



MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC-27001-2005 Certified)

SUMMER– 2015 Examinations

Subject Code: 17507

Model Answer

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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)	Define electric drive. List at least four advantages of electric drive.	
Ans:	<p><u>Electric Drive:</u></p> <p style="text-align: center;">It is a machine which gives mechanical power. e.g. drives employing electric motors are known as electric drives.</p> <p><u>Following advantages of electric drive:</u></p> <ol style="list-style-type: none">1. It is more economical.2. It is more clean.3. No air pollution.4. It occupies less space.5. It requires less maintenance.6. Easy to start and control.7. It can be remote controlled.8. It is more flexible.9. Its operating characteristics can be modified.10. No standby losses.11. High efficiency.12. No fuel storage and transportation cost.	<p style="text-align: right;">(2 Marks)</p> <p style="text-align: right;">(Any Four point expected: 1/2 each)</p>



	<p>13. It is reliable source of drive.</p> <p>14. Less maintenance cost.</p> <p>15. It has long life.</p>
b)	State the principle of induction heating. Write at least four applications of induction heating.
Ans:	<p>Principle of Induction heating: (2 Mark)</p> <p>The basic principle of induction heating is that, supply is given to primary winding of furnace transformer & heat is produced in the secondary (charge) due to electromagnetic action.</p> <p style="text-align: center;">OR</p> <p><u>Principle of Induction heating:</u></p> <p>It is based on principle of transformer. In this type 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.</p> <p>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.</p> <p>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.</p> <p>Where, R = Resistance of charge & I secondary current</p> <p>Following are applications of induction heating: (Any Four point expected: 1/2 each)</p> <ol style="list-style-type: none">1. Melting of steel and non ferrous metals at temperatures up to 1500 °C.2. Heating for forging to temperatures up to 1250 °C.3. Annealing and normalizing of metals after cold forming using temperatures in the range of 750 – 950 °C.4. Surface hardening of steel and cast iron work pieces at temperatures from 850 – 930 °C (tempering 200-300 °C)5. Soft and hard soldering at temperatures up to 1100 °C,6. Moreover, special applications such as heating for sticking, sintering



c)	State the laws of illumination.
Ans:	<p>Laws of illumination: - (Each Figure 1 Mark & Statement of each law 1 Mark, Total: 4 Mark)</p> <p>a) Inverse Square Law :-</p> <div data-bbox="613 510 1027 772"></div> <p>or Equivalent fig.</p> <p>Illumination is inversely proportional to the Square of distance between source and plain of the surface and directly proportional to light intensity. $E \propto \frac{I}{r^2}$</p> <p>b) Lambert's cosine law :-</p> <div data-bbox="599 942 992 1220"></div> <p>or Equivalent fig.</p> <p>The illumination of a surface is directly proportional to cosine of angle made by the normal to the illuminated surface with the direction of the incident flux.</p> <p>$E_B = E_A \cos^3 \phi_1$, $E_C = E_A \cos^3 \phi_2$, $E_D = E_A \cos^3 \phi_3$ and so on.</p>
d)	State any four causes of low power factor.
Ans:	<p>Following are the Causes of low power factor: - (Any Four causes expected: 1 Mark each)</p> <ol style="list-style-type: none"><u>Magnitude of Magnetizing Current (I_μ):-</u> As magnetizing current increases, power factor reduces.<u>Due to use of Induction Motor:-</u> Most of industrial drives, agriculture pumps, lift, irrigation pump set uses I.M. which works at lagging power factor, and so power factor reduces.<u>Due to use of Transformer: -</u> All transformers works at lagging power factor, so power factor of system reduces.<u>Due to welding transformer: -</u>



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	<p>Welding transformers are operated at low p.f. which reduces p.f. of the system.</p> <p>5. <u>Due to inductance of transmission & distribution Line: -</u></p> <p>In case of AC transmission & distribution lines, inductance is present which the main cause of low power factor is.</p> <p>6. <u>Series Reactor:-</u></p> <p>Series reactor is used in substation to minimize fault current causes low power factor.</p> <p>7. <u>Industrial electrical heating furnaces:-</u></p> <p>Induction and arc furnace used in steel manufacturing industry works at low p.f. which reduces p.f. of the system.</p> <p>8. <u>Arc Lamp:-</u></p> <p>Arc lamp & electric discharge lamps operates at low p.f. so p.f. of the system reduces.</p> <p>9. <u>Equipments operated at light load:-</u></p> <p>P.f. falls if equipments like alternator, transformer, I.M etc are not operated at full load.</p> <p>10. <u>Improper repairs and maintenance:-</u></p> <p>P.f. falls if proper maintenance or repairs of equipments are not done.</p>
Q.1B)	Attempt any ONE : 06 Marks
a) i)	State any six requirements of ideal braking system.
Ans:	<p>Following are different requirements of an ideal braking system:</p> <p style="text-align: center;">(Any Six requirement are expected: 1/2 Mark each, Total 3 Mark)</p> <ol style="list-style-type: none">1. The braking system should be simple easy to control & operate.2. It should be most reliable.3. Braking actuation time should be as small as possible.4. Braking force should be very gradual and smooth in case of emergency braking also to avoid discomforting to passenger & damage of goods.5. Braking force applied to each axle should be proportional to axle load.6. Reputed quick application of brake should be possible without needing any normalizing time in between two successive operations.7. It should have less maintenance.8. It should have long life.

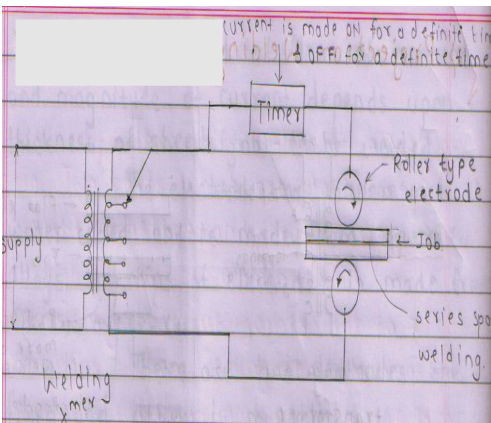
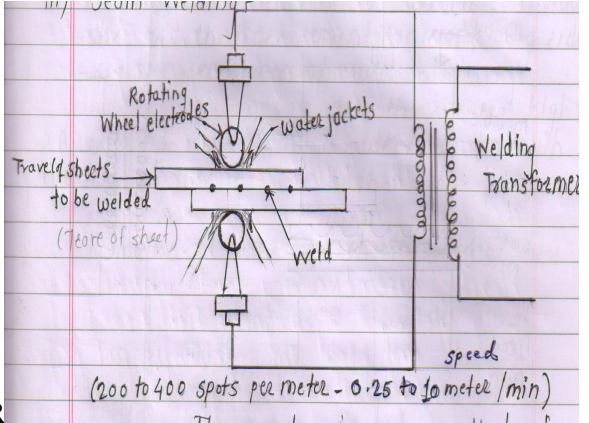


