SUMMER – 2022 EXAMINATION

Subject Name: Utilization of Electrical Energy **Model Answer:** **22626: UEE**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q. N.	Answer	Marking Scheme
1.		**Attempt any FIVE of the following:**	**10 Marks**
	a)	Define the following terms – (i) Solid angle (ii) Waste light factor **Ans:** **Solid angle:** Solid angle is the angle subtended at a point in space by an area. **OR** The angle enclosed in the volume formed by numerous lines lying on the surface and meeting at the point. **Waste light factor:** The ratio of "Total lumens emitted by source / total lumens available after waste of light" is called as waste light factor. **OR Equivalent Answers**	1 Mark 1 Mark
	b)	State the various types of reflectors used in industrial light fittings. **Ans:** **Types of Reflectors Used in Industrial Light Fittings:** • Dispersive type reflectors. • Concentrating type reflectors. • Mirror type reflectors. • Angle type reflectors. • Polished metallic type reflectors. • Diffusing glass type reflectors. • Enclosed Diffusing type reflectors. **OR Equivalent Answer**	1 Mark for each of any two reflectors = 2 Marks
	c)	State the classification of electric heating. **Ans:** **Classification of Electric Heating:** The various methods of Electric Heating are as: (A) Power Frequency Heating. a) Resistance Heating.	

i) Direct Resistance Heating.
ii) Indirect Resistance Heating.
iii) Radiant or Infrared Heating.

b) Arc Heating.
i) Direct Arc Heating.
ii) Indirect Arc Heating.

c) Electron bombardment Heating.

(B) High Frequency Heating.

a) Induction Heating.
i) Direct Induction Heating.
ii) Indirect Induction Heating.

b) Dielectric Heating.

2 Marks

d) Enlist the various types of electric drives used in Industry.

Ans:

Types of Electric Drives Used in Industry:

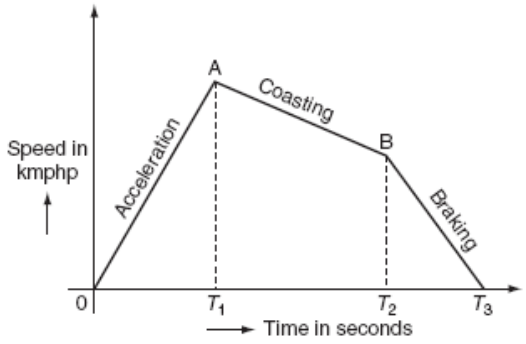
1. A. C. Motor Drive.
2. D. C. Motor Drive.
3. Individual Drive.
4. Group drive.
5. Multi motor Drive.
6. Constant Speed Drive.
7. Variable Speed Drive.
8. Vector Control Drive.
9. Constant power Drive.
10. Constant Torque Drive.

1 Mark for each of any two type drives = 2 Marks

e) Draw the speed-time characteristics of suburban services.

Ans:

Speed - Time Characteristics of Suburban Services:



2 Marks

f) State the various devices used for power factor improvement.

Ans:

Devices Used for Power Factor Improvement:

1. Static Capacitor **OR** Condenser.
2. Phase Advancer.
3. Over Excited Synchronous Motor.

1 Mark for each of any two devices = 2 Marks

g) Suggest the type of tariff for –

(i) Domestic consumer

(ii) HT Industrial consumer

Ans:

i) Domestic Consumer: — 1 Mark for any one
- Flat rate tariff.
- Block rate tariff.

ii) HT Industrial Consumer:
- Maximum demand (kVA) tariff.
- Time of day tariff.
- Two-part tariff
- Power factor tariff

1 Mark for any one

2. Attempt any THREE of the following: **12 Marks**

a) Compare fluorescent lamp and LED lamp on the basis of quality of light; lamp efficiency; Life of lamp and voltage regulation.

Ans:

Comparison Between Fluorescent Lamp and LED Lamp:

Sr. No.	Item	Fluorescent Lamp	LED Lamp
1.	Quality of light	Quality of light is not so good. (Fluorescent lighting, however, utilizes the blue, green and red colour wheel. This gives the lighting an extremely artificial feel).	Quality of light is very excellent. (Because of its inherent design, the entire colour wheel is represented through the diodes used in an LED. This allows it to produce all shades of colour, including even the slightest variations between bright white and natural light).
2.	Lamp efficiency	Fluorescent lamps are relatively less efficient. (Fluorescent lights produce between 50 to100 lumens per watt)	LED lamps are more efficient. (LEDs can produce roughly 130 lumens per watt)
3.	Life of lamp	Life of fluorescent lamp is less. (It can last up to 10,000 hours).	Life of LED lamp is much high. (It can last up to 50,000 hours).
4.	Voltage regulation	The voltage drop taking place in fluorescent lamp is somewhat higher so it has moderate value of voltage regulation.	The voltage drop across LED lamp is approximately constant over a wide range of operating current so it has very less value of voltage regulation.

