Important suggestions to examiners:

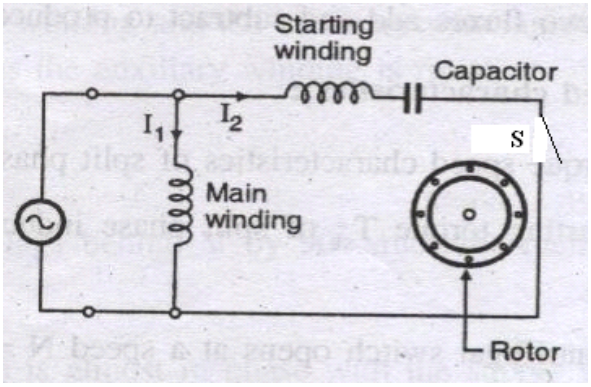
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skills)
4) While assessing figures, examiner may give credit for principle components indicated in a 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 some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1 A	**Attempt any TEN of the following :** **20 Marks**
a)	**Define : i) Frequencyii) Period.**
Ans:	**(i) Frequency :** ----------**(1 Mark)** The total number of cycles completed by an alternating quantity in one second. **ii) Period:** ----------**(1 Mark)** The time (in sec) required by an alternating quantity to complete its one cycle is known as time period.
b	**State working principle of PMMC meter.**
Ans:	**Working principle of PMMC meter:-** ----------**(2 Mark)** When a current carrying conductor is placed in a magnetic field, it experiences a force and tends to move in the direction as per Fleming's left hand rule.
c)	**Prove N = Ns (1 — S).**
Ans:	$s = \frac{N_s - N}{N_s}$ $= 1 - \frac{N}{N_s}$ ----------**(2 Mark)** $\frac{N}{N_s} = (1 - s)$ $N = (1 - s) N_s$

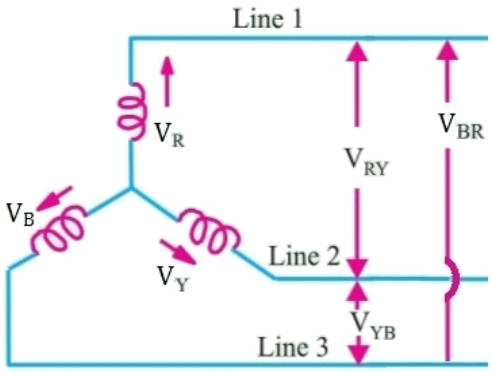
d)	**State two applications of universal motor.**
Ans:	**i) Application of Universal Motor :** **(Any Two application expected : 2 Mark each)** 1) Mixer 2) Food processor 3) Heavy duty machine tools 4) Grinder 5) Vacuum cleaners 6) Refrigerators 7) Driving sewing machines 8) Electric Shavers 9) Hair dryers 10) Small Fans 11) Cloth washing machine 12) portable tools like blowers, drilling machine, polishers etc
e)	**State the types of transformers on the basis of construction.**
Ans:	**Types of transformers on the basis of construction:** **----------(1 Mark each)** i) Shell Type transformer ii) Core type Transformer
f)	**Define : i) Transformation ratio ii) Voltage ratio.**
Ans:	**i) Transformation Ratio (k):-** **----------(1 Mark)** It is the ratio of secondary number of turns to primary number of turns. OR It is the ratio of secondary voltage to primary voltage. **OR** It is the ratio of primary current to secondary current. **OR** $Transformation\ \ ratio\ (k) = \frac{N_2}{N_1}\ or = \frac{E_2}{E_1}\ or = \frac{V_2}{V_1}\ or = \frac{I_1}{I_2}$ **i) Voltage Ratio:-** **----------(1 Marks)** It is the ratio of secondary voltage to primary voltage. $Voltage\ ratio = \frac{V_1}{V_2}$

g)	**Define rotating magnetic field of an induction motor.**
Ans:	**Rotating magnetic field of an induction motor:** **(2 Mark)** A rotating magnetic field is a magnetic field that has moving polarities in which its opposite poles rotate about a central point or axis.
h)	**Name any two electrical machines used in electro agro system.**
Ans:	**Electrical machines used in electro agro system:** **(Any two each carrying 1 Mark each)** 1) Three phase induction motor for pumping of water 2) Single phase induction motors for cutting purpose 3) PMDC motor for insecticide spraying machines
i)	**State the types of heating and welding.**
Ans:	**a) Types of heating :** ----------**(1 Mark)** **1) Power frequency electric heating:** i) Resistance heating: a) Direct resistance heating b) Indirect resistance heating ii) Arc Heating: a) Direct arc heating (furnace) b) Indirect arc heating **2) High frequency electric heating:** iii) Induction Heating: a) Direct core type induction heating (furnace) b) Vertical core type induction heating or Ajax Wyatt induction heating c) Indirect core type induction heating d) Core less induction heating iv) Eddy Current heating v) Dielectric heating

	a) Types of Welding: ----------**(1 Mark)** **i) Resistance Welding:-** 1) Spot welding 2) Seam welding 3) Projection Welding 4) Butt Welding- i) Simple butt welding ii) Flash butt welding **ii) Arc welding:-** 1) Carbon Arc Welding: a) shielded welding b) unshielded welding 2) Metal Arc Welding: a) shielded welding b) unshielded welding
j)	**State any two applications of multimeter.**
Ans:	**Applications of multimeter:** **(Any two each carrying 1 Mark each)** **1. Voltage Measurements** ➢ High and low value DC measurement ➢ Peak to Peak and DC average measurement **2. Current Measurements** ➢ DC current measurement ➢ True RMS AC current **3. Temperature and Environmental Applications** ➢ Low cost weather station ➢ DMM internal temperature **4. Resistance Measurement** ➢ Micro ohm meter ➢ Measuring resistance with constant voltage ➢ Measuring resistance with constant current **5. Time and Frequency measurement** ➢ frequency ➢ Time measurement

k)	**Draw neat labelled diagram of capacitance start motor.**
Ans:	**Diagram of Capacitor-start- Motor:-** **(Diagram-2 Marks)**  **or Equivalent fig**
l)	**State any two factors for selection of motors as drives.**
Ans:	**(Any Two factor are expected: 1 Mark each factor)** **Following Factors governing / or are considered while selecting electric drive (Motor) for particular application:** ➢ **Factors to be considered for selection of Electrical Drives:** **1) Nature of Supply:-** Whether supply available is AC, pure DC or rectified DC **2) Nature of Drive :-**Whether motor is used to drive individual machines or group of M/c **3) Nature of Load: -** Whether load required light or heavy starting torque or load having high inertia require high starting torque for long duration. **4) Electric Characteristics of drive: -** Starting, Running, Speed control and braking characteristics of electric drive should be studied and it should be match with load. **5) Size and rating of motor: -** Whether motor is continuously running, intermittently running or used for variable load cycle. **6) Mechanical Consideration: -** Types of enclosure, Types of bearings, Transmission of power, Noise level, load equalization **7) Cost: -** Capital, Running and maintenance cost should be less.

Q.2	**Attempt any FOUR of the following :** **16 Marks**
a)	**Draw star connected three phase load circuit. Mark line vtg., phase vtg., line current and phase current. Also write relation of active power and reactive power.**
Ans:	**3-phase star connected Load Circuit:** **(2 Marks)**



or equivalent figure

Relation of active power and reactive power:

i) Active Power (P):- **(1 Mark)**

$$P = \sqrt{3}\, V_l . I_l . Cos\phi = 3V_{ph} I_{ph} \cos\phi$$ **Unit: -** Watt **OR** KW

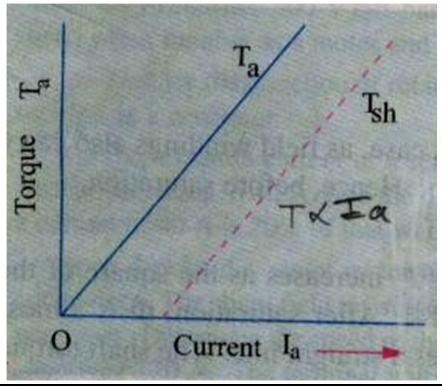
ii) Reactive Power (Q):- **(1 Mark)**

$$P = \sqrt{3}\, V_l . I_l . Sin\phi = 3V_{ph} I_{ph} Sin\phi$$

Units: - VAR **OR** kVAr

b)	**Draw and explain torque-armature current characteristic of DC shunt motor.**
Ans:	**(Characteristics 2 Marks & Explanation 2 Marks)**

Torque-armature current characteristic of DC shunt motor



Explanation:

$$T = \frac{1}{2\pi} \times \phi \, Z I_a \frac{P}{A}$$

$T \alpha \, I_a$ (Since all others are constant)

In case of shunt motor ϕ is constant therefore $T \alpha \, I_a$ from this equation it is clear that as armature current increases, torque increases. As shown in graph

c) State working principle of electric welding. Give two applications of it.

