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 THREE of the following: 12 Marks

a) Compare a group drive and an individual drive.

Ans:

(Any four point expected: 1 Mark each)

S.No.	Point	Group Drive	Individual Drive
1.	Initial Cost	Less	High
2.	Flexibility	Less Flexibility	More Flexibility
3	Safety	It is less Safe	It is more safe
4	Reliability	It has less reliability	It has high reliability
5	Space required	Less	More
6	Overload Capacity	Higher	Less
7	Maintenance cost	Less	More
8	Speed control	Difficult	Easily possible
9	Mechanical Power transmission losses	More Losses	Less losses
10	Addition/Alternation	Easily not possible	Easily possible

OR

S.No.	Point	Group Drive	Individual Drive
1	Definition	In a group drive single large capacity electric drives is used to run number of machine through a long common shaft.	In this type of drive each machine has its own separate electric drive (motor). It may be directly coupled or indirectly

			coupled
2	Cost	Less	High
3	Total HP	Less	More
4	Appearance	Not good	Good
5	Safety	It is less Safe	It is more safe
6	Flexibility	Less Flexibility	More Flexibility
7	Performance	Better if operated at full load	Better if operated at full load
8	Any one application of each	Textile Industry **(Similar application will be consider)**	Lathe Machine **(Similar application will be consider)**

b) State various applications of dielectric heating.

Ans: **Applications of Dielectric Heating:-** **(Any four application expected: 1 Mark each)**

1) In food processing industry, dielectric heating is used for Baking of cakes & biscuits in bakeries.
2) Cooking of food without removing outer shell (e.g.-boiled egg) and pasteurizing of milk.
3) For Rubber vulcanizing.
4) In Tobacco manufacturing industry for dehydration of tobacco.
5) In wood industry for manufacturing of ply wood.
6) In plastic Industry for making different containers.
7) In cotton industry for drying & heating cotton cloths for different processes.
8) In tailoring industry for producing threads.
9) For manufacturing process of raincoats & umbrellas.
10) In medical lines for sterilization of instruments & bandages.
11) For heating of bones & tissues of body required for certain treatment to reduces pains & diseases.
12) For removal of moisture from oil.
13) For quick drying gum used for book binding purpose.
14) In foundry for heating of sand, core, which are used in molding processes.

OR

Dielectric heating is used in following purposes:

1. Plywood industry
2. Sand core baking
3. Plastic industry
4. Tobacco industry
5. Bakeries
6. Electronic sewing
7. Dehydration of food
8. Electro medical application
9. Book binding

c) Define the following terms: i) Luminous Intensity ii) Lumen iii) Candle power iv) Waste light factor.

Ans:

i) Luminous intensity:- **(Each Definition: 1 Mark)**

The luminous intensity in any particular direction is the luminous flux emitted by source per unit solid angle is called the luminous intensity of the source. And its **unit is Candela**

OR $I = \frac{\phi}{w}$ $(Where\ \phi = luminous\ flux, w = Solid\ Angle)$

ii) Lumen:

It is defined as the luminous flux emitted by a source of one candle power per unit solid angle in all directions **OR**

It is unit of luminous flux. One lumen is defined as luminous flux emitted per unit solid angle from a point source of candle power.

iii) Candle power:

The candle power is the radiation capacity of the light source in the given direction. The candle power is always given in lumens output per unit solid angle of the given light source. $C.P = \frac{Lummens}{w}$, $(Where\ w = Solid\ Angle)$

iv) Waste light factor:

When a surface is illuminated by several numbers of the sources of light, there is certain amount of waste due to overlapping of light waves,

The waste of light is taken into account depending upon the type of area to be illuminated.

The value of waste Light factor 1 to 1.5

d) Explain any three disadvantages of low power factor and state three methods to improve it.

Ans:

Disadvantages of Low power Factor: -

(Any three disadvantages are expected: 1 Mark each)

1) Cross section of conductor increases: -

$$\text{C/s of conductor } \alpha\ I\ \alpha 1/(pf)$$

As power factor reduces current increases, cross section of conductor increases. Hence its cost increases.

2) Design of supporting structure: -

As power factor reduces, cross section of conductor increases, so its weight increases. To handle this weight design of supporting structure becomes heavier, so its cost increases.

3) Cross section of terminals increases: -

As power factor reduces, current increases, Hence cross section of switch gear, bus bar, contacts, and terminals increases. So its cost increases.

4) Copper losses increases: -

As power factor reduces current increases. So copper losses increases. As an effect efficiency reduces.

$$\text{Copper losses } \alpha\ I^2\ \alpha\ \frac{1}{(P.f)^2}$$

5) Voltage drop increases: -

As P.F. reduces current increases. Therefore voltage drop increases, so regulation becomes poor.

$$\text{Voltage drop } \alpha\ I\ \alpha\ \frac{1}{P.f}$$

6) Handling Capacity of equipment reduces:

Handling capacity (KW) of each equipment such as Alternator, transformer reduces as power factor reduces.

7) High KVA rating of equipment required:- $KVA \alpha I \alpha 1/pf$,

As power factor decreases KVA rating of all equipments increases, so that its cost increases.

$$\text{KVA rating } \alpha \text{ I } \alpha \frac{1}{\text{P. f}}$$

8) Cost/unit increases: - From all above disadvantages it is seen that cost of generation, transmission & distribution increases. Also its performance efficiency & regulation reduces, So that cost/unit increases.

Following are the methods of improving power factor:

(Any one methods expected: 1 Mark)

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.

Q.1B)	**Attempt any ONE :** **06 Marks**
a)	**What is electrical braking ? Explain regenerative braking for D.C. series motor.**

Ans:

Meaning of Electrical braking : **(2 Mark)**

It is necessary to stop the vehicle when mechanical working is over or when required within reasonable time. **OR** To reduce the speed of train electrical system is used for braking e.g. Plugging, dynamic braking & Regenerative braking.

Schematic diagram of regenerative braking of D.C. series:

(Figure: 2 Mark & explanation: 2 Mark)

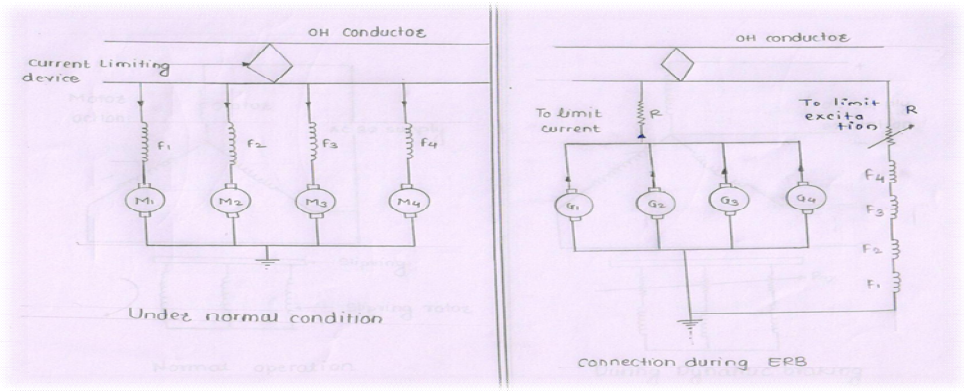


Fig. --- A Fig. --- B

➢ **Explanation of regenerative braking:**

- ➢ During normal running motors are connected in parallel with field winding in series w.r.t. armature as shown in figure A.
- ➢ At the time of regenerating braking all the armature are connected in parallel without series field winding and all series field winding are connected in series with external resistance & are separately excited as shown in fig.B
- ➢ At this time motor acts as a generator and excitation current is so adjusted that generated voltage (Eg) is greater than supply voltage (V), so that power will be fed back to supply.
- ➢ This process is continued up to the speed of train reaches up to 20 to 16 km/hr. after that it is difficult to maintain generated voltage greater than supply voltage. So, electric regenerative braking is stopped
- ➢ For final stop mechanical braking is applied.
- ➢ External Resistances are connected to limit the current.

b) Describe any two methods of current flow control in welding transformer.

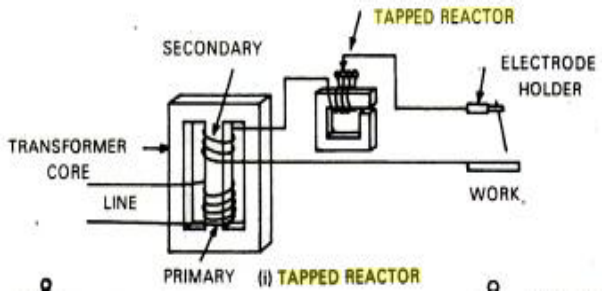
Ans: **Methods of current flow control in welding transformer:**

1. Tapped Choke (Reactor) method
2. Moving coil method
3. Magnetic shunt method

4. Moving core method
5. Saturable reactor method

Explanation: (Any Two method Expected: Each figure: 1Mark & each Explanation: 1Mark)

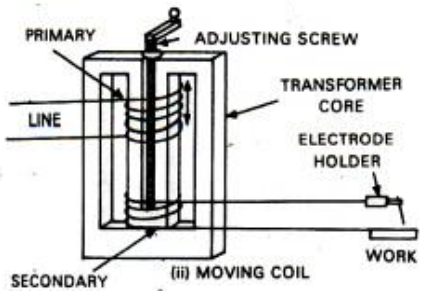
1. Tapped chock (Reactor) method:



or equivalent figure

- In this method tapping on reactor in the secondary circuit**.**
- Use a tapped reactor, which does not gives a continuous current output demands for certain important applications.
- The limited number of tapes restricts the values of output current available.
- However this system is relatively efficient and suitable general fabrication and repair work.