a) ii)	State the advantages and disadvantages of electric braking over mechanical braking.
Ans:	<p>(Any three advantages expected:1/2 Mark each & Any three disadvantages expected: 1/2 Mark each, Total : 3 Mark)</p> <p>Following are the advantages & disadvantages of electrical braking over mechanical braking system.</p> <p>Advantages: (Any three point expected)</p> <ol style="list-style-type: none">1. It is most reliable braking system. Because in mechanical braking heat is produced at break block & break shoes, which may be source of failure of break. In Electrical braking (dynamic) heat is produced at convenient place (external rheostat) which is not harmful to braking system2. Breaking actuation time is small as higher value of braking retardation is obtained.3. Electrical braking is smooth & gradual. Where as if mechanical breaks are not correctly adjusted then there are chances of sudden braking which is discomfort able to passenger.4. Life of braking system is more. Because mechanical braking provides metal dust due to friction, No such dust is formed in electrical braking.5. There is less wear & tear of brake shoes, break block etc. so there is less maintenance cost.6. Higher speeds are possible even when train is going down the gradient, as breaking system is reliable.7. Trains having heavy loads can be stopped even when train going up the gradient.8. Higher speeds of train is possible as braking system is reliable so pay load capacity increases.9. In case of electric regenerative braking we can utilize 60 to 80% of kinetic energy to generate electricity which is not possible with mechanical braking. <p>Disadvantages: (Any three point expected)</p> <ol style="list-style-type: none">1. In addition to electrical braking there must be arrangement of mechanical braking for final stop.



	<p>2. Special arrangement of circuit is to be provided which makes electrical braking system costly.</p> <p>3. Operation in substation becomes complicated at the time of regenerative braking when generated energy is surplus.</p> <p>4. Electrical braking need electric supply.</p>
b) i)	State the principle of resistance welding.
Ans:	<p><u>Working principle of resistance welding:</u> (2 Mark)</p> <p>In resistance welding, sufficiently heavy current at low voltage is passed directly through two metals in contact to be welded.</p> <p>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)</p> <p>When welding temperature is reached supply is cut down and external pressure is applied simultaneously across the job to complete weld.</p> <p><u>According to joules law,</u></p> <p>Heat produced $H = I^2 R t$ Watt-sec</p> <p>From this equation it is clear that heat produced depends on</p> <ul style="list-style-type: none">➤ Square of current (I^2)➤ Contact resistance (R)➤ Duration of current (t)
b) ii)	State the various types of resistance welding.
Ans:	<p><u>Types of Resistance Welding:-</u> (Any Two types expected) (2 Mark)</p> <ul style="list-style-type: none">1) Spot welding2) Seam welding3) Projection Welding4) Butt Welding5) Flash Butt welding



b) iii)	Describe with neat sketch the operation of seam type resistance welding.
Ans:	<div data-bbox="300 399 617 430">Sketch of Seam welding:</div> <div data-bbox="909 399 1421 430">(Figure: 1 Mark & operation: 1 Mark)</div> <div data-bbox="300 451 787 871"></div> <div data-bbox="795 850 836 871">OR</div> <div data-bbox="836 451 1421 871"></div> <div data-bbox="300 892 446 934">Operation:</div> <div data-bbox="341 945 1421 1459"><ul style="list-style-type: none">➤ Job is kept in between two electrodes under pressure. This pressure is kept constant throughout.➤ In this type intermittent current is used, it means current is ON for definite time and OFF for another time interval with the help of timer.➤ If current is continuously passes then heat produced may cause burning of job.➤ 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.</div>
Q.2	Attempt any FOUR : 16 Marks
a)	Describe in brief the size and shape of elevator car.
Ans:	<div data-bbox="1282 1596 1421 1627">(4 Marks)</div> <div data-bbox="300 1659 1063 1690">Size and shape of elevator car depends on following points:-</div> <div data-bbox="316 1722 1388 1858"><p>i) No. of passenger to be carried: While selecting the size of car it is a usual practice to allow.</p><ul style="list-style-type: none">➤ A Space of 2 Sq.ft/ person.</div>



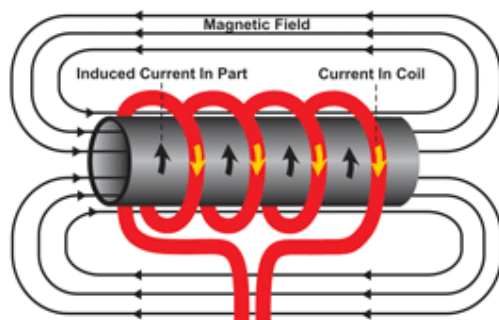
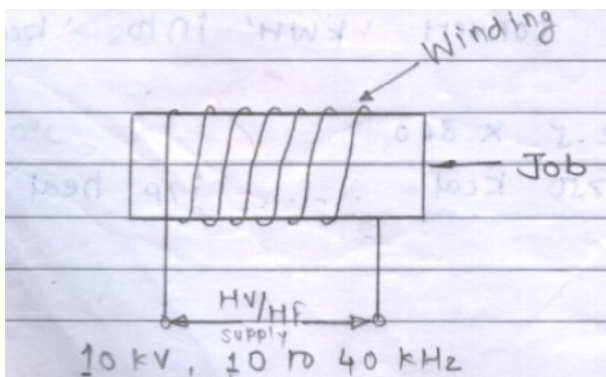
- Average weight of passenger is assumed 68 kg/person.
- Thus the maximum load capacity of elevator is considered 34 kg/sq.ft
- There should be wide frontage and shallow depth

ii) Limitation in the building design:

Shape of elevator depends on space available in building.

b) **State the principle and nature of supply used for eddy current heating. State the advantages and disadvantages of eddy current heating.**

Ans: **Principle of Eddy Current Heating:- (1 Mark)**



or Equivalent fig.

Principle:-

(1 Mark)

Heat produced \propto eddy current loss $\propto B^2 f^2$

Depth of penetration of heat $\propto \frac{1}{\sqrt{F}}$

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 pronounced (effective). Due to this surface of job is more heated as compared to its depth.



	<p><u>Nature of supply used for eddy current heating:</u> (1 Mark)</p> <ul style="list-style-type: none">➤ High voltage (10KV)➤ High frequency (10-40 KHz) <p><u>Advantages eddy current heating:-</u> (Any one point expected) (1/2 Mark)</p> <ol style="list-style-type: none">1) No heat transfer loss as heat is produced in job itself. So it has high efficiency.2) As heat is produced in job itself so time required for heating is less. For e.g. in some cases operating time taken for heating is of only one second.3) By simply controlling frequency, we can control temperature accurately.4) By simply controlling frequency, depth of penetration of heat can be controlled easily.5) Very thin material surface can be heated easily.6) Operation is simple & automatic.7) For heating low attention is required.8) Heating can be taken place in vacuum or other special atmospheric condition where other methods are not possible.9) It is clean and convenient method. <p><u>Disadvantages of eddy current heating:-</u> (1/2 Mark)</p> <ol style="list-style-type: none">1) High initial cost because of high voltage high frequency supply equipment is required.
c)	<p>State any six requirements of an ideal traction system.</p>
Ans:	<p>Any six requirements from the following: (First any Two Points: 1 Mark each & other any Four point : 1/2 each, Total : 4 Marks)</p> <p><u>Ideal Traction system should processes following requirement:-</u> (Any Six Point expected)</p> <ol style="list-style-type: none">1. It should have low capital, Running, maintenance cost.2. Quick starting time.3. It should have high rate of acceleration & retardation.4. Highest speeds are possible.5. Easy speed control method.6. Braking system should be reliable.