Ans: **Working principle of Electric welding:** ---------- **(2 Marks)**

In resistance welding, sufficiently heavy current at low voltage is passed directly through two metals in contact to be welded.

Heat is produced due to I^2R losses where 'R' is the contact resistance. This heat is utilized to obtain welding temperature (to become a plastic state)

When welding temperature is reached supply is cut down and external pressure is applied simultaneously across the job to complete weld.

According to joules law,

Heat produced $H = I^2 Rt$ …….. Watt-sec

From this equation it is clear that heat produced depends on

- Square of current (I^2)
- Contact resistance (R)
- Duration of current (t)

Hence to obtained more heat in less time high current is necessary.

OR

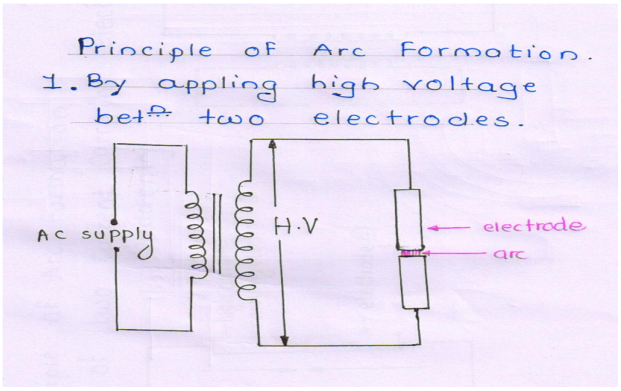
- **Principle of operation of Arc welding can be explained by any one of the following method.**

a) By applying High Voltage

b) By separation of two current carrying electrodes suddenly

Explanation:-

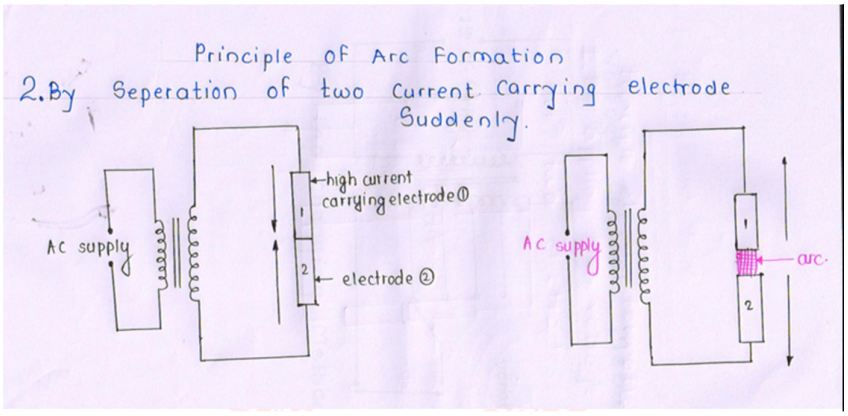
a) By applying High Voltage:- Figure:



Operation:

- When very high voltage is applied across any two electrodes separated by small air gap then air between two electrodes gets ionized and ionized air is conducting, so current starts flowing from one electrode to another electrode in the form of spark (arc).
- This arc produces heat energy which is utilized for melting the charge.
- High Voltage is required to produce arc and to maintain arc high voltage is not necessary.
- Once arc is struck between two electrodes then low voltage is sufficient to maintain the arc.

b) By Separation of two current carrying electrodes suddenly:-
Figure:



Operation:-

- Another way to produce arc is to short circuit two current carrying electrodes as shown in fig (a) and suddenly withdraw them, then there will be spark between two electrodes as shown in

figure (b)

- This arc then produce heat energy which is utilized for melting the charge.
- In this method high voltage is not necessary to produce the arc.

Applications Electric Welding : ----------**(2 Marks)**

In following Major Industrial Sectors electric welding systems are used:-

1. In automotive / auto suppliers industry
2. In electrical / electronics industry
3. In aerospace / air plane industry
4. In train carriage / rail industry
5. In ship building industry.
6. In radiator / container industry
7. In domestic hardware industry
8. In medical instruments industry
9. In nuclear equipment industry
10. In food and drink industry
11. In civil construction industry.
12. During construction of bridge, tunnel etc.
13. Manufacturing of heavy tanks.
14. In tool manufacturing industry.
15. For fabrication and repair work.
16. In other metal processing industries.

d) **State two applications of each : i) Shaded pole motor ii) Capacitor start capacitor run motor.**

Ans: **i) Applications of Shaded pole motor:** **(Any Two expected-2 Mark)**

(i) Small fans

(ii) Toys

(iii) Hair driers

(iv) Desk fans etc.

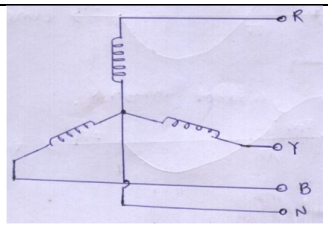
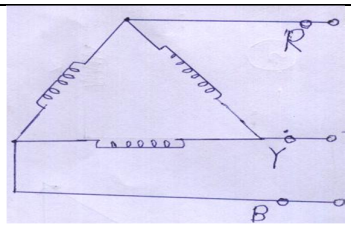
ii) Applications of Capacitor start and run motor: **(Any Two expected-2 Mark)**

i) Compressors of air conditioner

ii) Big water cooler

e) Write down any four points of differentiation of star and delta connection.

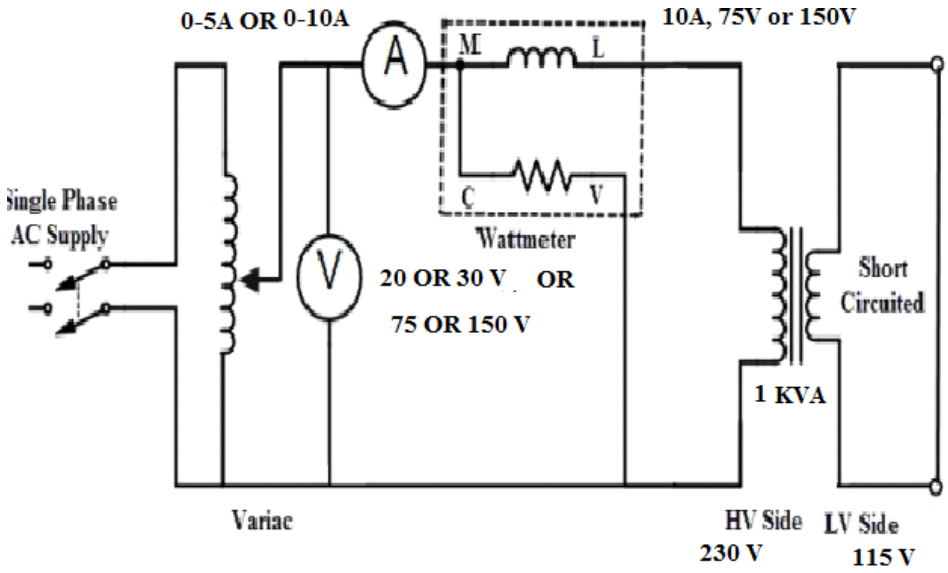
Ans: **(Each Point : 1 Mark)**

Sr no	Parameter	Star connection	Delta connection
1.	Way of connection		
2.	Voltage relationship	$V_L = \sqrt{3}\, V_{Ph}$	$V_L = V_{Ph}$
3.	Current relationship	$I_L = I_{Ph}$	$I_L = \sqrt{3}\, I_{Ph}$
4.	Neutral wire	Neutral point formed	No neutral point formed

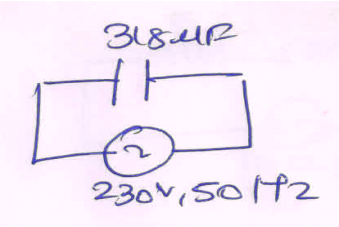
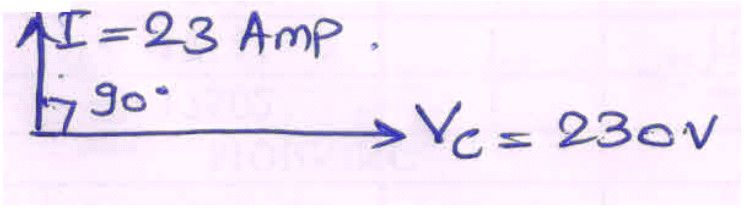
f) Draw experimental setup for short circuit test of single phase, 230/115V, 1 KVA transformer with proper meter ranges of meters.