2. Moving coil method:



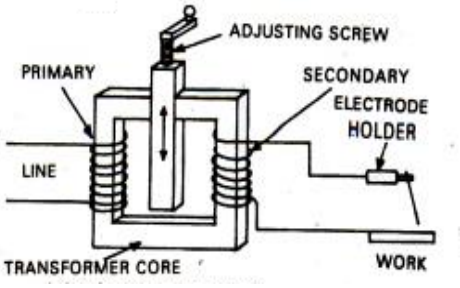
or equivalent figure

- In this method changing magnetic coupling between primary and secondary by physically changing the position of coil**.**
- Change the reactance of the transformer by changing the relative position s of the coils.
- Moving one coil away from the other increases the amount of leakage flux flow between them, thereby increasing the leakage reactance of the coils. This reduces the current output.
- The change in positions of coils is brought about by a lead screw which facilities continuous adjustment of current.
- With such a design, the coils may at times loosened and vibrate when the transformer is in

use, causes noise.

- The connections to coils may also create service problem because continues flexing.

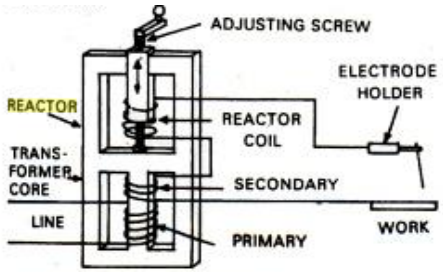
3. Magnetic shunt method:



or equivalent figure

- In this method changing magnetic coupling between primary and secondary by putting a movable magnetic shunt**.**
- In this method uses a different principle of changing the reactance of the coils.
- It employs path which diverts part of total lines of force linking with the secondary coils.
- The movement of this magnetic shunt causes the leakage flux to vary and thereby adjusts the output current.
- This method also gives rise to vibration of movable parts with attendant noise if the parts wear out and become loose in service.
- Sometimes mechanical parts such as the lead screw can dirty and difficult to move.
- These drawbacks can be taken care of through carefully assembly and efficient workmanship in manufacture and through good maintenance at the user ends.
- On large machines, movement of magnetic shunt can be conveniently motorized.

4. Moving core method:

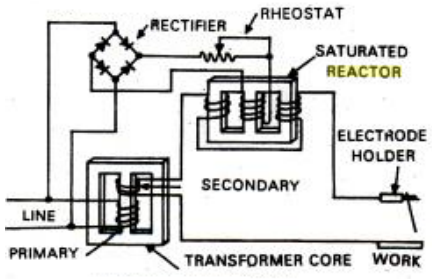


or equivalent figure

- In this method moving the iron core in the reactance instead of in the main core.
- The moving core changes the air gap which changes the reactance.

- The larger the air gap, the smaller the impedance and higher the output.
- This method also gives rise to vibration of movable parts with attendant noise if the parts wear out and become loose in service.
- The inside of the typical core moving transformer show in above figure.

5. Saturable reactor method:



or equivalent figure

- In this method putting saturable reactor unit secondary circuit.
- In this Method eliminates all the moving parts is with their service problems, but is more expensive.
- In this system, secondary reactor impedance is controlled by regulating the saturation level of the core electrically.
- The system uses a rectifier bridge and a rheostat to control the DC current in the control coil.
- When there is no DC current flowing through the control winding, the impedance is maximum and the output is minimum. Reverse is the case when the maximum DC current is flowing in the control winding.
- With this method, remote control of welding current is possible, i.e. the reactor current adjustment can be located near the welder by using an extension cord. The adjustment can be by the welder's hand or foot.
- Electrical circuit diagram of a typical heavy-duty welding transformer having maximum continuous hand welding current of 300 Amps. at 60% duty cycle is shown in above figure.
- This machine uses moving core magnetic shunt method of current control.

Q.2	**Attempt any FOUR :** **16 Marks**
a)	**What is load equalization? Explain with neat diagram and graphs, the process of the load equalization.**

Ans: **Meaning of load equalization:**

(Meaning : 2 Mark, Figure: 1 Mark & explanation: 1 Mark)

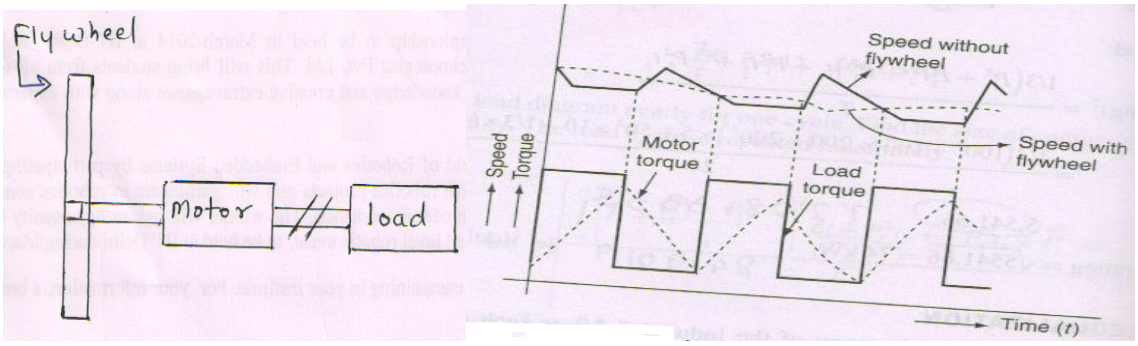
There are many types of load which are fluctuating in nature e.g. wood cutting m/c, Rolling mill. Etc. For such type of loads, load equalization is necessary to draw the constant power from supply. Because,

When there is sudden load on motor, it will draw more current from supply at start to meet additional power demand. Due to this heavy current there is large voltage drop in supply system. This will affect electrical instrument, equipment, m/c, other consumer etc. which are connected across same supply line.

Also to withstand heavy current, size of input cable increases so cost of cable increases, Hence it is necessary to smooth out load fluctuations on motor.

The process of smoothing out load fluctuation is called load equalization.

Diagram of Load Equalization:



How load equalization is done?

Load equalization is done by means of **flywheel**. It is mounted on motor shaft.

Flywheel stores kinetic energy when there is light or no load & it supplies kinetic energy when there is sudden heavy load on motor. In this way load demand on supply remains practically constant.

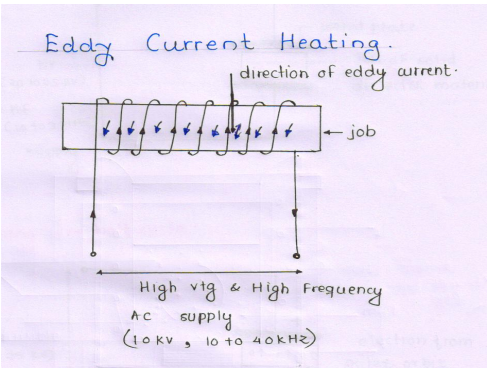
not necessary to use large size of cable as it will not draw more current from supply.

b) State the principle and application of eddy current heating.

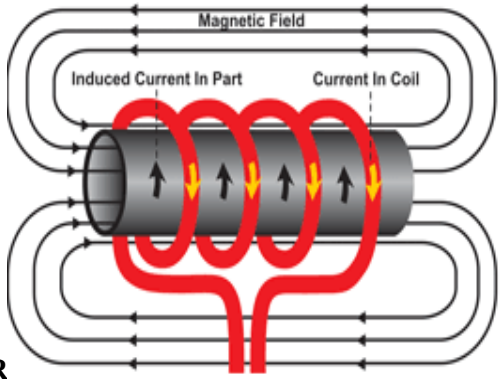
Ans:

Principle of Eddy Current Heating:-

(Figure: 1 Mark, Principle : 1 Mark & any four application : 1/2 Mark each, Total : 4 Mark)



OR



Principle of operation for eddy current heating:

The job which is to be heated is wound by coil as shown in figure.

Supply of high voltage (10KV) & high frequency (10-40 KHz) is given to coil which induces eddy current in job according to Faraday's law of Electromagnetic induction & these eddy currents are responsible to produce heat in job itself due to eddy current loss.

In high frequency eddy current heating the phenomenon of skin effect plays an important role.

Skin effect at high frequency is more pronouncedced (effective). Due to this surface of job gets more heated as compared to its depth.

Application of Eddy Current Heating:- (Any three application expected)

1) For Surface hardening of steel.
2) For analyzing of metals.
3) Sterilization of surgical instruments.
4) For electrolytic tin plating.
5) For soldering & welding.
6) For drying of paints & varnish.
7) Tempering of machine parts.
8) Forging of bolt heads & rivet heads etc

c) Compare AC and DC system of traction.