7. Absence of unbalance forces i.e. coefficient of adhesion should be more.
8. Centre of gravity should be lower.
9. Better riding quality (less vibration)
10. Traction system should be clean & long life.
11. It should be self contained.
12. No standby losses.
13. It should have high efficiency
14. Regenerative braking should be possible.

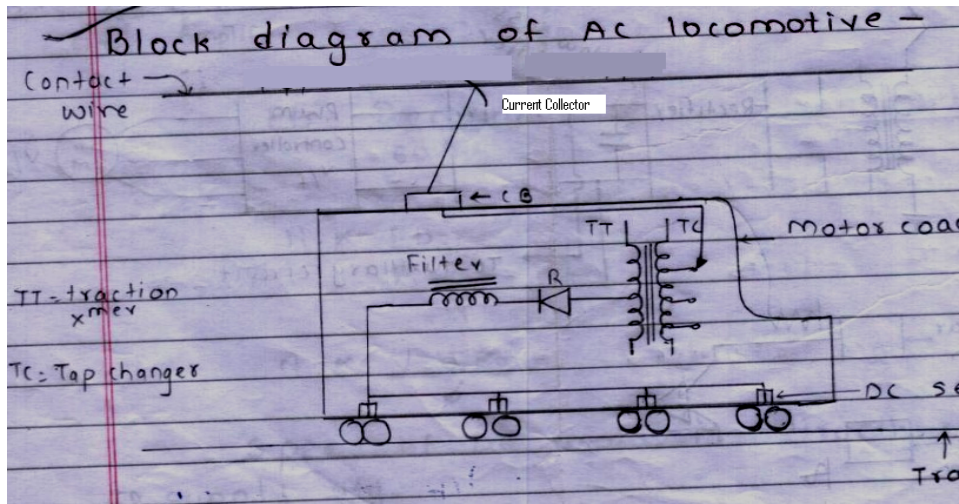
d)

Draw a neat labelled block diagram AC electric locomotive. State the function of each part.

Ans:

Block diagram of A.C. electric locomotive

(2 Marks)



Function of each part:

or equivalent fig.

(2 Mark)

1) Overhead contact wire:

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

2) Current collecting device:

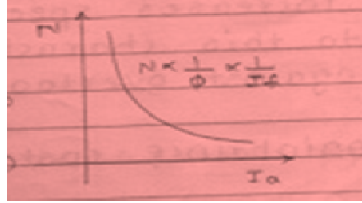
It collects current from overhead contact wire and passes it to tap changing transformer through circuit breaker.

3) Circuit breaker (C.B):

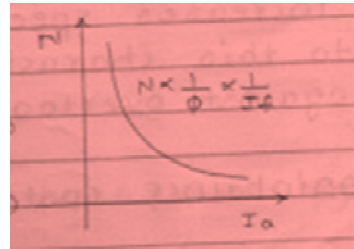
It is connected in between current collecting and no-load tap changing transformer.



	<p>SF6 circuit breaker is used.</p> <ul style="list-style-type: none">➤ To disconnect locomotive equipments whenever there is fault.➤ It opens automatically when train passes from zone No.1 to Zone No.2 i.e. neutral zone <p>4) On load tap changing transformer:</p> <p>It changes the tap without disconnecting the load on transformer. Its purpose is to vary the voltage for speed control of traction motor.</p> <p>5) Traction Transformer:</p> <p>It step down input voltage 25 KV to working voltage of traction motor (1500V/3000V).</p> <p>6) Rectifier:</p> <p>It converts secondary voltage of transformer into DC supply.</p> <p>7) Filter circuit (smoothing reactor):</p> <p>It is used to obtain pure DC</p> <p>8) Traction Motor:</p> <p>It gives mechanical power to run the train DC series motor is used as traction motor.</p> <p>9) Current Collector:</p> <p>To collect current from overhead line.</p>
e)	<p>"DC series motor is used for traction purpose". Justify your answer with any six characteristics.</p>
Ans:	<p>(First any Two Points: 1 Mark each & other any Four point : 1/2 each, Total : 4 Marks)</p> <p>DC series motor is used for traction purpose because of following characteristics:</p> <ol style="list-style-type: none">1) DC Series motor has high starting torque. <div data-bbox="704 1591 1133 1818"></div> <ol style="list-style-type: none">2) DC series motor has High torque at low speeds, low torque at high speeds, this is the basic requirement of traction unit.



- 3) DC Series motor speed-torque characteristics are such that as torque increases speed decreases. (Due to this characteristics motor is protected against overload)



- 4) DC Series motor variable speed motor.
5) DC Series motor has high rate of acceleration and retardation.
6) Torque obtained by DC series motor is smooth and uniform, so it improves riding quality.

OR Student may write following additional Point

- 7) When DC series motor are running in parallel the all motors share almost equal load.
8) DC Series motor maintenance cost is less.
9) DC Series motor robust in construction and capable to withstand against continuous vibration.
10) DC series motor weight is 1.5 times less than 1-Ph AC series motor for same H.P.

Q.3 Attempt any TWO : **16 Marks**

a) i) State the factors governing selection of electric drive.

Ans: Following are the factors governing selection of electric drive:

(Any Four factor expected: 1 Mark each, Total : 4 Mark)

1. Nature of supply:

Whether supply available is

- AC,
- Pure DC
- OR rectified DC.

2. Nature of Drive (Motor):

Whether motor is used to drive



- Individual machine
- OR group of machines.

3. Nature of load:

- Whether load required light or heavy starting torque
 - OR load having high inertia, require high starting torque for long duration.
 - OR Whether load torque increases with speed ($T \propto N$)
 - OR decreases with speed ($T \propto 1/N$)
 - OR remains constant with speed ($T = N$)
 - OR increases with square of speed ($T \propto N^2$)

4. Electric Characteristics of drive:

- Starting,
- running,
- speed control
- Braking characteristics of electric drive should be studied and it should be matched with load requirements.

5. Size and rating of motor:

- Whether motor is short time
- OR continuously
- OR intermittently running
- OR used for variable load cycle.
Whether overload capacity, pull out torque is sufficient.