Ans: **(Fully labeled 4 marks, partial 1 to 3 marks proportional)**

Neat Circuit Diagram: Short Circuit Test :



or equivalent circuit

Q.3	**Attempt any FOUR of the following :** **16 Marks**
a)	**A 318 μF capacitor is connected across a 230 V, 50 Hz supply. Find current flowing through the circuit, vtg. across the capacitor, capacitive reactance and draw phasor dig.**
Ans:	**Given Data :** C = 318 μF = 318 x10^{-6} F, V = 230V and F = 50 Hz  **i) Capacitive Reactance (X_C) =----------(1 Marks)** $X_C = \frac{1}{2\pi f C}$ $= \frac{1}{2\pi \times 50 \times 318 \times 10^{-6}}$ $X_C = 10\,\Omega$ **ii) Current in Circuit= ----------(1 Marks)** $I = \frac{V}{X_C} = \frac{230}{10}$ $I = 23\ Amp$ **iii) Voltage across capacitor = =----------(1 Marks)** $V_C = I\ X_C = 23 \times 10$ $V_C = 230\ volt$ **iv) Phasor Diagram = =----------(1 Marks)** 

b) Derive emf equation of transformer.

Ans:

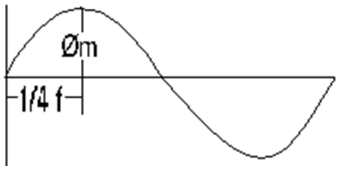
➢ **EMF equation of single phase Transformer:-** **(04 Marks)**

Let, N_1= Number of turns in the primary

N_2= Number of turns in the Secondary

Øm= Maximum flux in core (wb)= BmxA

F= Frequency



As shown in figure, flux increases from its zero value to maximum value Øm in one quarter of the cycle (i.e. ¼ f) sec

➢ Average rate of change of flux

➢ $\frac{\phi m}{1/4f} = 4 f\phi m$ (wb/sec)

Rate of Change of flux per turn means induced emf, If flux various sinusoidally then r.m.s value of induced emf is obtained by multiplying the average value with form factor.

From factor = $\frac{R.M.S\ Value}{average\ \ value} = 1.11$

R.M.S.value of emf /turn = 1.11 x 4 f Øm= 4.44 f Øm

R.M.S value in the whole primary winding

= (induced emf / turn) x No. of primary turns

$E_1 = 4.44\ f\ \phi_m N_1$

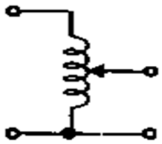
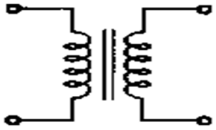
E_1 = 4.44 f B_mAN_1

R.M.S. value in the whole table secondary winding

E_2 = 4.44 f B_mAf N_2

c) Compare auto transformer and single phase two winding transformer. (any four points).

Ans: **(Any four points expected: Each point 1 Mark)**

Sr no.	Points	Autotransformer	Single Phase Two winding transformer
1.	**Symbol**		
2.	**Number of windings**	It has one winding	It has two windings
3.	**Copper saving**	Copper saving takes more as compared to two winding	Copper saving is less
4.	**Size**	Size is small	Size is large
5	**cost**	Cost is low	Cost is high
6	**Losses in winding**	Less losses takes place	More losses takes place
7.	**Efficiency**	Efficiency is high	Efficiency is low
8.	**Regulation**	Regulation is better	Regulation is poor
9.	**Electrical isolation**	There is no electrical isolation	Electrical isolation is present in between primary and secondary winding
10.	**Movable contact**	Movable contact is present	Movable contact is not present
11.	**Application**	Variac, starting of ac motors, dimmerstat.	Mains transformer, power supply, welding, isolation transformer

d) A circuit having resistance of 5 ohm and and L = 0.4 H are connected in series across a 100 V, 50 Hz supply. Calculate. a) Impedance, b) Inductive reactance, c) Current flowing through the circuit, d) Active power.

Ans: Given Data:

R = 5 ohm V = 100 V and L = 0.4 H F = 50 Hz

b) Inductive Reactance:- = ----------**(1 Marks)**

$$X_L = 2\pi FL$$

$X_L = 2\pi \times 50 \times 0.4$

$X_L = 125.66\ \Omega$

a) Impedance (Z):- = ----------**(1 Marks)**

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

$Z = \sqrt{(5)^2 + (125.66)^2}$

$Z = 125.76\,\Omega$

c) Current flowing through the circuit = =----------**(1 Marks)**

$I = \frac{V}{Z} = \frac{100}{125.76}$

$I = 0.79\ \ Amp$

d) Active Power:- = ----------**(1 Marks)**

$Cos\phi = \frac{R}{Z} = \frac{5}{125.66}$

$I = 0.039\ \ lag$

Power P =

$P = V\ I\ Cos\phi$

$P = 100 \times 0.79 \times 0.039$

$P = 3.08\ \ watt$

e)	**A vtg. v = 100 sin 314 t is applied across a circuit consisting of 25 ohm and capacitor of 80 μ F capacitor in series. Determine i) Maximum value of current, ii) Reactive power.**
Ans:	**Given Data:** R = 25 ohm V = 100 V sin 314 t and C= 80 micro F = 80 x 10^{-6} F From equation V_m= 100V ω_C = 314 rad/sec

i) Impedance of the circuit (Z):- =----------(1 Marks)

$$X_C = \frac{1}{\omega_C} = \frac{1}{314 \times 80 \times 10^{-6}} \qquad X_C = 39.80\,\Omega$$

$$Z = \sqrt{(\mathrm{R})^2 + (\mathrm{X}_C)^2} \qquad Z = \sqrt{(25)^2 + (39.80)^2}$$

$$Z = 47\,\Omega$$

ii) Maximum value of Current = ----------(1 Marks)

$$\mathrm{I_m} = \frac{V_m}{Z} = \frac{100}{47}$$

$$I = 2.13\ Amp$$

iii) Phase angle (ϕ):-= ----------(1 Marks)

$$Cos\phi = \frac{R}{Z} \qquad \phi = Cos^{-1}(\frac{R}{Z})$$

$$\phi = Cos^{-1}(\frac{25}{47})$$

$$\phi = 57.86^0$$

$$V_{rms} = 0.707\,V_m = 0.707 \times 100$$

$$V_{rms} = 70.70\ V$$

$$I_{rms} = 0.707\,I_m = 0.707 \times 2.13$$

$$I_{rms} = 1.50\ Amp$$

Reactive Power P = ----------(1 Marks)

