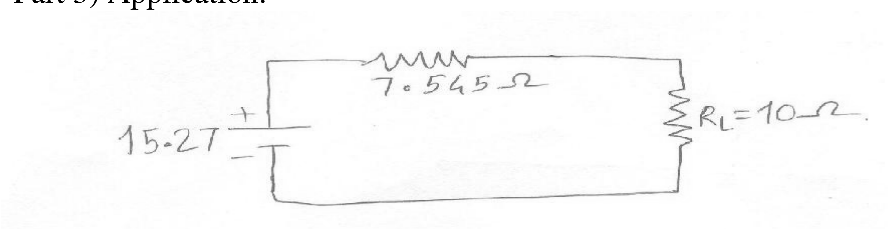
Part 2) Find R_{TH}



4Ω and 7Ω resistances are in parallel,
Their equivalent is,

$R_P = (4 * 7) / (4 + 7)$
$= 2.545\Omega$
5Ω resistance is in series with this combination,
. ' .$R_{TH} = 5 + 2.545$ 1 Mark
$= 7.545\Omega$

Part 3) Application:

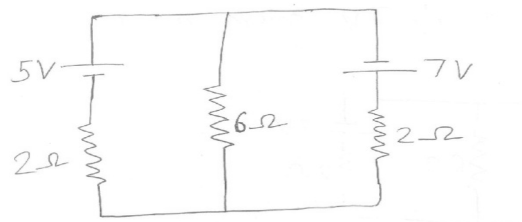


1 Mark

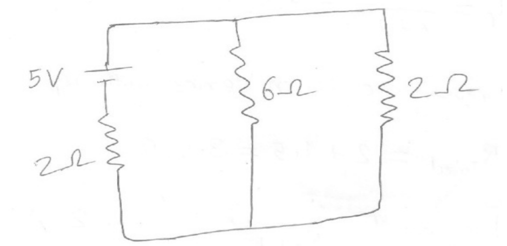
. ' . $I_L = V / R_{Total}$
$= 15.27 / (7.545 + 10)$
$= 15.27 / 17.545$
$= 0.87$ A

1 Mark

6 b)



Step 1) Using 5 V source only,



6Ω & 2Ω resistance are in parallel,

∴ $R_P = (6 \times 2) / (6 + 2)$
$= 1.5\Omega$

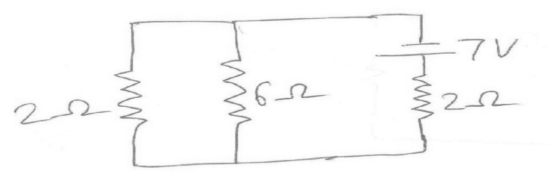
2Ω resistance is in series with R_P,

∴ $R_{Total} = 2+1.5$
$= 3.5\Omega$

∴ Total current is,
$I_T = V / R_{Total}$
$= 5 / 3.5$
$= 1.428$ A

By current division rule, current through 6Ω is,
$I_L' = [2 / (2+6)] * 1.428$
$= 0.357$ A 1 Mark

Step 2): Keeping only 7 V source,



2Ω and 6Ω resistance are in parallel.
∴ $R_P = (6*2) / (6+2)$
$= 1.5\Omega$
2Ω resistance is in series with R_P
∴ $R_{Total} = 2.1.5$
$= 3.5\Omega$
∴ Total current = V / R_{Total}

$= 7 / 3.5$
$= 2A$

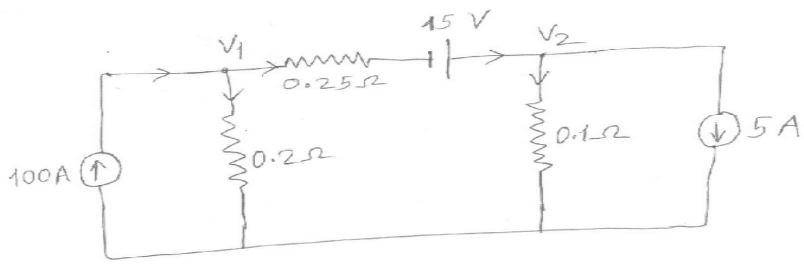
By current division rule, current through 6Ω resistance is,

$I''_L = [2 / (2+6)] * I_{Total}$
$= (2 / 8) * 2$
$= 0.5$ A — 1 Mark

Step 3): Total current through 6Ω resistance, according to superposition theorem is,

$I_L = I'_L + I''_L$
$= 0.357 + 0.5$
$= 0.857A$ — 2 Marks

6 c)



By KCL at node V_1,

$100 = (V_1 / 0.2) + [(V_1 + 15 – V_2)/ 0.25]$
$100 = 5V_1 + 4 (V_1 + 15 –V_2)$
$100 = 5V_1 + 4V_1 + 60 – 4V_2$
$\therefore 9V_1 – 4V_2 = 40$ ---------- Eq.1 — 1 Mark