Ans: **(Any four point expected: 1 Mark each)**

Sr.No	Points	AC System of Traction	DC System of Traction
1	Supply given to O/H conductor	1-ph, 25KV, AC 50Hz	DC 600/750V-Tromways 1500/3000V Urban/suburban
2	Type of drive used	1-ph, AC series motor	DC series motor for traction and DC compound motor for tramways.
3	Weight of traction motor	1.5 times more than D.C. series motor for same HP	1.5 times less then A.C. series motor for same HP
4	Weight of motor coach	More Because of transformer in motor coach and high weight of A.C. series motor.	less
5	Starting torque	Less starting torque than D.C. series motor	High starting torque
6	Acceleration and retardation	Less than D.C. series motor.	High
7	Overload capacity	Less than D.C. series motor	High
8	Method of speed control	Not limited	Limited, except chopper control method
9	Maintenance cost of traction motor	More	Less
10	Starting Efficiency	More	Less
11	Chances of radio interference	Yes	No
12	Ridding quality	Less better than D.C.	Smooth (Better)
13	Insulation cost	High	Low
14	Cross section of conductor	Less	More
15	Design of supporting straight	light	Heavy
16	Distance between two substation	More	Less
17	No. of substation required for same track distance	Less	More

18	Size (capacity) of traction substation	More	Less
19	Capital & maintenance cost of substation	Less	More
20	Cost track electrification	Less	More
21	Applications	Main line services	Urban and suburban services

d) Write any eight desirable characteristics of traction motors.

Ans: **Traction motor should posses Following Characteristics:**

(Any eight Characteristics expected: 1/2 Mark each)

A) Mechanical Properties or characteristics:

1) It should be simple in design
2) It should be robust in construction to withstand against continuous vibrations.
3) Weight of motor per HP should be minimum in order to increase pay load capacity.
4) It must be small in overall dimensions, especially in overall diameter.
5) It must have totally enclosed type enclosure to provide protection against entry of dirt, dust, mud, water etc. in drive.
6) When motors are running in parallel they should share almost equal load. (even when there is unequal wear & tear of driving wheels)
7) It should have high coefficient of adhesion.
8) It should have lower center of gravity.

B) Electrical Properties or characteristics:

9) It should have high starting torque.
10) It should possess high rate of acceleration & retardation.
11) It should be variable speed motor.
12) Its speed-torque characteristics should be such that it should produce high torque at low speed and low toque at high speed.
13) Motor must be capable of taking excessive overload in case of emergency.
14) It should have simple speed control methods.
15) Electrical braking system should be reliable, easy to operate and control, especially regenerative braking is possible.

16) Motor should draw low inrush current (Starting current, and if supply is interrupted and restore again.)
17) It should withstand for voltage fluctuation without affecting its performance.
18) It should have high power to weight ratio.

C) General Properties or characteristics:

19) It should have low initial cost.
20) It should have less maintenance cost.
21) It should have high efficiency

e) **State the difference between actual speed and schedule speed of train. State the factors affecting schedule speed of a train.**

Ans:

(Any two point expected: 1 Mark each)

S.No	Actual Speed	Schedule Speed
1	Distance / Time	Distance / Actual time of run + Stop time
2	Actual speed is the speed you are traveling at any given moment at any given point.	Schedule speed is a true speed which includes stop time also
3	Railway or any time table is not based on actual speed	Railway or any time table is based on schedule speed
4	Actual Speed is more	Scheduled Speed is less

The following factors affect the schedule speed of a train:

(Any two point expected: 1 Mark each)

1. Acceleration:

By increasing acceleration we can reduce actual time of run, so schedule speed increases.

2. Retardation:

By increasing retardation we can reduce actual time of run, so schedule speed

increases.

3. Both Acceleration and Retardation:

For a given run by increasing both acceleration and retardation we can reduce actual time of run, so schedule speed increases.

4. Maximum speed:

By increasing maximum speed we can reduce actual time of run, so schedule speed increases.

5. Stop time:

By reducing stop time we can reduce the schedule time so schedule speed increases.

6. Coasting period:

For a given run by reducing coasting period we can reduce actual time of time. so schedule speed increases.

Q.3	**Attempt any TWO :**	**16 Marks**
a)	**A motor has to perform the following duty cycle: 1) Load rising from 200 kW to 500 kW in 4 minutes. 2) Uniform load of 350 kW for 2 minutes. 3) Regenerative braking power returned to supply from 150 kW to zero in 2 minutes. 4) Remains ideal for 1 minute. Determine power rating of motor.**	

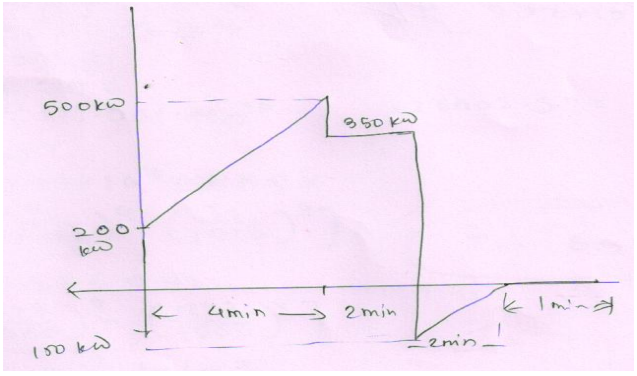
Ans:

i) Load rising from 200 to 500 Kw :- 4 min

ii) Uniform load of 350 Kw :- 2 min

iii) Regenerative braking from 150 Kw to zero :- 2 min

iv) idle for :- 1 min



or Equivalent fig-------(1 Mark)

Rating of Motor in KW =

$$KW = \sqrt{\frac{\frac{1}{3}\left(KW_1^2 + KW_1\,KW_2 + KW_2^2\right)\times t_1 + KW_3^2 t_2 + \frac{1}{3}\,KW_4^2 t_3 + KW_5^2 t_4}{T}}$$ ---------- **(1Mark)**

Where, $T = t_1 + t_2 + t_3 + t_4$

$T = 4 + 2 + 2 + 1$

$T = 9$ min. ---------- ---------- **(1 Mark)**

$$KW = \sqrt{\frac{\frac{1}{3}\left(KW_1^2 + KW_1\,KW_2 + KW_2^2\right)\times t_1 + KW_3^2 t_2 + \frac{1}{3}\,KW_4^2 t_3 + KW_5^2 t_4}{9}}$$ ------ **(1 Mark)**

$$KW = \sqrt{\frac{\frac{1}{3}\left(200^2 + 200\times 500 + 500^2\right)\times 4 + 350^2\times 2 + \frac{1}{3}\,(-150)^2\times 2 + 0^2\times 1}{9}}$$ ------- **(1 Mark)**

$$KW = \sqrt{\frac{780000}{9}}$$

$KW = 294.39\ KW$ ----------Answer---------- **(3 Mark)**

So, Select nearest standard rating of motor available in the market.

b) **A 50 kW, three phase, 440 V resistance oven is to provide nickel-chrome strip 0.3 mm thick, for the three-star connected heating elements. If the temperature of the wire is to be 1500° C and that of the charge is to be 1000° C, calculate a suitable width of the strip. Take emissivity as 0.91 and radiation efficiency as 0.6. The specific resistance of nichrome alloy is 1.016 X 10^6. What would be the temperature of the element, when charge is cold at 20° C ?**

Ans: **Given Data:**

$T_1 = 1500^0C = 1500 + 273 = 1773^0K$

$T_2 = 1000^0C = 1000 + 273 = 1273^0K$

Radiation efficiency = 0.6, specific resistance of Ni-Cr = 1.016×10^{-6} ohm m, emissivity = 0.91.

(NOTE :_**This problem is solved by taking value Specific resistance of Ni-Cr = 1.016 x 10^6 and also by taking value Specific resistance of Ni-Cr = 1.016 x 10^{-6} : Give marks to both answers)**

Solution By take Specific resistance of Ni-Cr = 1.016 x 10^6 :

$$\mathbf{H} = 5.72\times10^4\ k.e\left[\left(\frac{T_1}{1000}\right)^4-\left(\frac{T_2}{1000}\right)^4\right]\ \ w/m^2$$ ---------- **(1/2 Mark)**

$$\mathbf{H} = 5.72\times10^4\ 0.6\times0.91\left[\left(\frac{1773}{1000}\right)^4-\left(\frac{1273}{1000}\right)^4\right]\ \ w/m^2$$

$$\mathbf{H} = 226602.97\ \ w/m^2$$ ---------- **(1 Mark)**

$\Rightarrow$ *Thickness* : 0.3 *mm* $\therefore 0.3\times10^{-3}\ m$

➢

$$\therefore \frac{l}{w\ t} = \frac{V^2}{P\ \rho}$$ ---------- **(1/2 Mark)**

$$Voltgae\ across\ each\ \ resis\tan ce = \frac{V}{\sqrt{3}} = \frac{440}{\sqrt{3}}$$

$$Voltgae\ across\ each\ \ resis\tan ce = 254.03\ volt$$ ---------- **(1 Mark)**

$$Power = \frac{50\ KW}{3} = 16.6666\times10^3\ \ watt$$ ---------- **(1 Mark)**

$$\therefore \frac{l}{w\ t} = \frac{V^2}{P\ \rho}$$

$$\therefore \frac{l}{w\times(0.3\times10^{-3})} = \frac{(254.03)^2}{(16.66\times10^3)\times1.061\times10^6)}$$

$$\therefore \frac{l}{w} = \frac{(254.03)^2\times(0.3\times10^{-3})}{(16.6666\times10^3)\times1.061\times10^6)}$$

$$\therefore \frac{l}{w} = 1.1433\times10^{-9}\ \ .....Equation.....I$$ ---------- **(1 Mark)**

$$\therefore \frac{t}{l^2} = \frac{2\ \rho\ H}{V^2}$$ ---------- **(1/2 Mark)**

$$l^2 = \frac{V^2 t}{2\,\rho H}$$

$$l = \sqrt{\frac{V^2 t}{2\,\rho H}}$$

$$l = \sqrt{\frac{(254.0341)^2 \times 0.3 \times 10^{-3}}{2 \times 1.016 \times 10^6 \times 226602.97}}$$

$\therefore \quad l = 6.4841 \times 10^{-6} \ mtr$

---------Equation II---------- **(1 Mark)**

Putting in Equation : I

$$\therefore \quad \frac{l}{w} = 1.1433 \times 10^{-9}$$

$$\therefore \ w = \frac{6.4841 \times 10^{-6}}{1.1433 \times 10^{-9}}$$

$\therefore \quad w = 5671.3898 \ mtr$

---------- **(1 Mark)**

Answer : $\therefore$ *Length* $l = 6.4841 \times 10^{-6}$ *mtr* $\therefore$ *Widgth* $w = 5671.3898$ *mtr*

PART - II: When charge is cold at 20° C?