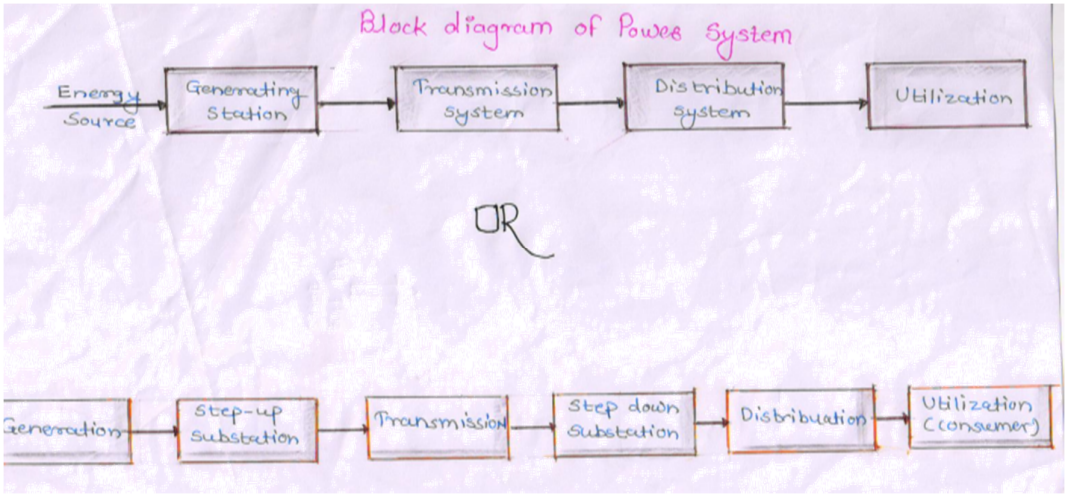
$$P = V_{rms}\ I_{rms} Sin\phi$$

$$P = 70.70 \times 1.50 \times Sin\ 57.86$$

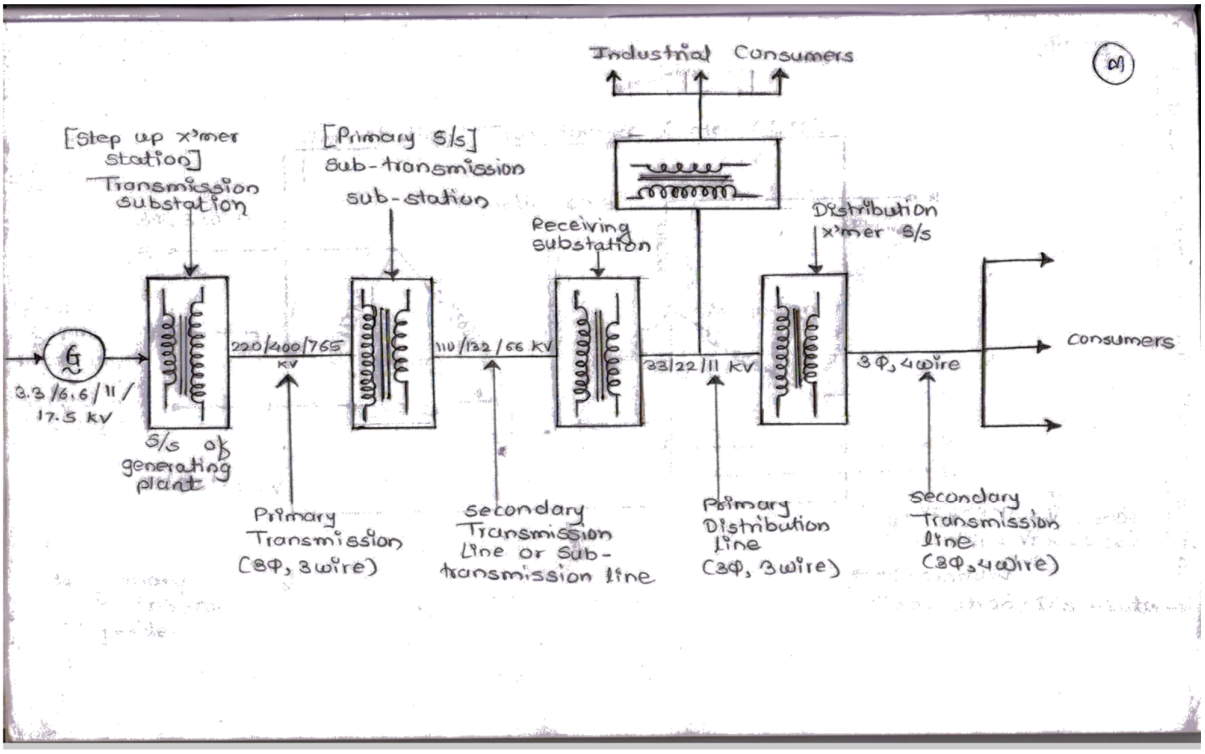
$$\mathrm{Re}active\ \ Power = 89.80\ \ VAR$$

f)	**Describe any one fire extinguishing method useful for electrical laboratory.**
Ans:	**Explanation =** ---------- **(4 Marks)** Stand 6 to 8 feet away from the fire and follow the four-step PASS procedure. If the fire does not begin to go out immediately, leave the area at once. Always be sure the fire department inspects the fire site. ➢ **P**ull the safety pin from the handle. ➢ **A**im the extinguisher nozzle at the base of the fire. ➢ **S**queeze the handle or lever slowly to discharge the agent. ➢ **S**weep side to side over the fire until expanded
Q.4	**Attempt any FOUR of the following : 16 Marks**
a)	**Current flowing through the circuit is i = 141.4 Sin (314 —π /6). Calculate :** **i) Amplitude ii) RMS value of current iii) Frequency iv) Phase difference.**
Ans:	Given Data; **i = 141.4 Sin (314 —π /6)** Comparing with Standard equation of current : I = I_m Sin (ω t) I_m = 141.4 Amp ω = 314 rad/sel **i) Amplitude :** 141.4 Amp = ----------**(1 Marks)** **ii) RMS value of current:- =** ----------**(1 Marks)** = 0.707 x I_m = 0.707 x 141.4 **I_{RMS}= 99.96** **iii) Frequency :- =-** ----------**(1 Marks)** $\omega = 2\pi F$ $314 = 2\pi F$ $F = \frac{314}{2\pi}$ $F = 49.97 \cong 50\ Hz$ **iv) Phase difference of current w.r.t reference is :** $\pi/6\ rad$ *or* 30^0 =----------**(1 Marks)**

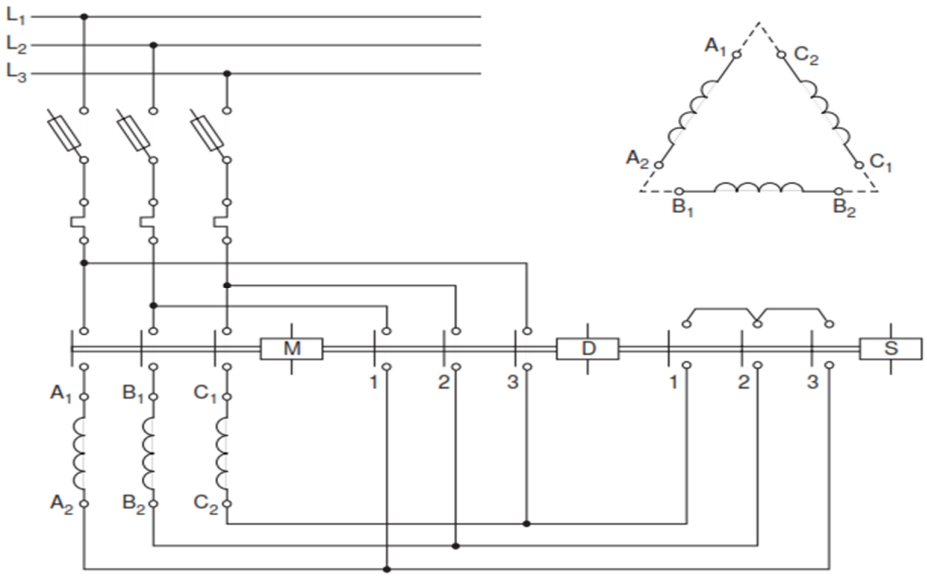
b)	**Draw a neat single line diagram of electrical power system with voltage levels.**
Ans:	**single line diagram of electrical power system with voltage levels;** **(4 Marks)**

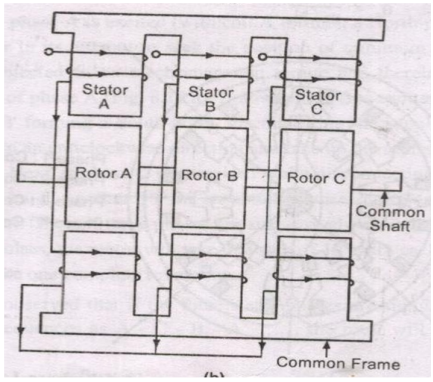


OR



c)	**A three phase 50 Hz, 4 pole, induction motor operated at a slip of 4%. Calculate: Synchronous speed and actual speed.**
Ans:	Given data: F = 50 Hz, P = 4 pole S = 4% **i) Synchronous speed:** ----------**(2 Marks)** $N_S = \frac{120 f}{P}$ $N_S = \frac{120 \times 50}{4}$ $N_S = 1500\ rpm$ **ii) Actual speed:** ----------**(2 Marks)** $N = N_S\ (1 - S)$ $N = 1500\ (1 - 0.04)$ $N = 1440\ rpm$
d)	**State types of enclosures of electric drives.**
Ans:	**Types of enclosures & their Applications: (Any Four Expected: 1 Mark each, Total 4 Marks)** Enclosures of motors are selected to suit the requirement of particular environment conditions. Following are some types of enclosures, **i) Open type enclosure:-** It is used where motor is installed in clean atmosphere and in closed room. **ii) Screen Protected enclosure:-(***Guarded enclosure:***)** Here screen is provided for rotating parts for better protection. It is also used where motor is installed in clean atmosphere and in closed room. **iii) Drip proof (moisture) enclosure:-(***Weather-protected type 1 enclosur, Weather-protected type 2 enclosure, Waterproof enclosure,)* This type of enclosure is used in very damp atmospheric condition such as water pumping station motor on ship sub-merssible motors, etc. **iv) Flame (Fire) proof enclosure:- (***Splash-proof enclosure, Dust-ignition-proof enclosure***)** It is used where motors are installed in explosive atmosphere likechemical plants, mines etc. **v) Totally enclosed type enclosure:-** It is used where there is dusty atmosphere such as saw mill, stone crushing plant, coal handling plant, cement manufacturing plant, cotton industry etc. As it is totally enclosed it requires special cooling arrangement. **vi) Pipe ventilated totally enclosed type enclosure:**