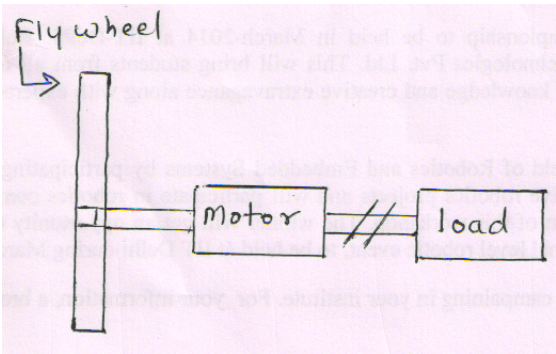
6. Mechanical Considerations:

- Types of enclosure,
- Types of bearing,
- Transmission of mechanical power,
- Noise
- load equalization

7. Cost:

- Capital,
- running
- And maintenance cost should be less.



a) ii)	Define load equalisation for electric motors. Explain how it is obtained for electric motors.
Ans:	<p>➤ Define Load equalization: (2 Mark)</p> <p>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,</p> <p>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.</p> <p>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.</p> <p><u>The process of smoothing out load fluctuation is called load equalization.</u></p> <p>How load equalization is done? (2 Mark)</p> <p>Load equalization is done by means of <u>flywheel</u>. It is mounted on motor shaft.</p> <p>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.</p> 
b)	<p>A 40 kW, 3-phase, 400 V resistance oven uses nickel-chromium strip of 0.3 mm thickness. The heating elements are star connected. If wire temperature is to be 1127°C and that of charge is to be 727°C, estimate suitable width and length of the wire required.</p> <p>Given: radiation efficiency = 0.6, specific resistance of Ni-Cr = 1.03×10^{-6} ohm m, emissivity = 0.9.</p>



Ans:

Given Data:

$$T_1 = 1127^{\circ}\text{C} = 1127 + 273 = 1400^{\circ}\text{K}$$

$$T_2 = 727^{\circ}\text{C} = 727 + 273 = 1000^{\circ}\text{K}$$

Radiation efficiency = 0.6, specific resistance of Ni-Cr = 1.03×10^{-6} ohm m, emissivity = 0.9.

$$H = 5.72 \times 10^4 \text{ k.e} \left[\left(\frac{T_1}{1000} \right)^4 - \left(\frac{T_2}{1000} \right)^4 \right] \text{ w/m}^2 \text{----- (1 Mark)}$$

$$H = 5.72 \times 10^4 \times 0.6 \times 0.9 \left[\left(\frac{1400}{1000} \right)^4 - \left(\frac{1000}{1000} \right)^4 \right] \text{ w/m}^2$$

$$H = 87771.3408 \text{ w/m}^2 \text{----- (1 Mark)}$$

➤ $\Rightarrow \text{Thickness} : 0.3 \text{ mm} \therefore 0.3 \times 10^{-3} \text{ m}$

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

$$\text{Voltage across each resistance} = \frac{V}{\sqrt{3}} = \frac{400}{\sqrt{3}}$$

$$\text{Voltage across each resistance} = 230.94 \text{ volt}$$

$$\text{Power} = \frac{40 \text{ KW}}{3} = 13.3333 \text{ KW} = 13.3333 \times 10^3 \text{ watt}$$

$$\therefore \frac{1}{w \ t} = \frac{V^2}{P \ \rho}$$

$$\therefore \frac{l}{w \times (0.3 \times 10^{-3})} = \frac{(230.94)^2}{(13.3333 \times 10^3) \times 1.03 \times 10^{-6}}$$

$$\therefore \frac{l}{w} = \frac{1.59999 \times 10^{-3}}{0.0137332}$$

$$\therefore \frac{l}{w} = 1165.0442 \text{Equation.....} \text{----- (1 Mark)}$$

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

$$\therefore \frac{t}{l^2} = \frac{2 \times (1.03 \times 10^{-6}) \times 87771.3408}{(230.94)^2}$$

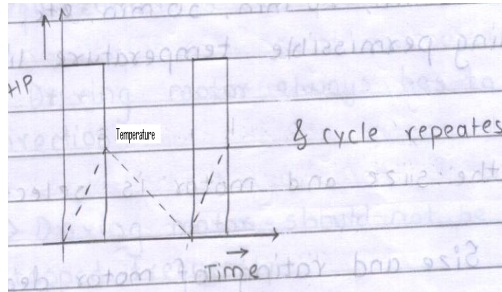
$$\therefore \frac{t}{l^2} = \frac{0.1808089}{53333.284}$$



	$\therefore \frac{t}{l^2} = 3.39017 \times 10^{-6} \quad \text{----- (1 Mark)}$ $\therefore \frac{t}{3.39017 \times 10^{-6}} = l^2$ $\therefore \frac{0.3 \times 10^{-3}}{3.39017 \times 10^{-6}} = l^2$ $\therefore l^2 = 88.491138$ $\therefore l = 9.4069728 \text{ mtr} \quad \text{----- (1 Mark)}$ <p>Putting in Equation : I</p> $\therefore \frac{l}{w} = 1165.0442$ $\therefore w = \frac{9.4069728}{1165.0442}$ $\therefore w = 0.00807434 \text{ mtr} \quad \text{----- (1 Mark)}$ <p><i>Answer : \therefore Length $l = 9.4069728 \text{ mtr}$ \therefore Width $w = 0.00807434 \text{ mtr}$</i></p>
c)	<p>Describe the concept of load cycle with their graphical representation.</p> <p>i) Continuous loading ii) Short time loading iii) Long time (intermittent) loading iv) Continuous operation with short time loading.</p>
Ans:	<p>i) Continuous loading:- (Each Graphical representation : 2 Mark, Total: 8 Mark)</p> <div data-bbox="534 1400 967 1698" data-label="Figure"></div> <p>or equivalent figure</p> <p>In this case motor is operated continuously non-stop for few days or month also without exceeding the permissible temperature limit. e.g. water pumping motor, generating power house auxiliary motors etc.</p>



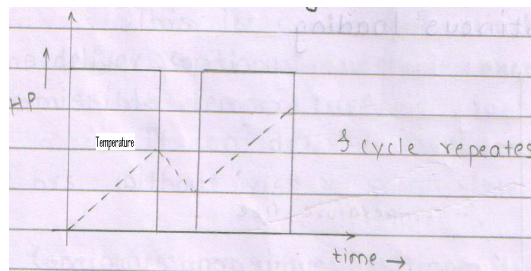
ii) Short time loading:- Graphical representation



or equivalent figure

In short time loading motor is operated for short time continuously without exceeding the permissible temperature limit.e.g. 15min., 20min., 30min. etc than it is made OFF This OFF load interval is sufficient to cool the motor temperature to its normal value.

iii) Long time (Intermittent) Loading :- Graphical representation

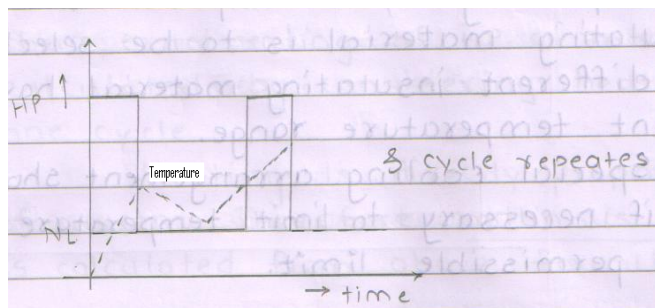


or equivalent figure

In long time loading motor is operated for long time continuously without exceeding the permissible temperature limit than it is made OFF for short time This OFF load interval is not sufficient to cool the motor temperature to its normal value so temperature of drive continuously increases.

iv) Continuous operations with short time loading:-

Graphical representation



or equivalent figure

In this case motor is operated continuously for short time and interval between two load is not OFF- load but motor runs at no load for long time. So temperature of drive continuously increases. So

Temperature rise is more than short-time loading.