Temperature of charge = $T_2 = 20^0C + 273^0C = 293^0C$

$$\mathbf{H} = 5.72 \times 10^4 \ k.e \left[\left(\frac{T_1}{1000}\right)^4 - \left(\frac{T_2}{1000}\right)^4 \right] \ w/m^2$$

$$\mathbf{H} = 5.72 \times 10^4 \times 0.6 \times 0.91 \left[\left(\frac{T_1}{1000}\right)^4 - \left(\frac{293}{1000}\right)^4 \right] \ w/m^2$$

$T_1 = 1640^0 K$

---------- **(1/2 Mark)**

OR Student may solve this type

Solution By take Specific resistance of Ni-Cr = 1.016 x 10^{-6} :

$$\mathbf{H} = 5.72\times10^{4}\ k.e\left[\left(\frac{T_1}{1000}\right)^{4}-\left(\frac{T_2}{1000}\right)^{4}\right]\ \ w/m^{2}$$ ---------- **(1/2 Mark)**

$$\mathbf{H} = 5.72\times10^{4}\ 0.6\times0.91\left[\left(\frac{1773}{1000}\right)^{4}-\left(\frac{1273}{1000}\right)^{4}\right]\ \ w/m^{2}$$

$$\mathbf{H} = 226602.97\ \ w/m^{2}$$ ---------- **(1 Mark)**

$\Rightarrow$ *Thickness* : $0.3\ mm\ \ \therefore 0.3\times10^{-3}\ m$

➢ $$\therefore \frac{l}{w\ t} = \frac{V^2}{P\ \rho}$$ ---------- **(1/2 Mark)**

$$Voltgae\ across\ each\ \ resistance = \frac{V}{\sqrt{3}} = \frac{440}{\sqrt{3}}$$

$$Voltgae\ across\ each\ \ resistance = 254.03\ volt$$ ---------- **(1 Mark)**

$$Power = \frac{50\ KW}{3} = 16.6666\times10^{3}\ \ watt$$ ---------- **(1 Mark)**

$$\therefore \frac{l}{w\ t} = \frac{V^2}{P\ \rho}$$

$$\therefore \frac{l}{w\times(0.3\times10^{-3})} = \frac{(254.03)^2}{(16.66\times10^{3})\times1.061\times10^{-6})}$$

$$\therefore \frac{l}{w} = \frac{(254.03)^2\times(0.3\times10^{-3})}{(16.6666\times10^{3})\times1.061\times10^{-6})}$$

$$\therefore \frac{l}{w} = 1143.24\ \ .....Equation.....I$$ ---------- **(1 Mark)**

$$\therefore \frac{t}{l^2} = \frac{2\ \rho\ H}{V^2}$$ ---------- **(1/2 Mark)**

$$l^2 = \frac{V^2 t}{2\rho H}$$

$$l = \sqrt{\frac{V^2 t}{2\rho H}}$$

$$l = \sqrt{\frac{(254.0341)^2 \times 0.3 \times 10^{-3}}{2 \times 1.016 \times 10^{-6} \times 226602.97}}$$

$\therefore \quad l = 6.4841 \times 10^{-6} \ mtr$

---------Equation II---------- **(1 Mark)**

Putting in Equation : I

$$\therefore \quad \frac{l}{w} = 1143.24$$

$$\therefore \ w = \frac{6.4841}{1143.24}$$

$\therefore \quad w = 0.005671 \, mtr$

---------- **(1 Mark)**

Answer : $\therefore$ *Length* $l = 6.4841 \, mtr$ $\therefore$ *Widgth* $w = 0.005671 \, mtr$

PART - II: When charge is cold at 20° C?

Temperature of charge = $T_2 = 20^0C + 273^0C = 293^0C$

$$\mathbf{H} = 5.72 \times 10^4 \ k.e \left[\left(\frac{T_1}{1000}\right)^4 - \left(\frac{T_2}{1000}\right)^4 \right] \ w/m^2$$

$$\mathbf{H} = 5.72 \times 10^4 \times 0.6 \times 0.91 \left[\left(\frac{T_1}{1000}\right)^4 - \left(\frac{293}{1000}\right)^4 \right] \ w/m^2$$

$T_1 = 1640^0 K$

---------- **(1/2 Mark)**

c) What are the different safety and protective devices used in elevators? Also state functions of each device.

Ans:

➢ **Safety Devices used in elevators & its function**:-

(Any four safety device & their function expected: 1 Mark each)

S.No	Safety Devices	function
1	Door safety switch	Door will not open when elevator is in operating condition.
2	Over travel switch	It avoids over travel
3	Over speed control switch	It controls the speed
4	Car safety switch	It protects the car
5	Car operating switch	It operates the car
6	Emergency STOP Switch	In case of emergency this switch is operated
7	Fire Fighting Equipment	For Extinguishing Small Fire

➢ **Protective Devices used in elevators & its function:-**

(Any four Protective device & their function expected: 1 Mark each)

S.No	**Protective Devices**	**function**
1	Main line service switch (main switch and fuse)	for a ON-OFF purpose
2	CB and overload relay	for protection against over current fault
3	Phase failure protective relay.(1-ph preventer)	It as good as single phase preventer, It protects motor to run on single phasing
4	Phase reversal protective relay	It avoids motor to run in reverse direction
5	Over speed, slow down relay	It avoids to run motor in over speed

Q.4 A) Attempt any THREE : 12 Marks

a) Write classification of electric welding and its advantages.

Ans: **Classification of electric welding** : **(2 Mark)**

i) Resistance Welding:-(Plastic / Non- Fusion / Pressure Welding)

1) Spot welding

2) Seam welding

3) Projection Welding

4) Butt Welding

5) Flash Butt welding

ii) Arc welding (Fusion/Non pressure welding):-

1) Carbon Arc Welding:

a) shielded welding b) unshielded welding

2) Metal Arc Welding:

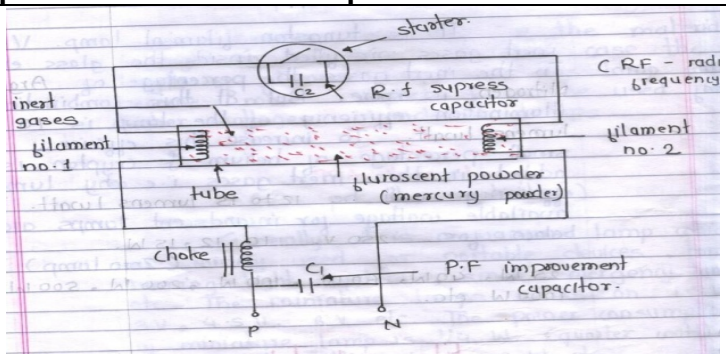
a) shielded welding b) unshielded welding

Advantages of electric welding: **(Any Four advantages are expected: 1/2 Mark each)**

1. It requires less time for joining (welding) two metals.
2. Two similar and dissimilar metals can be welded.
3. Control of current (temperature) and welding time can be controlled accurately and automatically.
4. More perfect (sound) and uniform weld is obtained.
5. Properties of weld and joining material remain same.
6. It is more reliable.
7. Welding process is clean
8. Easy to operate and handle.
9. Welding equipments are portable.
10. No Standby losses. So high efficiency.

b) Explain the operating principle and working of a fluorescent lamp. Mention the function of following components: i) Electrodes ii) Choke in) Capacitor in glow type starter. iv) Capacitor connected across input terminals.

Ans:



Operation: **(2 Mark)**

- When switch is ON current flows through the choke.
- At that time choke induces high voltage which is applied to two filaments
- Due to this there will be ionization so that light will be emitted through the tube.

OR

- Fluorescent lamps produce light by passing an electric current through a gas that emits light when ionized by current. An auxiliary device known as a ballast supplies voltage to the lamps's electrodes, which have been coated with a mixture of alkaline earth oxides to enhance electron emission.