	It is used where there is dusty atmosphere such as saw mill, stone crushing plant, coal handling plant, cement manufacturing plant, cotton industry etc. As it is totally enclosed it requires pipe ventilation, clean and cold air is circulated through pipe forcefully for cooling of motors and hot air is taken out through pipe.
e)	**Draw neat labelled circuit diagram of "star delta" starter of three phase induction motor.**
Ans:	**Diagram of star-Delta starter:- (Fully labeled 4 marks, partial 1 to 3 marks proportional)** 
f)	**State two applications of each : i) Servo motor ii) Stepper motor.**
Ans:	**i) Applications of servo motor : (Any Two expected: 2 Mark)** 1. Robotics 2. Conveyor Belts 3. Camera Auto Focus 4. Robotic Vehicle 5. Solar Tracking System 6. Metal Cutting & Metal Forming Machines 7. Antenna Positioning 8. Woodworking/CNC 9. Textiles 10. Printing Presses/Printers 11. Automatic Door Openers

	ii) Applications of stepper motor- **(Two application expected-2 Mark)** 1.Suitable for use with computer controlled system 2. Widely used in numerical control of machine tools. 3. Tape drives 4. Floppy disc drives 5. Computer printers 6. X-Y plotters 7. Robotics 8. Textile industries 9. Integrated circuit fabrication 10. Electric watches 11. In space craft's launched for scientific explorations of planets. 12. In the production of science friction movies 13 Automotive 14. Food processing 15. Packaging
Q.5	**Attempt any FOUR of the following :** **16 Marks**
a)	**State working principle and specifications of stepper motor.**
Ans:	**1) Variable Reluctance Motors:** **(Any one type expected: Explanation - 2 Mark & Diagram 2 marks)**  **or equivalent dia.** **Working:-** When phase A is excited rotor attempts minimum reluctance between stator and rotor and is subjected to an electromagnetic torque and there by rotor rotates until its axis coincides with the

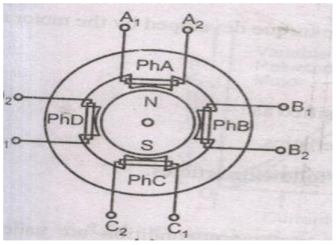
axis of phase A.

Then phase 'B' is excited disconnecting supply of phase 'A' then rotor will move 30 anticlockwise directions. The Same process is repeated for phase 'C'

In this way chain of signals can be passed to get one revolution and direction can be also changed.

OR

2) Permanent Magnet Motor:-



or equivalent dia.

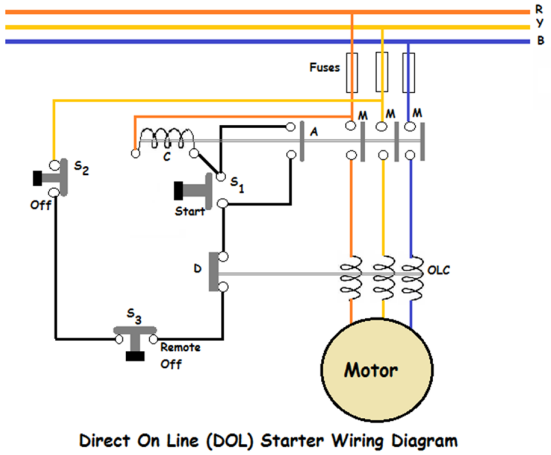
Working :-

If the phase is excited in ABCD, due to electromagnetic torque is developed by interaction between the magnetic field set up by exciting winding and permanent magnet. Rotor will be driven in clockwise direction.

b) Draw a circuit diagram of DOL starter for three phase induction motor.

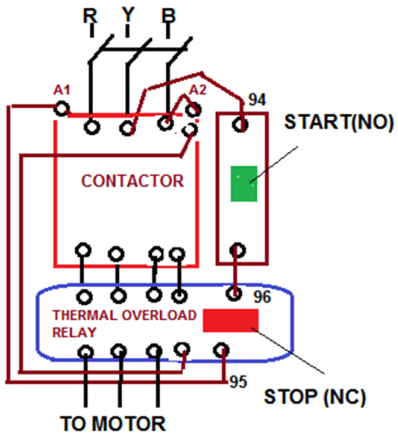
Ans: **(4 Marks)**

Circuit diagram of direct on line starter:



Direct On Line (DOL) Starter Wiring Diagram

OR



or equivalent figure

c)	State the types of tariff and describe any one in brief.
Ans:	**Types of Tariff:-** **(Any Four Types expected: 1/2 each, Total 2 Marks)**

1) Flat-demand Tariff

2) Simple-demand Tariff or Uniform Tariff

3) Flat-rate Tariff

4) Step-rate Tariff

5) Block-rate Tariff

6) Two-part Tariff

7) Maximum demand Tariff

8) Three-part Tariff

9) Power factor Tariff :- a) KVA maximum demand Tariff

b) Sliding Scale Tariff or Average P.F. Tariff

c) KW and KVAR Tariff

10) TOD (Time of Day) Tariff

11) ABT:-This tariff system is called availability based tariff. As its name suggest it is a tariff system which depends on the availability of power.

Explanation of Types of Tariff (Any ONE Types explanation Expected: 2 Mark)

1) Block Rate Tariff:-

- In case of block rate tariff there are blocks of units consumed and each block tariff rate/unit (KWH) is different plus consumer has to pay fix charges e.g.
- If generation is less than utilization than tariff rate/unit in each block goes on increasing and vice versa. e.g.

2) Two Part Tariff:-

- In this type of tariff energy bill is split into two parts.

	ENERGY BILL= FIXED CHARGE which depends on load (KW) +RUNNING CHARGE which depends on actual energy consume (KWH) ➢ Fixed charge which depends on load (KW) which is declared by consumer on test report. ➢ There is no separate meter is installed to measure load. ➢ Only one energy meter is used to measure number of units consumed. ➢ This type of tariff system is used for residential and commercial consumers.(up to 20 KW) ➢ This type of tariff is not used for industrial consumers. **3) Maximum Demand Tariff/KVA Maximum Demand Tariff / Load factor tariff:-** ➢ This is basic tariff for all industrial / commercial consumers with contract demand above 80 KW/ 100KVA/107 HP ➢ It is similar to two part tariff except that maximum demand (KVA) is actually measured by installing maximum demand meter(in KVA) ➢ M.D. Meter (it is an electromagnetic or electronic trivector meter) is installed in the premises of consumer, in addition to energy meter. Maximum Demand Tariff / Load factor Tariff = $M.D.(KVA) \times Rs\ 'X'\ permonth + \{Number\ of\ units\ (KWH)\ Actual\ consumer\} \times Rs\ 'Y'$ **4) Power Factor Tariff:-** **In addition to basic tariff** (Maximum Demand Tariff/KVA Maximum Demand Tariff / Load factor tariff) **the tariff in which P.F. of industrial consumer is taken into consideration.**Is known as Power Factor Tariff. ➢ If the P.F. of consumer is less than P.F. declare by Supply Company (say below 0.9 Lag.) than penalty will be charged in energy bill. ➢ If The P.F. of consumer is more than P.F. declare by Supply Company (say above 0.95lag.) than discount will be given in energy bill. ➢ As usual consumer has to pay actual energy consumption charges

- Application :-

  This type of tariff is applicable to industrial consumer/H.T/ commercial consumers with contract demand above 80 kw/ 100Kva/107 hp consumer.

- Incentives and Penalties to Power factor tarrif :-

Power factor incentive:- e.g.

Power Factor	Percentage of incentive
0.95	0% of energy bill
Above 0.96	1% of energy bill
Above 0.97	2% of energy bill
Above 0.98	3% of energy bill
Above 0.99	4% of energy bill
At unity P.F.	5% of energy bill

Power factor penalty:- e.g.

Power factor lagging	Percentage of penalty
For0.90Power factor lagging	0% of energy bill
For 0.89 Power factor lagging	2% of energy bill
For 0.88 Power factor lagging	3% of energy bill
For 0.87 Power factor lagging	4% of energy bill
For 0.86 Power factor lagging	5% of energy bill
For 0.85 Power factor lagging	6% of energy bill
For 0.84 Power factor lagging	7% of energy bill
For 0.83 Power factor lagging	8% of energy bill
For 0.82 Power factor lagging	9% of energy bill
For 0.81 Power factor lagging	10% of energy bill

There are three types of P.F. tariff ;-

a) KVA maximum demand Tariff: (All ready explain above)

b) Sliding Scale Tariff or Average P.F. Tariff:

- If the P.F. of consumer is less than P.F. declare by Supply Company (say below 0.9 Lag.) than penalty will be charged in energy bill.
- If The P.F. of consumer is more than P.F. declare by Supply Company (say above 0.95lag.) than discount will be given in energy bill.
- As usual consumer has to pay actual energy consumption charges

c) KW and KVAR Tariff:

- In this type both active (KW) & reactive power (KVAr) supplied are charged separately and actual energy consumption charges
- A consumer having low power factor draw more reactive power and shall have to pay more charges and vice-versa.
- So consumer is trying to improve power factor to reduce KVAr charges in energy bill, so power factor of power system increases.

$$Energy\ Bill = \{Rs\ 'A'(KW)\ Charges\} + \{Rs\ 'B'(KVAR)\ Charges\} + \{Rs\ 'C'(KWH)\ Charges\}$$

5) Time of Day (TOD) Tariff or OFF-load Tariff:-

- **In addition to basic tariff** (Maximum Demand Tariff / KVA Maximum Demand Tariff / Load factor tariff also the tariff in which P.F. of industrial consumer is taken into consideration.**)** Consumer has to pay energy consumption charges according to time for which energy is consumed.
- TOD energy meter is installed in the consumer premises.
- This meter is specially designed to measure energy consumption w.r.t. time.
- This type of tariff is such that energy consumption charges/unit are less at during OFF-load period
- Energy consumption charges/unit are more during PEAK -load period
- This type of tariff is introduced to encourage industrial consumers to run their maximum

load during OFF-load period.