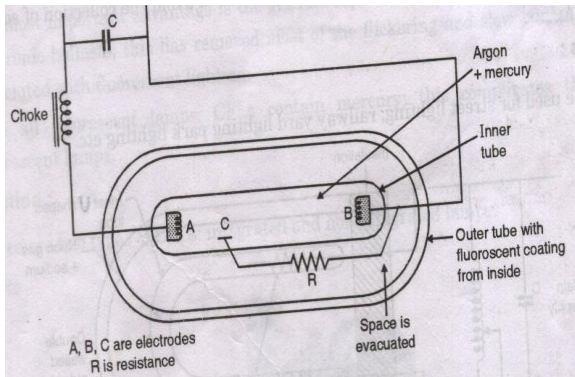
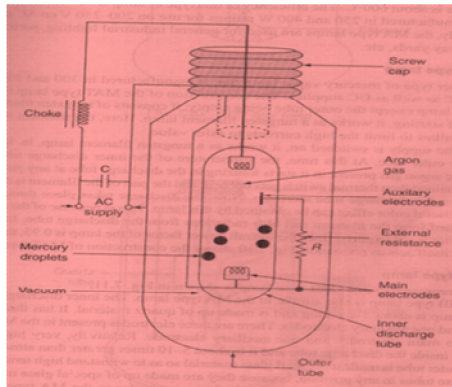
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Q.4 A)	Attempt any THREE :	12 Marks																																																								
a)	Compare D.C. welding and a.c. welding on any six points.																																																									
Ans:	((Any Four Point Expected: 1 Mark each: Total :4 Marks)																																																									
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b)	Describe the construction of high pressure mercury vapour lamp with neat sketch.																																																									
Ans:	➤ Figure mercury vapour discharge lamp :-	(2 Mark)																																																								
	<div>OR</div>																																																									
	Construction:-	(2 Mark)																																																								
	➤ It consists of an inner bulb generally of silicon, to withstand high temperatures.																																																									



- The bulb contains a small quantity of mercury and argon.
- It is protected by outer glass, this may be cylindrical or elliptical.
- The space between the two bulbs is filled with nitrogen at a pressure of half atmosphere.
- The discharge tube has three electrodes, namely two main electrodes A and B and one starting electrode.
- The starting electrodes are connected through a resistance of about 10-30 k ohm to the main electrode, located at the far end.
- The electrodes are of tungsten wire helices filled with electron emissive materials, usually barium and strontium carbonates mixed with thorium.

OR Student may write

The construction & connection diagram is as shown in figure. As per this construction there are following components.

- **Choke:** The choke is acting as the ballast. At the time of supply voltage variation of current flowing through the inner tube is maintained constant to keep uniform light intensity. Sometimes choke can be designed for to get the higher voltages & to apply the inner tube of mercury vapour lamp.
- **Starting resistance/limiting resistance:** Whenever current flows through the starting resistance there is a I^2R loss which is converted into heat. If the temperature of this heat goes near about 600°C then there will be heating effect & inert gases ionization will be start.
- **Auxiliary electrode & Main electrode:** It is made by high resistive element. The ionization is taking place through the inert gases whenever current flows from auxiliary electrode to main electrode.
- **Inner Tube:** The various inert gases e.g. Argon, Nitrogen etc with mercury powder are filled in the inner tube at low pressure or high pressure.
- **Outer Tube:** The function of outer tube is to make the vacuum surrounding the inner tube to avoid thermal dissipation or to maintain 6000°C surrounding the inner tube.
- **Power factor improvement Capacitor:** The function of power factor improvement capacitor is to improve the power factor 0.5 to 0.95



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c)	Compare block-rate tariff and flat rate tariff. (any four points)		
Ans:	(Each Point: 1 Mark: Total :4 Marks)		
	S. No	Block-rate Tariff	Flat rate Tariff
	1	In case of block rate tariff there are blocks of units consumed	In case of flat rate tariff there are no blocks of units consumed
	2	Each block tariff rate and each block tariff rate/unit (KWH) is different.	There is flat tariff rate/unit (KWH).
	3	If generation is less than utilization than tariff rate/unit in each block goes on increasing and vice versa.	Tariff rate/unit (KWH) not depends on generation and utilization.
	4	Used for Residential ,commercial consumers	Where is constant for a fixed load for fixed hours.
d)	State any four advantages of good power factor for electric supply system.		
Ans:	Advantages of Good (High) power factor for electric supply system:		
	(Any Four Point Expected: 1 Mark each: Total :4 Marks)		
	1. P.F. increases current reduce so; cross section of conductor decreases hence its cost is reduces.		
	2. P.F. increases current reduce so, cross section of conductor decreases hence weight decreases. So design of supporting structure becomes lighter.		
	3. Copper losses Decreases, Hence transmission efficiency increases.		
	4. Voltage drop reduces, hence voltage regulation becomes better		
	5. Handling capacity (KW) of each equipment increases as p.f. increases.		
	6. Less capacity (KVA) rating of equipments are required so capital cost decreases.		
	7. Cost per unit (KWH) decreases.		
	OR		
	Following advantages are observed due to good power factor:		
	1. Generation:		
	a) Low KVA rating of equipment (alternator) is required.		
	b) Handling capacity of equipment (alternator) increases.		
	c) Cost per unit increases.		
	2. Transmission:		
	a) Low KVA rating of equipment (Transformer) is required.		



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	<ul style="list-style-type: none">b) Handling capacity of equipment (Transformer) increases.c) Cost of conductor decreases.d) Cost of supporting structure decreases.e) Copper losses decreasesf) Transmission efficiency increases.g) Voltage drop decreases.h) Regulation becomes improved
Q. 4B)	Attempt any ONE of the following : 06 Marks
a)	Describe electric arc welding in brief. How arc is formed in electric arc welding? State the characteristics of electric arc.
Ans:	<p><u>Electric Arc Welding:-</u> (2 Mark)</p> <p>The processes in which two metal parts to be welded are brought to a molten state and then allowed to solidify is called as arc welding.</p> <p>Melting of metal is obtained due to heat developed by an arc struck between an electrode and metal to be welded (job) OR</p> <ul style="list-style-type: none">➤ In this type of welding heat is developed due to arc produced in between electrode & job.➤ High voltage is required to produce arc at starting .once arc is struck low voltage is sufficient to maintain arc.➤ No mechanical pressure is required, so this type of welding is also known as non-pressure welding.➤ Temperature obtained by arc is very high (3500⁰C to 6000⁰C)➤ Arc welding power factor is poor. And power consumption is high.➤ At the time of welding external filler material is required. <p>Arc is formed in electric arc welding by any one of the following method: (2 Mark)</p> <ul style="list-style-type: none">a) By applying High Voltageb) By separation of two current carrying electrodes suddenly <p>Following are the characteristics of electric arc: (Any Two Point expected) (2 Mark)</p> <ul style="list-style-type: none">1. To produce arc high voltage is required then to maintain the arc.2. Arc is conducting.3. Arc has negative temperature coefficient of resistance.