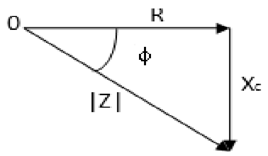
By KCL at node V_2,

$(V_1 + 15 – V_2) / 0.25 = (V_2 / 0.1) + 5$
$4(V_1 + 15 –V_2) = 10 V_2 + 5$
$\therefore 4V_1 + 60 – 4V_2 – 10V_2 = 5$ — 1 Mark
$\therefore 4V_1 – 14V_2 = -55$ -----------------Eq.2

Solving eqns 1 and 2,

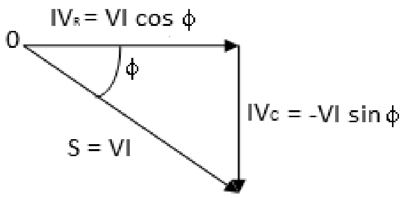
$V_1 = 7.09$ V — 1 Mark
$V_2 = 5.95$ V — 1 Mark

6 d) For RC series circuit :



Labeled 2 Marks

Impedance Triangle



Power Triangle

Labeled 2 Marks

6 e) The initial and final conditions given are for switching constant direct supplies to the elements (resistor and inductor).

For Resistor

Initial condition:

According to ohm's law; the relationship between voltage and current, is given by,

$$v = i.R$$

This equation is time independent equation as R is a constant. Thus the current changes instantaneously as soon as the voltage changes or vice versa. That means initial condition at time t = 0 is same as that exists then. Hence if at t = 0 voltage v is applied the initial current will be v/R at $t = 0^+$. 1 Mark

Final Condition: 1 Mark

As ratio of voltage to current is a constant (= R) at t = ∞; and there is no change in the value of resistor. Hence if at t = ∞, for voltage existing the current will be v/R again.

For Inductor:

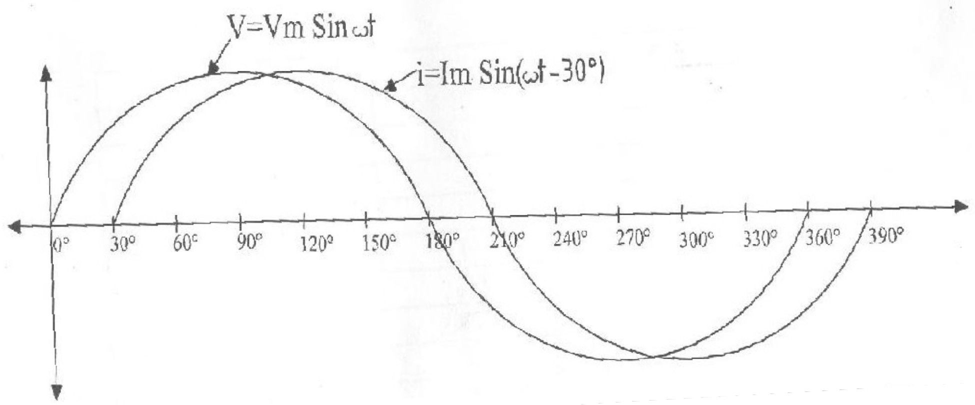
Initial condition:

By definition of inductor it opposes any change in current in it, hence for any new circuit conditions imposed on it by switching DC it opposes it and behaves as open circuit for the change (switching). Thus the initial condition in an inductor is same 1 Mark condition that exists before switching. (that is open circuit for new switching)

Final Condition:

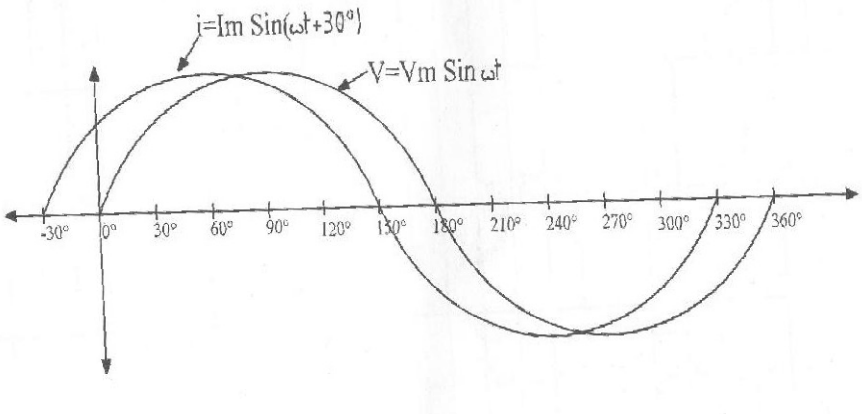
After a long time has elapsed when switching has been done, t = ∞, Voltage across inductor becomes zero as supply current is constant (di = 0, from $V_L = Ldi/dt$). This means it act as short circuit. 1 Mark

6 f)



2 Marks

Fig. Waveform when current lags voltage by 30^0



2 Marks

Fig. Waveform when current leads voltage by 30^0