- e.g.

Sr.No	Block	Rate / KWH Rs	Remark
1	8.00 am to 12.00 noon	Rs. 6.00 per unit+0.80 Rs. Per unit	Peak load period
2	12.00 noon to 6.00 pm	Rs. 5.00 per unit+ 0 Rs. Per unit	Base load
3	6.00 pm to 10.00 pm	Rs. 6.00 per unit+ 1.10 Rs. Per unit	Peak load period
4	10.00 pm to 8.00 am	Rs. 5.00 per unit – 1.50 Rs. Per unit	OFF load period

6) Three part Tariff:-

- Fixed charges per month depend on connected load.
- Semi-fixed charges depend on KVA maximum demand.
- Running charges depend on actual energy consume.

d) State the types of an alternator. Which types of rotor is suitable for slow speed diesel engines ?

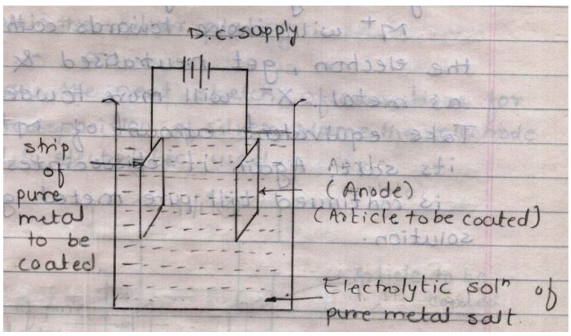
Ans: **Types of an alternator** : ----------**(one type 1 mark each total 2 Marks)**

1. Salient pole type.
2. Cylindrical rotor type.

Which types of rotor is suitable for slow speed diesel engines: Salient pole type rotor **(2 Marks)**

e) What is electroplating ? Give its two applications.

Ans: **Process of Electroplating:-** **(02 Marks diagram & 02 Marks explanation)**



or equivalent fig

A DC current passed through a solution of chemical compound then the solution can be

dissociated into its constituent's parts & deposition of metal takes place on the cathode. Metal is the constituent part of the solution.

The solution used for electrolysis due to which electroplating is to be carried out is known as electrolyte or salt solution. In such a solution each molecule of the substance dissolved is negatively charged.

Electroplating is carried out with a desire to coat particular metal on the surface of other metal. At first, the orticle be coated is properly cleaned. Then it is made cathode. The metal of which coating is desired is taken in pure form as a strip & it is connected to anode. In an electrolytic bath, Solution of the salt of the pure metal to be coated is taken By closing the key.

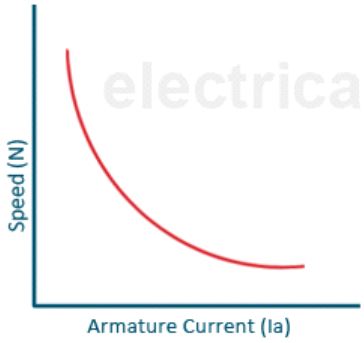
M^+ will move towards cathode, accept the electron, get neutralized & depositioned as metal .X^- will move towards anode. Take equipment amount of M^+ & from its salt. Again it dissociates & process is continued till pure metal goes into solution.

Application of Electroplating: …… **(2 Marks)**

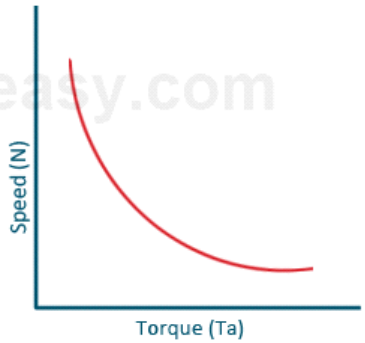
1. Protection of metal against corrosion.
2. Repairing worn out parts of machinery.
3. Giving shining experience to metal parts for decoration purpose.

f) **Draw the speed Vs. armature current and speed Vs. torque characteristics of D.C. series motor.**

Ans: **1) Speed Vs. armature current characteristics of D.C. series motor:** **(2 Marks)**



or equivalent Figure

	2) Speed Vs. torque characteristics of D.C. series motor: **(2 Marks)**  **or equivalent Figure**
Q.6	**Attempt any FOUR of the following :** **16 Marks**
a)	**State advantages of electric heating over the other types of heating methods.**
Ans:	**(Any Four Types expected: 1mark each)** **Advantages of Electric heating over the other types of heating methods:** 1. It can be put into service immediately. 2. No standby losses. 3. High efficiency. 4. More economical than other conventional types of heating system. 5. Easy to operate and control. 6. No air pollution. 7. System is clean, as there is no waste produced. 8. No fuel transportation cost. 9. No space is required for storage of fuel and waste. 10. Noiseless operation. 11. Uniform heating is possible, heating at particular point is also possible (spot welding) 12. Dielectric material can be heated. 13. Electrical heating equipments are generally automatic, so it requires low attention and supervision. 14. Protection against overheating can be provided by suitable switch gear.

b)	**Define the voltage regulation of transformer. Why the rating of transformer is given interms of KVA and not in KW ?**
Ans:	**Voltage regulation of transformer** Voltage regulation is nothing but voltage drop in transformer expressed in % of receiving end voltage **% Regulation** = $\frac{Sending\ End\ Voltage - Receiving\ End\ Voltage}{Receiving\ End\ Voltage} \times 100$ -------**(1 Mark)** % Voltage Regulation = $\frac{V_S - V_R}{V_R} \times 100$ ---------- **for 1-phase** Where, V_R = receiving end voltage V_S = Sending end voltage $\%\ Regulation = \frac{I_R(R_T\ Cos\phi_R \pm X_T\ Sin\phi_R}{V_R} \times 100$ ---------- **For 1-phase** **Where,** R_T = Total resistance & X_T = Total reactance % Voltage Regulation = $\frac{V_S ph - V_R ph}{V_R ph} \times 100$ ---------- **(1 Mark)** **--- For 3-phase** $\%\ Regulation = \frac{I_R(R_{ph}\ Cos\phi_R \pm X_{ph}\ Sin\phi_R}{V_R ph} \times 100$ ---------- **For 3-phase** **Where, "+ ve"** sign is used when Power factor is lagging. **"- ve"** sign is used when Power factor is Leading. ➢ **Reason & explanation for transformer rating is in kVA and not in kW** **(2 Mark)** We know that copper loss in a transformer depends on current and iron loss depends on voltage. Therefore, the total loss in a transformer depends on the volt-ampere product only and not on the phase angle between voltage and current i.e., it is independent of load power factor. For this reason, the rating of a transformer is in KVA and not in KW.
c)	**Explain any one P.F improvement method.**
Ans:	**Explanation P.F improvement (Any ONE Types explanation Expected: 4 Mark)** **Types of power factor improvement** 1) By use of static capacitor (Condenser)

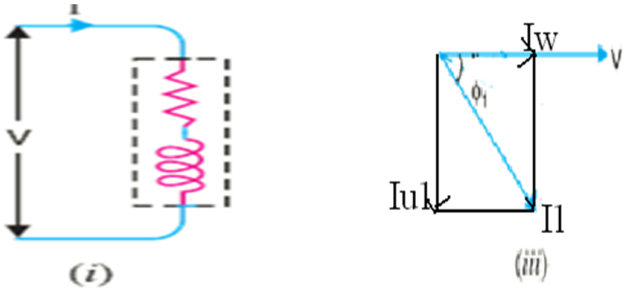
2) By use of over excited synchronous motor (Synchronous condenser)

3) By use of over excited Schrage motor

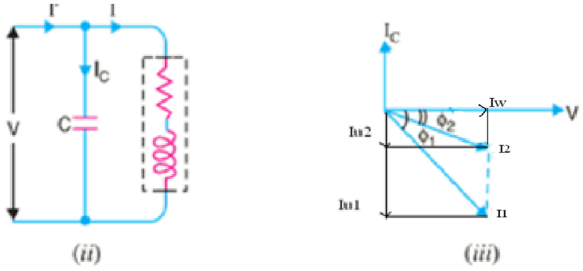
4) By use of phase advancer.