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b)		<p>A factory has a maximum demand of 300 kW with a load factor of 0.6. The following tariffs are offered :</p> <p>a) Two part tariff z 80/kW of M.D./year + 5 paise / kWh.</p> <p>b) A flat rate of 12 paise/kWh.</p> <p>Calculate tariff in both cases and write with reason. Which tariff will be cheaper?</p>																													
Ans:		<p>➤ No. of Units consume in One Year</p> <p style="text-align: right;">$= \text{Load Factor} \times M.D(KW) \times 8760$ ----- (1/2 Mark)</p> <p style="text-align: right;">$= 0.6 \times 300 \times 8760$</p> <p style="text-align: right;">$= 15768000 \text{ Kwh}$ ----- (1 Mark)</p> <p>➤ Case-I: Energy Bill :-</p> <p style="text-align: right;">$= (\text{Tariff given Rs. 800 of M.D. / year} + \text{Rs. 5 paise / Kwh})$ ----- (1/2 Mark)</p> <p style="text-align: right;">$= (300 \times 80) + (1576800 \times 5/100)$</p> <p style="text-align: right;">$= (\text{Rs. 24000} + \text{Rs. 78840})$</p> <p style="text-align: right;">$= 102840 \text{ Rs.}$ ----- (1 Mark)</p> <p>➤ Case-II: Energy Bill :-</p> <p style="text-align: right;">$= (\text{Tariff given flat rate of 12 Paise / Kwh})$ ----- (1 Mark)</p> <p style="text-align: right;">$= (1576800 \times 12/100)$</p> <p style="text-align: right;">$= 189216 \text{ Rs.}$ ----- (1 Mark)</p> <p>➤ According to energy bill Case-I is economical ----- (1 Mark)</p> <p>➤ For industrial consumer Case-I is economical</p>																													
Q.5		Attempt any FOUR :	16 Marks																												
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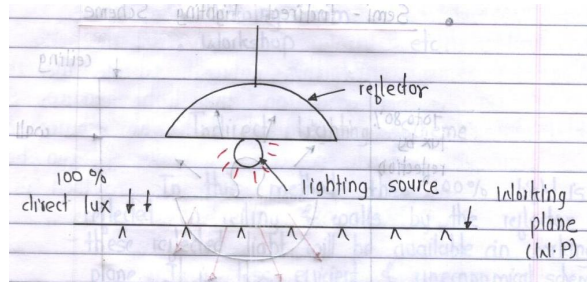
7	Running	Less	More
8	Maintenance	Less	More
9	Stand by losses	Less	More
10	Efficiency	More	Less
11	Voltage required	72 to 100 volt A.C	50 to 60 volt D.C
12	Types	Shielded & unshielded welding	Flux is used and flux is not used
13	Application	For Ferrous Metal	for non ferrous metals
14	Limitation	Can be used for vertical & overhead welding	Not suitable for overhead welding

b) Describe through illustration following types of lighting scheme :
i) Direct lighting ii) Indirect lighting

Ans:

1) Direct lighting -

(Figure: 2 Mark & Explanation: 2 Mark)



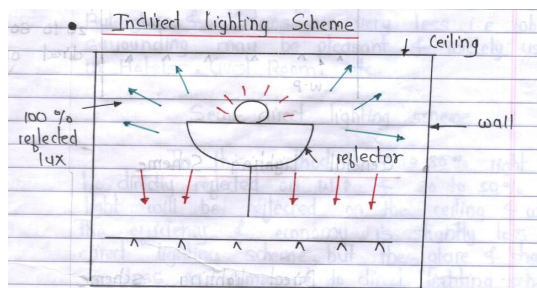
or equivalent fig.

In this method, the reflector is used on the lighting source. The 100% light is reflected by this reflector on the working plane. So efficiency of direct lighting scheme is very high and it is economical also. But limitation of direct lighting scheme is that glare & shadows are more.

Application:

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

2) Indirect lighting scheme:-



or equivalent fig.



	<p>In this method the 100% light is reflected on ceiling and walls by the reflector and these reflected light will be available on working plane. It is less efficient and uneconomical scheme but glare and shadows are very less. i.e. Why surrounding may be pleasant</p> <p>Application:</p> <p>Widely used in hotels, guest room, Show room etc.</p>
c)	<p>Write the different systems of track electrification.</p>
Ans:	<p>Following are the different track electrification system:</p> <p style="text-align: right;">(Any Four System Expected: 1 Mark each)</p> <ol style="list-style-type: none">1. Direct current track electrification:<ul style="list-style-type: none">➤ 600V, 750V DC for tramways➤ 1500V, 3000V DC for Train (Urban service)2. 1-Phase, low frequency AC Supply system:<ul style="list-style-type: none">➤ 1-Ph, 25KV, 16 2/3 Hz or 25 Hz (formerly it was 1-ph 15/16 KV)3. 1-Ph, High frequency AC supply system:<ul style="list-style-type: none">➤ 1-Ph, 3.3 KV, 2500 Hz or 3000 Hz4. 3-Ph, Low frequency AC supply system;<ul style="list-style-type: none">➤ 3-Ph, 3.3 KV, 16 2/3 Hz or 25 Hz5. Composite system:<ul style="list-style-type: none">➤ 1-Ph AC (1-ph, 25KV) – DC Supply System (1500 / 3000V DC)➤ Kando System (1-Ph AC – 3-Ph AC)
d)	<p>Write any six desirable characteristics of traction motors.</p>
Ans:	<p>Following are the desirable characteristics of traction motors:</p> <p style="text-align: right;">(First any Two Points: 1 Mark each & other any Four point : 1/2 each, Total : 4 Marks)</p> <p>A) Mechanical Properties or characteristics: (Any Six Point Expected)</p> <ol style="list-style-type: none">1) <u>It should be simple in design</u>2) <u>It should be robust in construction to withstand against continuous vibrations.</u>3) <u>Weight of motor per HP should be minimum in order to increase pay load capacity.</u>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 in drive.