Function of following components: **(Each function of components: 1/2 Mark)**

i) Electrode:

- It is made by high resistive element. to initiate an arc

ii) Choke: For providing high voltage at the time of starting and limit the current.

iii) Capacitor in glow type starter: To make and break the circuit to start the tube.

iv) Capacitor connected across input terminals: To improve the power factor, To minimize the radio interference

c) Write short notes on the following: i) Two part tariff. ii) Power factor tariff

Ans: **i) Two part tariff:-** **(2 Mark)**

- 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. e.g.

Note :- Table not necessary

For Residential consumers: e.g.

Fixed/Demand Charge	Energy Charge (Rs./kWh)
Single Phase : Rs. 40 per month Three Phase : Rs. 130 per month	Flat rate e.g. Rs. 5 / Kwh for all units consumed OR Block rate tariff

For Industrial / commercial consumers load up to 20 Kw :- e.g.

Fixed/ Demand Charge	Energy Charge (Rs./kWh)
Rs. 190 per month	Flat rate e.g. Rs. 6 / Kwh for all units consumed OR Block rate tariff

ii) Power Factor Tariff:- **(2 Mark)**

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.

Note :- Table not necessary

- 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

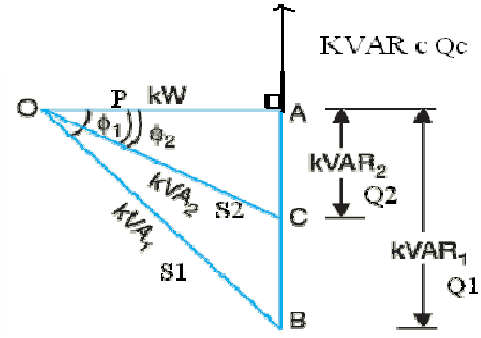
Note :- Table not necessary

Power factor penalty:- e.g.

Power factor lagging	Percentage of penalty
For 0.90 Power 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

d) Derive an expression for the most economical value of power factor.

Ans: **Derivation:**



or equivalent figure… **(1/2 Mark)**

Let,

P = Active power KW

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

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

Q_C = Leading Reactive power drawn by Capacitor

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

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

Rs X = Tariff charges towards M.D. (KVA) /year

Rs Y = Expenditure towards KVAr to be neutralized per year (Expenditure towards P.F. improving apparatus)

1) Before improving Power factor: ---------- **(1/2 Mark)**

$$Q_1 = P \tan \phi_1$$

$$\text{Cos } \phi_1 = \frac{P}{S_1}$$

$$S_1 = \frac{P}{\text{Cos } \phi_1}$$

$$\therefore KVA_1 \ (S_1) = P \sec \phi_1$$

2) After improving Power factor: ---------- **(1/2 Mark)**

$$Q_2 = P \tan \phi_2$$

$$\text{Cos } \phi_2 = \frac{P}{S_2}$$

$$S_2 = \frac{P}{\text{Cos } \phi_2}$$

$$\therefore KVA_2 \ (S_2) = P \sec \phi_2$$

3) Saving in KVA charges: ---------- **(1/2 Mark)**

$$= \text{Rs X } (S_1 - S_2)$$

$$= \text{Rs X } (P \sec \phi_1 - P \sec \phi_2)$$

$= Rs\ X\ .P\ (\ \sec\phi_1 - \sec\phi_2)$

4) Expenditure towards KVAr to be neutralized: ---------- **(1/2 Mark)**

$= Rs\ Y\ (Q_1 - Q_2)$

$= Rs\ Y\ (P \tan\phi_1 - P \tan\phi_2)$

$= Rs\ Y x P\ (\ \tan\phi_1 - \tan\phi_2)$

5) Net Saving: ---------- **(1/2 Mark)**

= Saving in KVA charges - Expenditure towards KVAr to be neutralized.

$= [Rs\ X\ .P\ (\ \sec\phi_1 - \sec\phi_2)]\ -\ [\ Rs\ Y\ (P \tan\phi_1 - P \tan\phi_2)]$

Saving will be maximum when differentiate above equation with respect to ϕ_2 and equate to zero.

$$\frac{ds}{d\phi_2} = \frac{d}{d\phi_2}\left[\ Rs\ X\ P\ (\sec\phi_1 - \sec\phi_2)\right] - \left[\ Rs\ Y\ P\ (\tan\phi_1 - \tan\phi_2)\right]$$

$$= 0 - X\ P \sec\phi_2 \times \tan\phi_2 - 0 + Y\ P \sec^2\phi_2$$

$$0 = -\ Rs\ X\ P \sec\phi_2 . \tan\phi_2 - 0 + Rs\ Y\ P \sec^2\phi_2$$

$$Rs\ X\ P \sec\phi_2 . \tan\phi_2 = Rs\ Y\ P \sec^2\phi_2$$

$$\therefore Rs\ X\ \tan\phi_2 = Rs\ Y\ \sec\phi_2$$

$$\therefore Rs\ X\ \frac{\sin\phi_2}{Cos\phi_2} = Rs\ Y\ \frac{1}{Cos\phi_2}$$

$$\therefore Rs\ X\ \sin\phi_2 = Rs\ Y$$

$$\therefore\ \sin\phi_2 = Rs\ \frac{Y}{X}$$

6) $\therefore\ \sin^2\phi_2 + Cos^2\phi_2 = 1$ ---------- **(1/2 Mark)**

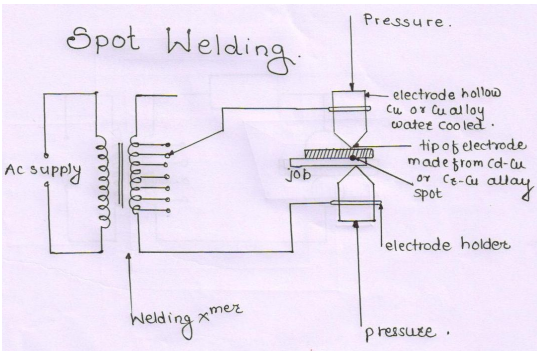
$$Cos^2\phi_2 = 1 - \sin^2\phi_2$$

Most economical power factor = $Cos\ \phi_2 = \sqrt{1-(Y/x)^2}$

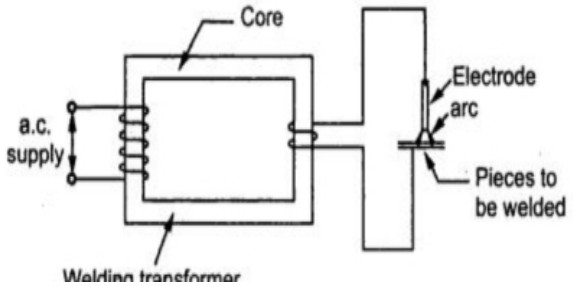
---------- **(1/2 Mark)**

Most economical power factor at which maximum saving will occurs

Q. 4B)	**Attempt any ONE of the following :** **06 Marks**
a)	**With the help of neat sketch explain construction and working of spot welding machine.**
Ans:	**1) Spot Welding:** **(Figure: 2 Marks, Construction: 2 Marks & Working: 2 Marks)**



OR



Construction:

Spot welding means the joining of two metal sheets at suitable spaced interval.

It consists of:

- Transformer used for spot welding is designed for low voltage and high current secondary.
- Transformer is oil cooled and portable
- There are two electrodes one is fixed and other is movable
- The electrodes are hollow and water cooled.
- Electrodes are made from copper or copper alloys and tips of electrodes are made from Cd-Cu or Cr-Cu.

Working:

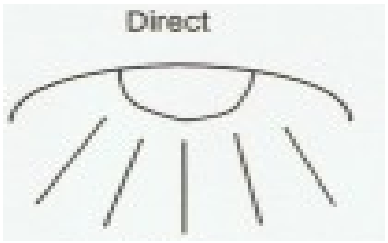
- As shown in fig. Job to be welded is placed one over the other between two electrodes under pressure
- Sufficiently heavy current at low voltage is passed directly through two metals in contact to be welded.

	➢ 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. ➢ Magnitude of current varies from 1000A to 10000A.and the voltage between electrodes is usually less than 2V. ➢ The period of flow of current and magnitude of current depends upon thickness of sheet (job) to be welded.
b)	**The monthly reading of a Consumer's meter are as follow : Maximum demand = 50 kW Energy consumed = 36,000 kWh, Reactive energy = 23,400 KVAR. If the tariff is Rs. 80 per kW of maximum demand plus 8 paise per unit plus 0.5 paise per unit for each 1% of power factor below 86%, calculate the monthly bill of the consumer.**
Ans:	**Note:** **(4 Marks)** 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. In case some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands **Given Data:** Maximum demand = 50 kW Energy consumed = 36,000 kWh Reactive energy = 23,400 KVAR $Total\ \ Bill = Annual\ Demand\ Charges + Annual\ energy\ charges + reactive\ \ energy/annum$ $Total\ \ Bill = (50) \times (Rs.80) + (36000) \times (0.08) + (23400)\ (0.005)$ $Total\ \ Bill = Rs.6997$ **OR** $Total\ \ Bill = Annual\ Demand\ Charges + Annual\ energy\ charges + reactive\ \ energy/annum$ $Total\ \ Bill = (50) \times (Rs.80) + (36000) \times (0.08)$ $Total\ \ Bill = Rs.6880$
Q.5	**Attempt any FOUR :** **16 Marks**
a)	**Draw the following types of lamp fittings and lighting systems with the help of light**

distribution graphs and its applications.
i) Direct lighting h) Indirect lighting iii) Semi-direct lighting iv) Semi-indirect lighting.