1) static capacitor method of power factor improvement.

Before connecting capacitor phasor diagram



After connecting capacitor phasor diagram



$\text{Cos}\phi_1$ = Initial Power factor

$\text{Cos}\phi_2$ = Improved Power factor

Calculation from current vector diagram:

$$I_C = I\mu_1 - I\mu_2$$

$$\therefore I_C = [Iw \tan\phi_1] - [Iw \tan\phi 2]$$

Now, $I_C = \frac{V}{X_C} \therefore X_C = \frac{V}{I_C} \therefore X_C = \frac{1}{2 \times \pi \times f \times c}$

$$\therefore C = \frac{1}{2 \times \pi \times f \times X_C}$$

Magnitude of new current:

$$I_2 = \sqrt{(I_w)^2 + (I\mu_2)^2}$$

Calculation from power triangle: Where ,

P = Active power KW

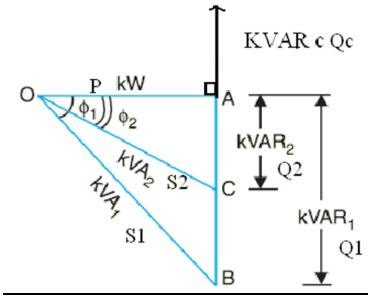
Q_1, Q_2 = Lagging reactive power before & after improving power factor

Q_C = Leading Reactive power drawn by Capacitor

S_1, S_2 = KVA Maximum demand before and after improving power factor

$\text{Cos}\phi_1$ = Initial Power factor

$\text{Cos}\phi_2$ = Improved Power factor



$Q_C = Q_1 - Q_2$

$Q_C = [P \tan\phi_1] - [P \tan\phi_2]$ KVAr rating of capacitor

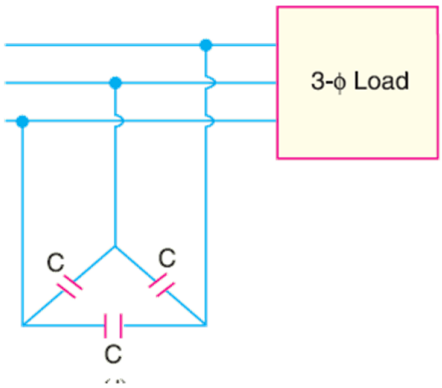
Observation:

- From above vector diagram & power triangle calculations, if capacitor is connected across load than following observations are observed.

S.No.	Parameter	Effect
1	Power factor	Improves
2	Magnetizing current ($I\mu$)	Reduces

3	Total current	Reduces
4	Lagging reactive power (KVAr)	Reduces
5	Apparent power (KVA)	Reduces

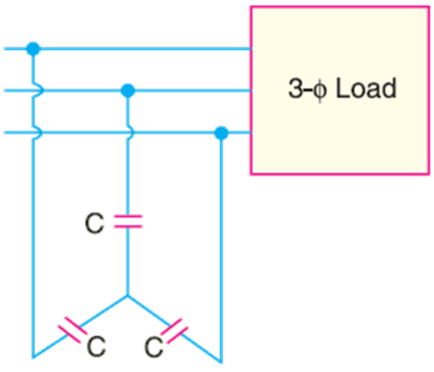
➢ **Connection diagram to connect capacitor to improve power factor (Delta connection)**



$$(Cph) = \frac{KVAR}{3\,\omega\,V^2}\ \text{Farad}$$

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

➢ **3-ph Star connected Capacitor Bank:**



$$(\text{Cph})_{\lambda} = \frac{\text{KVAR}}{\omega\ \text{V}^2}\ \text{Farad}$$

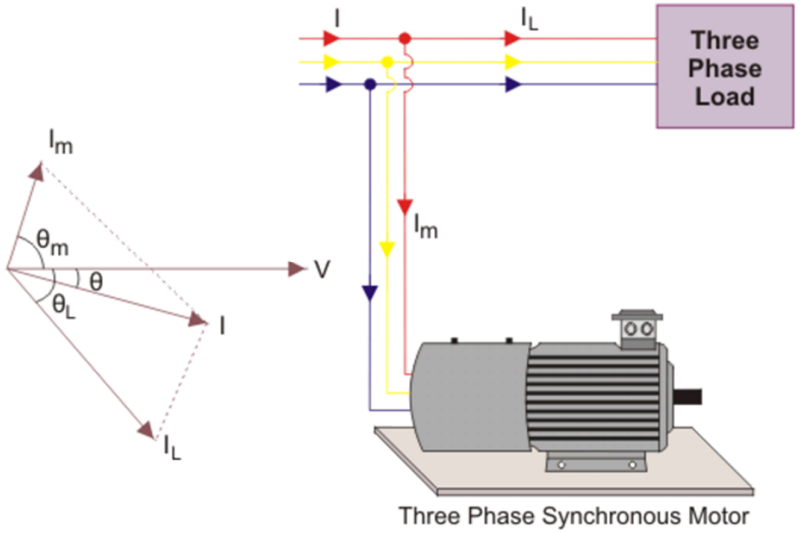
$$\omega = 2\pi\ f$$

Precautions to handle the capacitor bank**:**

1. Capacitors get easily damaged if the voltage exceeds than its rated value.
2. When capacitor is switched OFF then precaution is taken before making it ON. In between OFF and ON time, time should be kept to discharge the capacitor, otherwise capacitor may fail.
3. Switching current of capacitor is many times that of rated current; therefore cable size should be double of the normal current carrying capacity, so its cost increases.
4. When there is no load or system is lightly loaded at that time capacitor bank must be made OFF otherwise voltage across transformer increases

2) **By use of over excited synchronous motor (Synchronous condenser)**

Like capacitor bank, we can use an overexcited synchronous motor to improve the poor power factor of a power system. The main advantage of using synchronous motor is that the improvement of power factor is smooth. When a synchronous motor runs with over-excitation, it draws leading current from the source. We use this property of a synchronous motor for the purpose.



3) By use of over excited Schrage motor

To improve power factor an angular displacement of ρ is introduced between tertiary winding axis and secondary winding axis. Now flux φ cuts the tertiary winding axis some time later after it has covered an angular displacement of ρ degrees. Therefore emf phasor – Ej in this case lags

the emf phasor – Ej in case b by an angle ρ.

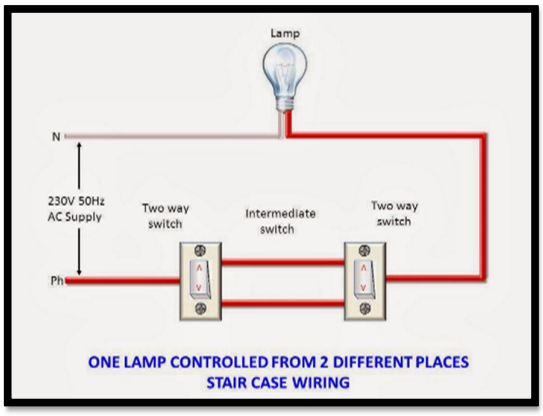
4) **By use of phase advancer.**

Phase advancers are used to improve the power factor of induction motors. The phase advancer is mounted on the same shaft as the main motor and is connected in the rotor circuit of the motor. It provides exciting ampere turns to the rotor circuit at slip frequency. By providing more ampere turns than required, the induction motor can be made to operate on leading power factor like an over-excited synchronous motor.

d) Draw a circuit dig. for controlling one lamp by two switches.

Ans: **(Fully labeled 4 marks, partial 1 to 3 marks proportional)**

Circuit dig. for controlling one lamp by two switches:



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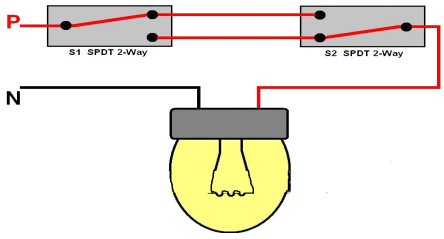


OR Equivalent figure

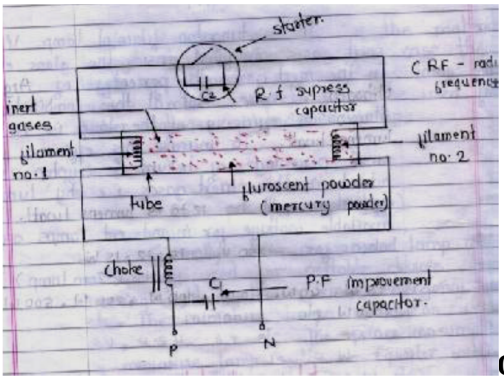
e) Enlist any four types of lamps and explain any one used for domestic application.