- 6) When motors are running in parallel they should share almost equal load. (even where there is unequal wear & tear of wheels)

B) Electrical Properties or characteristics:

- 7) It should have high starting torque.
- 8) It should possess high rate of acceleration & retardation.
- 9) It should be variable speed motor.
- 10) Its speed-torque characteristics should be such that high torque at low speed and less torque at high speed.
- 11) Motor must be capable of taking excessive overload in case of emergency.
- 12) It should have simple speed control methods.
- 13) Electrical braking system should be reliable, easy to operate and control, especially regenerative braking is possible.
- 14) Motor should draw low inrush (Starting current) current.
- 15) It should withstand for voltage fluctuation without affecting its performance.

C) General Properties or characteristics:

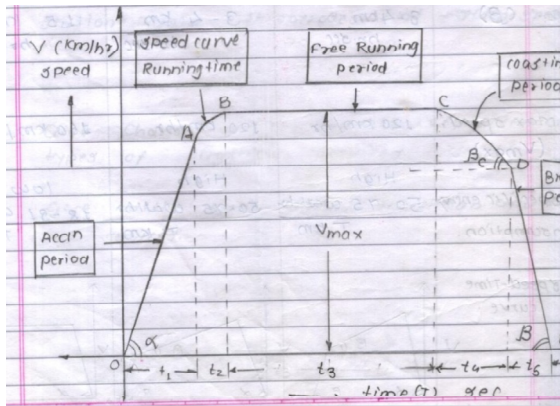
- 16) It should have less maintenance cost.
- 17) It should have high efficiency.
- 18) It should have long life.
- 19) It should have low initial cost.

e) Draw speed time curve. Show and list various time periods associated with it.

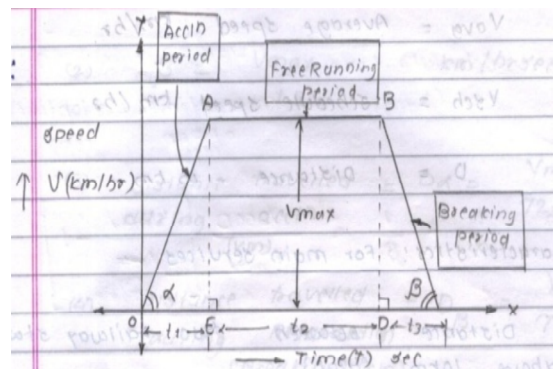
Ans:

Typical speed time curve for main traction line service:

(2 Marks)



OR





	<p>There are five periods in the run of train as shown in speed time curve: (2 Marks)</p> <p>i) Constant acceleration period (o to A) :-</p> <p>During this period starting resistance in motor circuit are gradually cut down. At point 'A' all the starting resistance in motor circuit has been cut down.</p> <p>ii) Acceleration on speed –Time curve (A to B) For T_2 sec. :-</p> <p>Now train is continuous to accelerate & torque gradually falls until speed of train exactly balance train resistance during this period.</p> <p>iii) Free Running or constant speed tun period (B to C) For T_3 sec. :-</p> <p>At the end of acceleration period train attend maximum speed. During this free tuning period train runs at constant speed & constant power is taken from supply by train.</p> <p>iv) Coasting period (C to D) For T_4 sec. :-</p> <p>At the end of free running period the supply to traction motor is cut down & train allow to run under its own movement. The speed of train goes on decreasing due to resistance to motion of train. Rate of decreasing of speed during costing period is known as costing acceleration (P_c)</p> <p>v) Braking period (D to E) For T_5 sec. :-</p> <p>At the end of costing period brakes are applied to bring the train to rest (stop) During this period speed of train rapidly decreases & reduces to zero. The rate of decreases of speed during braking period is known as 'Braking retardation' (β)</p>
Q.6	Attempt any TWO of the following : 16 Marks
a) i)	State any four advantages and any two disadvantages of electric heating.
Ans:	<p>Advantages of Electric heating:</p> <p>(First any Two Points: 1 Mark each & other any Two point : 1/2 each, Total : 3 Marks)</p> <ol style="list-style-type: none">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.



	<p>7. System is clean, as there is no waste produced.</p> <p>8. No fuel transportation cost.</p> <p>9. No space is required for storage of fuel and waste.</p> <p>10. Noiseless operation.</p> <p>11. Uniform heating is possible, heating at particular point is also possible (spot welding)</p> <p>12. Dielectric material can be heated.</p> <p>13. Electrical heating equipments are generally automatic, so it requires low attention and supervision.</p> <p>14. Protection against overheating can be provided by suitable switch gear.</p> <p>Disadvantages of Electric heating: (Any Two expected) (1 Mark)</p> <p>1. It depends on electricity, so not self-content.</p> <p>2. This system is used only where electricity is available</p> <p>3. Electrical system is costly</p>
a) ii)	<p>Describe any four causes of failure of heating elements.</p>
Ans:	<p><u>Following of the different causes of failure of heating element:</u></p> <p>i) Formation of hot spot: (Each Causes: 1 Mark, Total: 4 Mark)</p> <p>Hot spot on heating element is the point which is at higher temperature than remaining heating element portion. So there is possibility of breaking of heating element at hot spot.</p> <p>ii) Due to oxidization:</p> <p>At high temperature material gets oxidized which may cause failure of heating element.</p> <p>iii) Due to corrosion:</p> <p>If heating element is directly exposed to chemical fumes then there is possibility of rusting of heating element which causes failure of heating element.</p> <p>iv) Mechanical consideration/Failure:</p> <p>Measure heating element alloy contain iron which is brittle. Due to frequent heating & cooling of heating element, it may break (fail) due to small mechanical injury also.</p>
b)	<p>A train has schedule speed of 60 kmph between stops which are 6 km apart. Determine the crest speed over the run assuming :</p> <p>i) Duration of stops as 60 sec</p> <p>ii) Acceleration as 2 kmphs</p> <p>iii) Retardation as 3 kmphs, The speed time curve is trapezoidal</p>



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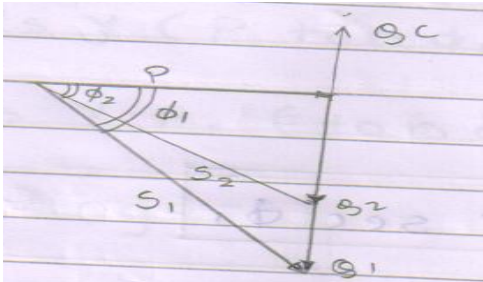
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Ans:	$V_{sch} = 60 \text{ Km/hr} \quad D = 6 \text{ M} \quad T_{stop} = 50 \text{ sec} \quad \alpha = 2 \text{ km/hr-sec} \quad \beta = 3 \text{ Km/hr.sec}$
	Solution:
	$\Rightarrow V_{sch} = \frac{3600 D}{\text{Schedule Time } (T_{sch})} \text{----- (1 Mark)}$
	$\therefore \text{Schedule Time } (T_{sch}) = \frac{3600 \times D}{V_{sch}}$
	$\therefore \text{Schedule Time } (T_{sch}) = \frac{3600 \times 6}{60}$
	$\therefore \text{Schedule Time } (T_{sch}) = \frac{21600}{60}$
	$\therefore \text{Schedule Time } (T_{sch}) = 360 \text{ sec.} \text{----- (1 Mark)}$
	$\Rightarrow \text{SchudeleTime}(T_{sch}) = \text{Actual Time of Run } (T) + \text{Stop time } (T_{stop})$
	$\therefore \text{ActualTime of Run } (T) = \text{ScheduleTime } (T_{sch}) - \text{Stoptime } (T_{stop})$
	$\therefore \text{ActualTime of Run } (T) = 360 - 60$
	$\therefore \text{ActualTime of Run } (T) = 300 \text{ sec.} \text{----- (1 Mark)}$
	$\Rightarrow \text{Maximum Speed} =$
	$V_{\max} = \frac{T - \sqrt{T^2 - 4K3600D}}{2K} \text{----- (1 Mark)}$
	$\text{But, } K = \frac{\alpha + \beta}{2(\alpha \times \beta)} \text{----- (1 Mark)}$
	$K = \frac{2 + 3}{2(2 \times 3)}$
	$K = 0.4167 \text{----- (1 Mark)}$
	$\text{Now, } V_{\max} = \frac{T - \sqrt{T^2 - 4K3600D}}{2K} \text{----- (1 Mark)}$
	$V_{\max} = \frac{300 - \sqrt{300^2 - 4 \times 0.4167 \times 3600 \times 6}}{2 \times 0.4167}$