Ans:

1. Direct lighting: (Each Figure: 1/2 Mark & Each Application: 1/2 Mark, Total : 4 Mark)

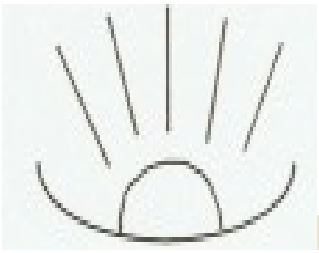


Direct: All the light goes downward or toward (90–100%)

Application:

The direct lighting scheme is widely used in drawing room, workshop and flood lighting etc.

2. Indirect lighting:

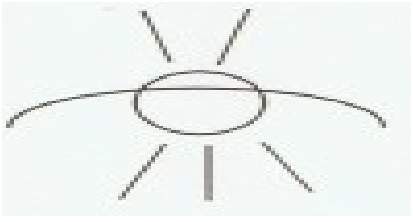


Indirect: All the light goes upward or away (90–100%)

Application:

Which is useful for drawing offices and composing rooms. It is also used for decoration purposes in cinema halls, hotels etc.

3. Semi direct lighting:

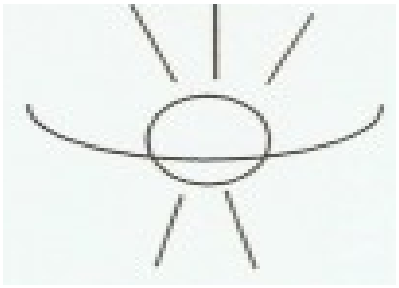


Semi–direct: Most light goes downward (60–90%)

Application:

It is mainly used for interior decoration.

4. Semi indirect lighting:



or equivalent figure.

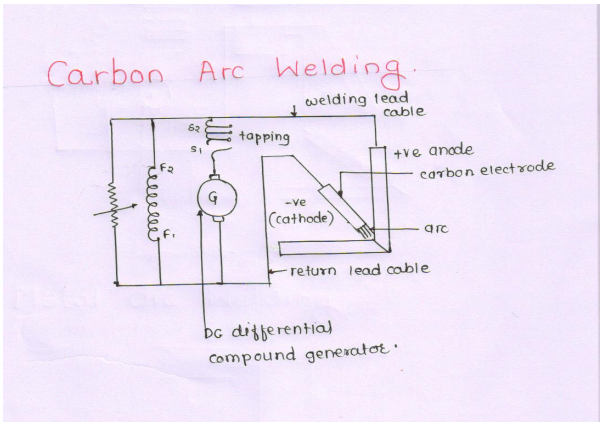
Semi–indirect: Most of the light goes upward or away (60–90%)

Application:

It is mainly used for interior decoration.

b) Describe carbon arc welding with neat sketch.

Ans: **Figure carbon arc welding**: **(Figure : 2 Mark & Explanation: 2 Mark)**



or equiavlent figure

It is explain on following points

Principle of arc welding:

The process in which two metal parts to be welded are brought to a molten state and then allowed to solidify is called as arc welding. Melting of metal is obtained due to heat developed by an arc struck between carbon electrode and metal to be welded (Job) and the additional metal is deposited in the weld from a filler rod.

Carbon arc welding is explain on following points :- (Any four points are expected)

	1. Type of supply used:	Only DC supply is used.
	2. Type of Electrode:	Carbon Electrode are used.
	3. Supply Equipment used:	D.C Differential component Generator or Rectifier
	4. Arc Stability:	D.C Differential component. Generator has dropping characteristics.
	5. Temperature obtain:	More
	6. Possibility of arc blow is more.:	More
	7. Capital Cost:	More
	8. Running cost:	More
	9. Maintenance cost:	More
	10. Stand by losses:	More
	11. Efficiency:	Less
	12. Voltage required:	50 to 60 volt D.C
	13. Types:	Flux is used and flux is not used
	14. Application:	For welding non ferrous metals
	15. Limitation:	Not suitable for overhead welding

c) What are the requirements of ideal traction system ? What are the different traction systems?

Ans: **Ideal Traction system should processes following requirement:-**

(Any Four requirement expected: 1/2 Mark each)

1. It should be Pollution free.
2. It should have low capital, Running and maintenance cost.
3. It should have quick starting time.
4. It should have high starting torque.
5. It should have high rate of acceleration & retardation.
6. Highest speeds are possible.
7. It should have easy speed control method.
8. Its braking system should be reliable and causes less wear.
9. It should have better riding quality (less vibration)

10. It should be free from unbalance forces i.e. coefficient of adhesion should be more.
11. It should have lower centre of gravity.
12. The locomotive should be self-contained and able to run on any route
13. There should be no standby losses.
14. It should have high efficiency
15. Regenerative braking should be possible.
16. The wear caused on the track should be minimum.
17. Equipment should be capable of overloads for short periods.
18. Capability of withstanding voltage fluctuations.
19. Parallel running usually more than one motor (2 or 4 motors) should be possible.
20. Traction system should be clean & long life.
21. There should be no interference to the communication lines running along the lines.

Following are the different types of traction system are used:

(2 Marks)

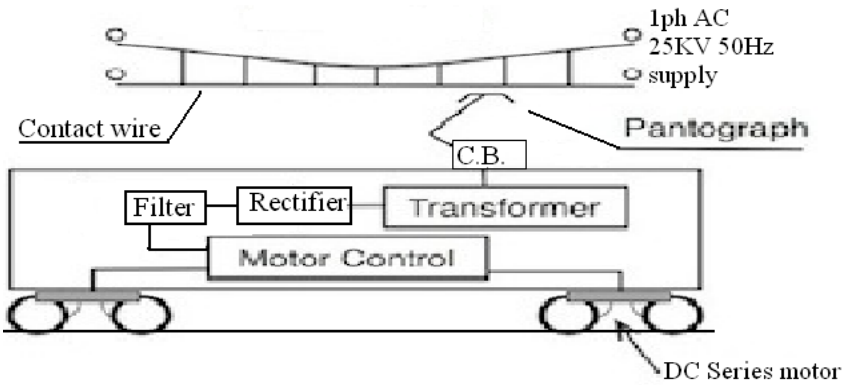
1. Steam Engine Traction system
2. Diesel Engine (IC) Traction system
3. Diesel-Electric Traction system
4. Battery operated Traction system
5. Electric Traction System

OR

1. AC Traction System
2. DC Traction System
3. Composite traction system :-
   a)1-Ph AC (1-ph, 25KV) – DC Supply System
   b) Kando System (1-Ph AC – 3-Ph AC)

d)	**Draw a neat diagram of A.C. electric locomotive and explain function of each part in it.**
Ans:	**Diagram of A.C. electric locomotive:** **(Figure: 2Mark & Function : 2 Mark)**

Block Diagram of AC electrical locomotive



Explanation:

1) Overhead contact wire:

Supply of 1-ph, 25KV, 50Hz, AC is given to overhead conductor.

2) Current collecting device:

It collects current from overhead contact wire and passes it to tap changing transformer through circuit breaker.

3) Circuit breaker (C.B):

- It is connected in between current collecting devices and tap changing transformer.

  SF6 circuit breaker is used.
- To disconnect locomotive equipments whenever there is fault.
- It opens automatically when train passes neutral zone (from zone No.1 to Zone No.2)

4) On load tap changing transformer:

It changes the tap without disconnecting the load on transformer. Its purpose is to vary the voltage for speed control of traction motor.

5) Traction Transformer:

It step down input voltage 25 KV to working voltage of traction motor (1500V/3000V).

6) Rectifier:

It converts secondary voltage of transformer into DC supply.

7) Filter circuit (smoothing reactor):

It is used to obtain pure DC supply.

8) Motor control unit: It controls operation of traction motor.

9) Traction Motor:

It gives mechanical power to run the train DC series motor is used as traction motor

e) With a suitable diagram explain series-parallel control of D.C. series motor.