Ans: **(Types of lamp 2 Marks & Explanation of any one lamp 2 Marks: Total 4 Marks)**

Types of lamps used for domestic application:-

1) Fluorescent lamp
2) CFL Lamp
3) LED Lamp
4) Halogen Lamp
5) Metal Halide Lamp

1) Fluorescent lamp:-



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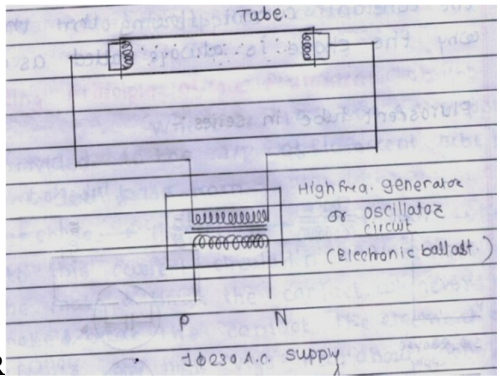


Construction:-

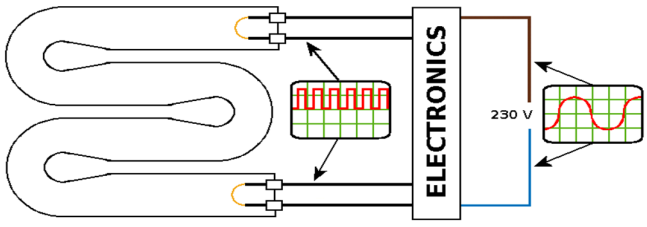
Fluorescent tube consists of tube, choke, starter & power factor improvement capacitor.

Operation:-

When switch is ON current flows through the choke-filament no1-starter-filament no. 2-to neutral, At that time choke induces high voltage which is applied to two filaments and ionized gas, Due to this there will be high voltage ionization so that light will be emitted through the tube. Choke is acting as ballast starter is used for make and break the circuit. To operate the fluorescent lamp, need a ballast (choke) to limit the current &provide the necessary starting voltage and starter for starting the tube.

OR

2) CFL Lamp:-



Construction OF CFL:-

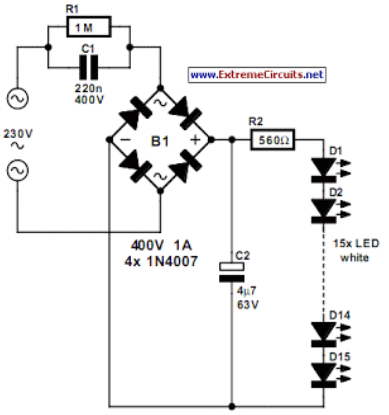
- CFL is basically a low pressure mercury vapor lamp having two electrodes placed in a glass tube.
- The tube is coated internally with some fluorescent material in the form of powder.
- In the tube one drop of mercury and argon gas is filled at low pressure.

- And consist of an electronic ballast circuit

Operation:-

- The electronic ballast circuit takes a 220 V input from external power source and sends high frequency supply is applied to that two terminals of CFL
- This ionizes the argon and mercury vapor particles.
- The ionized particles emit ultra violet radiations which strike with the fluorescent layer of material coated on the tube.
- In turn, fluorescent material spread a white light which lights up the room.

3) LED lamp:



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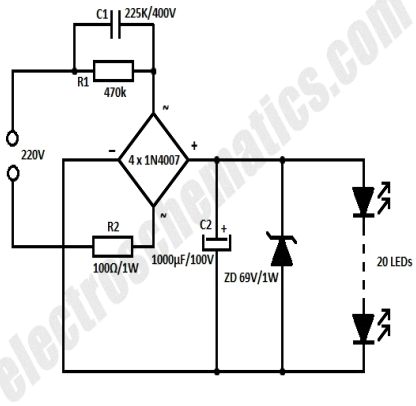


OR

or equivalent figure

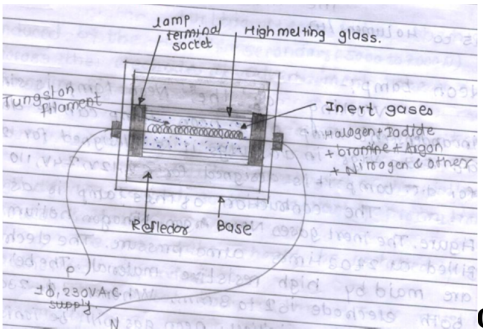
LED Lamp explanation of construction & working:-

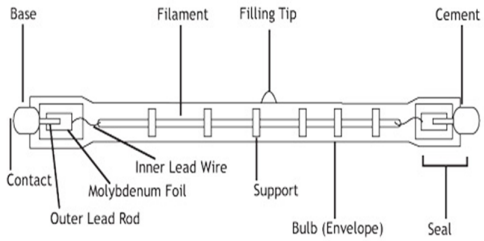
The working principle of LED is similar to diode (P-N junction) whenever DC current flows through the light emitting diode, if the current path is from anode to cathode there will be voltage drop across the diode. Ti is 1.5V to 2.1V then light will be emitted through this diode.

- The LED lamps are energy saving lamps,
- The power consumption of the single LED is very less. It is in mw. So by using series & parallel combination of LED.
- The LED lamp is manufactured the available wattage for the LED lamps are 1W,2W 3W, 5W etc.
- The LED lamps is available is various colours and diameter. The life of LED lamp is very high minimum 10000 working hours.

OR

4) Halogen Lamp:-





OR

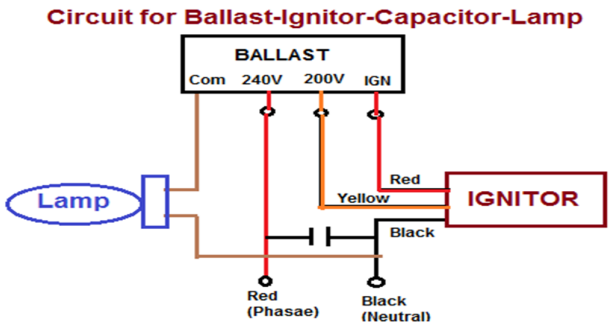
or equivalent figure

Working of Halogen Lamp:- **(Working : 2 Mark)**

- This is one type of incandescent lamp having number of advantages over the ordinary incandescent lamp.
- The life & efficiency of an incandescent lamp is affected by the gradual & evaporation of tungsten and also its operating temperature but the addition of small amount of halogen vapour to the gas in bulb restores.
- The evaporated tungsten vapour back to the filament by means of chemical reaction and the cycle goes on.
- Halogens are a group consisting of the elements chlorine, fluorine & bromine & iodine. As a result halogen lamps have the following advantages.
- There is no blacking of bulb so there is no depression of light output.
- It has 50 % more efficiency than that of an ordinary incandescent lamp.
- It is smaller in size.
- It gives better coloured radiation.
- Halogen lamps are manufacture upto 5KW and are suitable for outdoor illuminations.

OR

5) Metal Halide lamp:



Construction is similar to mercury lamp.

- MH lamps consist of an arc tube (inner) enclosed by an outer tube.
- Vacuum is created between the inner & outer glass tube to prevent heat loss.
- The inner arc tube contains the electrodes and various metal halides, along with mercury and inert gases that make up the mix.
- MH lamp has three electrodes – two for maintaining the arc and a third internal starting electrode
- **OR** Pulse-start MH lamps do not have a starting electrode. An igniter in the pulse start system delivers a high voltage pulse (typically 3 to 5 kilovolts) directly across the lamp's operating electrodes to start the lamp
- IT require a ballast to give high voltage at staring to produce the arc
- The capacitor is used to improve the power factor.

f) State the necessity of enclosures for motors. Enlist one application of each type of enclosure used for electric drives.

Ans: **Necessity of enclosures for motors:-** **(2 Marks)**

1. It protects the operator against the contact with live and moving parts.
2. It provides protection to internal parts of motor against mechanical injury.
3. It gives mechanical support.
4. It provides protection against entry of moisture, dirt, dust particles inside the motor.
5. Main purpose of enclosure is to fold the machines.

Application of enclosures- **(Any two type enclosures one application 2 Marks)**

1. **Open type enclosure**
   It is used where motor is installed in clean atmosphere and in closed room.
2. **Screen protected enclosure**
   It is used where motor is installed in clean atmosphere and in closed room.
3. **Drip proof enclosure**
   It is used where there is damp atmosphere condition such as water pumping station ,

	motor on ship. **4. Flame proof enclosure** It is used where motor is used in explosive atmosphere such as chemical and plants mines. **5. Totally enclosed type enclosure** It is used where dusty atmosphere such as stone crushing plant, coal handling plant, saw mill, cotton industry. **6. Pipe ventilated totally enclosed enclosure** It is used where dusty atmosphere such as saw mill, stone crushing plant.

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