	$V_{\max} = \frac{300 - 232.372}{2 \times 0.4167}$ $V_{\max} = 81.1471 \text{ Km/hr} \text{ -----Answer----- (1 Mark)}$
c) i)	Derive the equation for most economical power factor.
Ans:	Derivation for most economical power factor: (4 Mark)  <p style="text-align: right;">or equivalent figure</p> <p>Let,</p> <p>P = Active power KW</p> <p>S₁, S₂ = KVA Maximum demand before and after improving power factor</p> <p>Q₁, Q₂ = Lagging reactive power before & after improving power factor</p> <p>Q_C = Leading Reactive power drawn by Capacitor</p> <p>cos φ₁ = Initial Power factor</p> <p>cos φ₂ = Improved Power factor</p> <p>Rs X = Tariff charges towards M.D. (KVA) /year</p> <p>Rs Y = Expenditure towards KVAR to be neutralized per year (Expenditure towards P.F. improving apparatus)</p> <p>1) Before improving Power factor:</p> $Q_1 = P \tan \phi_1$ $\cos \phi_1 = \frac{P}{S_1}$ $S_1 = \frac{P}{\cos \phi_1}$ <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> $\therefore \text{KVA}_1 (S_1) = P \sec \phi_1$ </div> <p>2) After improving Power factor:</p> $Q_2 = P \tan \phi_2$ $\cos \phi_2 = \frac{P}{S_2}$



$$S_2 = \frac{P}{\cos \phi_2}$$

$$\therefore \text{KVA}_2 (S_2) = P \sec \phi_2$$

3) Saving in KVA charges:

$$\begin{aligned} &= Rs \times (S_1 - S_2) \\ &= Rs \times (P \sec \phi_1 - P \sec \phi_2) \\ &= Rs \times P (\sec \phi_1 - \sec \phi_2) \end{aligned}$$

4) Expenditure towards KVAR to be neutralized:

$$\begin{aligned} &= Rs \times Y (Q_1 - Q_2) \\ &= Rs \times Y (P \tan \phi_1 - P \tan \phi_2) \\ &= Rs \times Y \cdot P (\tan \phi_1 - \tan \phi_2) \end{aligned}$$

5) Net Saving:

$$\begin{aligned} &= \text{Saving in KVA charges} - \text{Expenditure towards KVAR to be neutralized} \\ &= [Rs \times P (\sec \phi_1 - \sec \phi_2)] - [Rs \times Y (P \tan \phi_1 - P \tan \phi_2)] \end{aligned}$$

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

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

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

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

$$Rs \times P \sec \phi_2 \cdot \tan \phi_2 = Rs \times Y P \sec^2 \phi_2$$

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

$$\therefore Rs \times \frac{\sin \phi_2}{\cos \phi_2} = Rs \times Y \frac{1}{\cos \phi_2}$$

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

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

6) $\therefore \sin^2 \phi_2 + \cos^2 \phi_2 = 1$

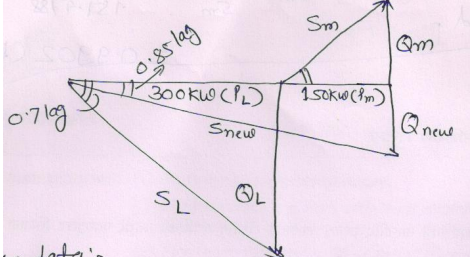
$$\cos^2 \phi_2 = 1 - \sin^2 \phi_2$$

$$\cos \phi_2 = \sqrt{1 - (Y/x)^2}$$

$$\text{Most economical Power factor } \cos \phi_2 = \sqrt{1 - (Y/x)^2}$$

Most economical power factor at which maximum saving will occurs



c) ii)	<p>A factory takes 300 kW at 110 volts from a 3-phase supply and power factor of 0.7 lagging. A synchronous motor is installed which takes an additional 150 kW. What must be the kVA rating of this motor to raise the power factor of the system to 0.85 lagging?</p>
Ans:	<div style="text-align: center;">  <p>or equivalent diagram</p> </div> <p>Given Data: $P_L = 300 \text{ KW}$ $\cos \phi = 0.7 \text{ lag}$ $\sin \phi_L = 0.7$ $\tan \phi_L = 1$ Power factor improved to 0.85 lag $\therefore \tan \phi_{new} = 0.6197$ $P_m = 150 \text{ KW}$</p> <ul style="list-style-type: none"> ➤ Reactive Power taken by load (Q_L) = $P_L \tan \phi_L$ ----- (1/2 Mark) $= 300 \times 1$ $= 300 \text{ KVAR (lag)}$ ----- (1/2 Mark) ➤ Reactive Power taken after synchronous motor is connected (Q_{new}) = $= (P_L + P_m) \tan \phi_{new}$ ----- (1/2 Mark) $= (300 + 150) \times 0.6197$ $= 450 \times 0.6197$ $= 278.8849 \text{ KVAR (lag)}$ ----- (1/2 Mark) ➤ Reactive Power taken by synchronous motor to improve P.f = $= (\phi_L - \phi_{new})$ $= 300 - 278.8849$ $= 21.115 \text{ KVAR (leading)}$ ----- (1/2 Mark) ➤ KVA Rating of Synchronous Motor $S_m = \sqrt{(P_m + \phi_m)^2}$ ----- (1/2 Mark) $= \sqrt{(150)^2 + (21.115)^2}$ $= \sqrt{22500 + 445.845}$ $= \sqrt{22945.845}$ $= 151.4788 \text{ KVA}$ ----- (1/2 Mark) ➤ Power factor of Synchronous Motor $\cos \phi_m = \frac{P_m}{S_m} = \frac{150}{151.4788}$ $= 0.9902 \text{ leading}$ ----- (1/2 Mark)