Ans: **Series parallel control of DC series motor:**

1. For traction purpose, two motors are operated in following steps.

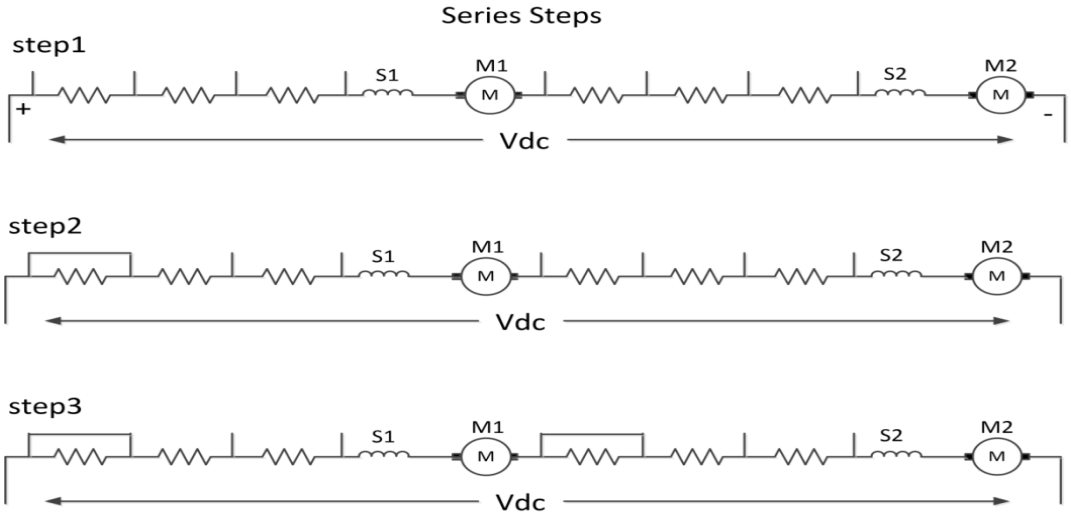
Series steps of traction motor: **(Steps for series control : 2 Mark)**

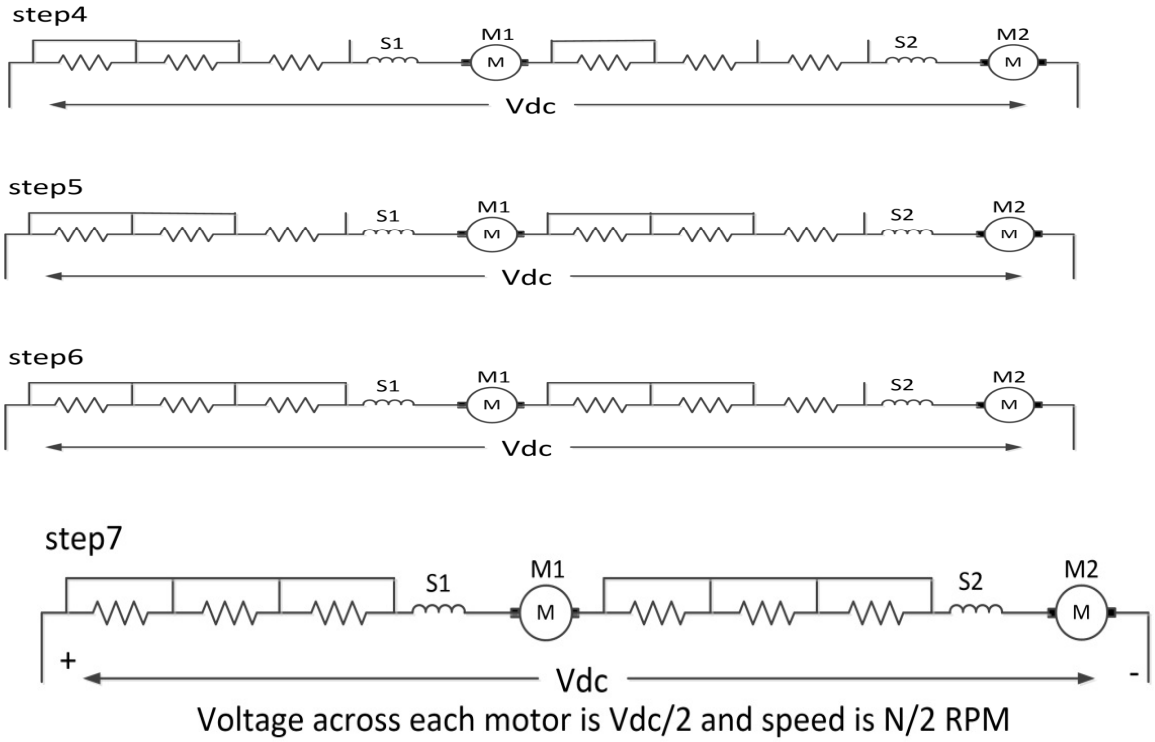
Step 1 –

- Two traction motors M1 and M2 are connected in series and started with all starting resistances in series.

Step 2 to 7 –

- The starting resistances are cut out one by one gradually and finally two motors are in series without any resistance.
- In series connection the supply voltage V is divided in two motors. (Both motors get half or (V/2) volts). So speed is also half. (N/2)





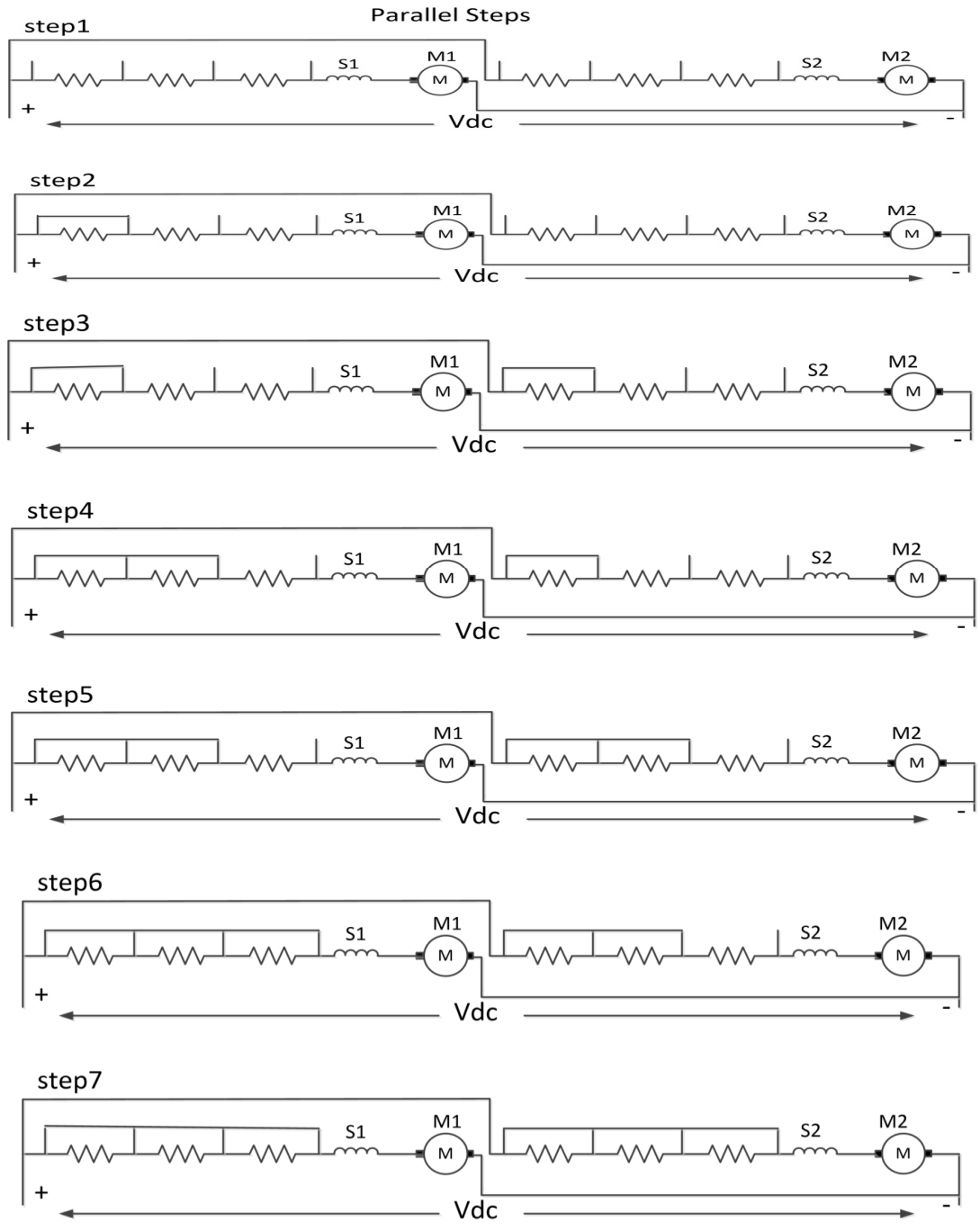
Parallel steps of Control of D.C. series Motor: **(Steps for parallel control : 2 Mark)**

Step 1 –

- After completion of series last step motors are now connected in parallel again with series resistance otherwise motor will draw very high current and may damage itself.

Step 2 to 7 –

- Both motors are now connected in complete parallel and starting resistances are cut out one by one.
- In parallel connection, voltage across M1 and M2 will be full i.e. V (voltage is always same in parallel).
- Voltage across each motor = V and speed of each motor = N
- So, voltage is now increased from (V/2) to V.
- Hence, speed also increases from (N/2) to N and motor runs with full speed.

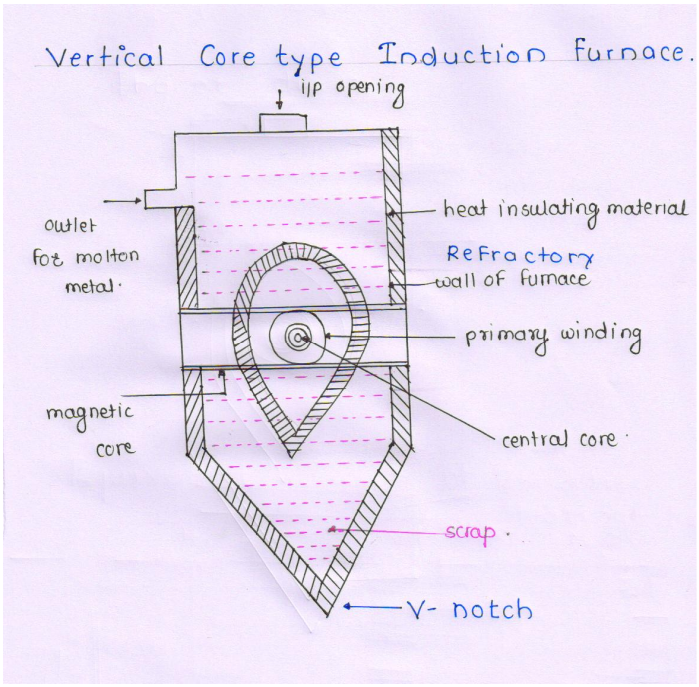


Voltage across each motor is Vdc and speed is N RPM

Q.6	**Attempt any TWO of the following :** **16 Marks**
a)	**Describe the core type (Ajay Wyatt) induction furnace with a neat sketch and state its application and advantages.**

Ans: **(Figure: 2 Mark, Explanation: 2 Mark, Application: 2 Mark & Advantages: 2 Marks)**

Neat sketch of 'Ajax Wyatt' vertical core furnace:



Principle of Induction heating:

It is based on principle of transformer. In this type of Induction heating primary winding is as usual which is wound around one limb of magnetic core but secondary winding is actually charge which is to be melted is kept in crucible.

When AC Supply is given to primary winding current flows through primary winding which creates alternating flux in magnetic core this flux links to the secondary winding i.e. charge through magnetic core. Hence according to faraday's law of electromagnetic induction emf will be induced in secondary winding that is in the charge.

As charge forms a close circuit (secondary) heavy current flows through charge this current is responsible to produce heat in charge due to I^2R losses. This heat is utilized to melt the charge.

Where, R = Resistance of charge & I secondary current.

OR Student may write construction also instead of principle

Construction of 'Ajax Wyatt' vertical core furnace:

Vertical core type induction heating furnace is nothing but transformer. It consists of

- Magnetic Core:

  Primary winding

  Secondary Winding:
- Refractory Wall
- Opening

- Cooling arrangement
- Tilting arrangement
- Control panel
- APFC

Application of 'Ajax Wyatt' vertical core furnace: (Any Two expected)

1. It is used for melting metal having low resistivity.
2. It is used for heat treatment of silver, Copper, nickel etc.
3. Such type of furnace are used for continuous operations only and not used for intermittent services.

Advantages: (Any Two expected)

1) As furnace has narrow 'V' shape crucible at bottom. So small quantity of molten metal remains in narrow 'V' notch from previous operation, which will help to keep secondary short circuited.

So no extra care is required to start the furnace

2) Magnetic coupling between primary & secondary winding is better because both windings are on central limb of magnetic core. So there will be less leakage flux, Hence leakage reactance is less, so power factor is better than horizontal crucible direct core type induction furnace.

- Due to pinch effect in ordinary core type induction furnace there are chances of temporary interruption in secondary circuit when current density exceeds above 500A/cm^2 OR 5Amp/mm$^{2.}$.
- But in this type of induction furnace there are no chances of interruption in secondary circuit even if current density exceeds 500A/cm^2 OR 5Amp/mm^2 Because tendency of weight of charge keep them in contact due to narrow 'V' shape.
- So we can increase current density above 500A/cm^2 OR 5Amp/mm^2 to obtain more heat in less time.

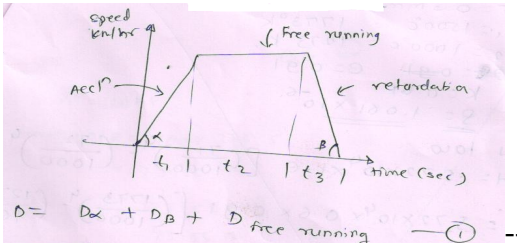
1) Vertical crucible is always better than horizontal crucible for pouring and taking out the metal. Also space required is less.
2) As heat is produced directly in the charge there is no heat transfer loss. So efficiency of furnace is more.
3) As heat is directly produced in the charge time required for melting metal is less. So energy consumption is less.
4) As current is directly induced in the charge there is automatic stirring action taking place in the charge due to electromagnetic forces developed in the charge due which,
   - Through mixing of molten metal is possible.
   - Uniform heating is possible
5) Accurate temperature control.
6) Ideal working condition in a cool atmosphere with no dirt, noise and fuel.

b) **The speed-time curve of a train consists of :**
i) Uniform acceleration of 5 km phps for 30 Sec. Free running for 10 min. iii) Uniform retardation of 6 km phps to stop the train.
iv) A stop time of 5 min. Find the distance between the stations, the average and schedule speed.

Ans: **Given Data:**

t_1= 30 sec t_2= 10min = 600 sec T_{stop}= 5 min = 300 sec

acceleration α = 5 km phps retardation β = 6 km phps



---------- **(1 /2Mark)**

➢ $\alpha = \frac{V_{max}}{t_1}$ ---------- **(1 /2Mark)**

$V_{max} = t_1 \times \alpha = 30 \times 5$

$V_{max} = 150\ Km/\ hr$ ----------Answer---------- **(1/2 Mark)**

➢ $\beta = \frac{V_{max}}{t_3}$ ---------- **(1/2 Mark)**

$t_3 = \frac{V_{max}}{\beta} = \frac{150}{6}$

$t_3 = 25$ sec ----------Answer---------- **(1 /2 Mark)**

➢ Distance covered during Acceleration ($D\alpha$) =

$D\alpha = \frac{V_{max}^{\ 2}}{7200\ \alpha}$ ---------- **(1 /2Mark)**

$D\alpha = \frac{(150)^{\ 2}}{7200 \times 5}$

$D\alpha = 0.625$ sec----------Answer---------- **(1/2 Mark)**

Distance covered during Retardation ($D\beta$) =

$D\beta = \frac{V_{max}^{\ 2}}{7200\ \beta}$ ---------- **(1/2 Mark)**

$D\beta = \frac{(150)^2}{7200 \times 6}$

$D\beta = 0.5208$ sec----------Answer------- **(1 /2 Mark)**

$\therefore$ $D\ Free\ \ running = \frac{t_2 \times V_{max}}{3600}$ ---------- **(1/2 Mark)**

$$D\ Free\ \ running\ = \frac{600 \times 150}{3600}$$

$D\ Free\ \ running\ = 25\ Km$ ----------Answer-------- **(1 /2 Mark)**

$Dis\tan ce\ 'D'\ = D\alpha + D\beta +\ D\ Free\ \ running$

$Dis\tan ce\ 'D'\ = 0625 + 0.5208 +\ 25$

$Dis\tan ce\ 'D'\ = 26.1458\ \ Km$ ----------Answer------- **(1 /2 Mark)**

$Time\ 'T'\ = t_1 + t_2\ +\ t_3\ = 30 + 600 + 25$

$Time\ 'T'\ = 655\ \ Sec$ ----------Answer-------- **(1 /2 Mark)**

- $V_{av} = \frac{3600\ D}{Time}$ ---------- **(1/2 Mark)**

$$V_{av} = \frac{3600 \times 26.1458}{655}$$

$V_{av} = 143.702\ \ Km\ /\ hr$ ----------Answer--- **(1 /2 Mark)**

- $V_{schv} = \frac{3600\ D}{T + T_{stop}}$ ---------- **(1/2 Mark)**

$$V_{schv} = \frac{3600 \times 26.1458}{655 + 300}$$

$V_{schv} = 98.56\ Km\ /\ hr$ ----------Answer------ **(1 /2 Mark)**

b) **A 3-phase, 50 Hz, 400 V motor develops 100 HP, the power factor being 0.75 lagging and efficiency 93%. A bank of capacitors is connected in delta across the supply terminals and power factor raised to 0.95 lagging. Each of the capacitance unit is built of four similar 100 V capacitors. Determine the capacitance of each capacitor.**

Ans: **Given Data**

Volt : line volts V = 400V, f= 50 Hz P= 100 HP x 735.5/093 = 79.086 kW

$\cos\phi_1$=0.75 $\cos\phi_2$ =0.95

$\therefore\ Cos\ \phi_1 = 0.75$

$\tan\phi_1 = 0.88$ ---------- **(1 Mark)**

$\tan\phi_2 = 0.3286$ ---------- **(1 Mark)**

$Q_1 = P \tan\phi_1$

$= 79.086 \times 0.88$

$= 69.595$ KVAR ---------- **(1 Mark)**

$Q_2 = P \tan\phi_2$

$= 79.086 \times 0.3286$

$= 25.9876$ KVAR ---------- **(1 Mark)**

$Q_C = Q_1 - Q_2$

$= P \tan\phi_1 - P \tan\phi_2$ ----------**(1 Mark)**

$= 69.595 - 25.9876$

$= 436074$ KVAR ---------- **(1 Mark)**

∴ Capacitor when connected in Delta:-

$$C \text{ per phase} = \frac{Q_C}{3\omega V^2}$$ ---------- **(1 Mark)**

$$C \text{ per phase} = \frac{43.6074 \times 10^3}{3 \times 2\pi \times 50 \times 400^2}$$

$$C \text{ per phase} = \frac{436074 \times 10^3}{3 \times 50.265 \times 10^6}$$

$C \text{ per phase} = 2.891 \times 10^{-4}$ F ---------- **(1 Mark)**

In ease delta connected phase 4 similar 100V capacitors are connected in series:

The capacitance of each capacitor = $2.891 \times 10^{-4} \times 4$

The capacitance of each capacitor = 11.564×10^{-4} ---------- **(1 Mark)**

----------**END**----------