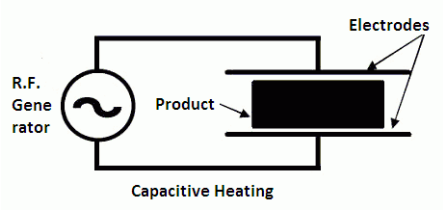
1 Mark for each of any four points = 4 Marks

b) Explain with neat sketch; the working principle of Dielectric heating.

Ans:

Working Principle of Dielectric Heating:

Dielectric heating is a type of heating which makes use of the dielectric loss in imperfect dielectric materials and is therefore, suitable for heating non-metals. The below figure shows the schematic arrangement of dielectric heating.



1 Mark for sketch

- In dielectric heating, high frequency, high voltage ac voltage is applied across dielectric material.
- The dielectric work piece is held between two metal electrodes as shown in figure. The dielectric material can be plastic, wood, insulators etc.
- Due to high voltage RF excitation, current flows through the dielectric material and due to this current flow, loss take place in the dielectric which is called as "dielectric loss".
- This power loss takes place in the form of heat and the dielectric material gets heated up due to it. This is the principle of dielectric heating.

3 Marks for explanation

c) Recommend relevant motor for the following application with justification.
(i) Rolling mill drives
(ii) Air compressor

Ans:

Relevant Motor for Rolling Mill Drives and Air Compressor:

Sr. No.	Application	Relevant Motor	Justification
1.	Rolling mill drives	1. Salient pole synchronous motors that meet high power and torque demands. 2. Squirrel cage rotor motor applied to medium power requirements. 3. D. C. Compound motor coupled with flywheel.	Following features make those motors suitable for Rolling mill drives. • Superior efficiency • Robust frame and shaft construction • Less demand for maintenance • High degree of control • Great capacity for acceleration and deceleration. • Greater flexibility for extreme operating conditions • Medium starting torque • Constant speed • High mechanical strength
2.	Air compressor	1. Standard induction motor for fixed speed compressor 2. HPM (Hybrid permanent magnet) motor for highly accurate variable flow compressor 3. Invertor duty motor for VFD compressors	Following features make those motors suitable for Air compressors • Very much reliable • Robust frame and shaft construction • Less demand for maintenance • High degree of control • Meets constant torque requirements. • Suitable for light load applications • Portable

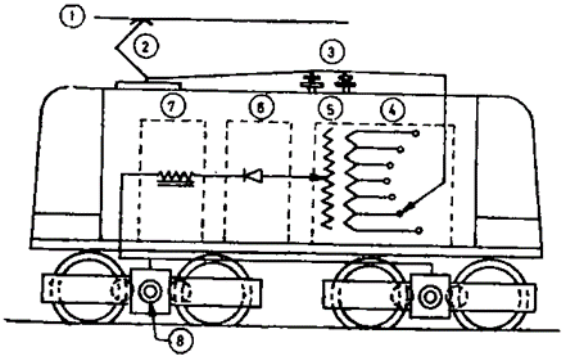
2 Marks For each application

(1 Mark for motor and 1 Mark for its two justifications)

d) Draw the block diagram of 25 kV; 1ϕ; 50Hz A. C. locomotive used for traction system. State the function of each part.

Ans:

Block Diagram of 25 kV; 1ϕ; 50Hz A. C. Locomotive used for Traction System:



1. OHE
2. Pantograph
3. Circuit breaker
4. On load tap changer
5. Transformer
6. Rectifier
7. Smoothing choke
8. Traction motor

2 Marks for diagram

Functions of Part / Equipment:

1. **Over Head Line:** Provides supply input to the locomotive.
2. **Pantograph:** It is the current collecting equipment from overhead line to motor power / control circuit.
3. **Circuit Breaker**: Disconnects the locomotive equipment from the supply in the event of fault in the equipment / locomotive etc.
4. **On Load Tap Changer:** Used to control the voltage of the traction motors through the rectifier for speed control.
5. **Traction Transformer:** Steps down the voltage to the suitable value for the traction motors. It has a ratio of 20:1.
6. **Rectifier:** Converts input AC to DC for further use by series traction motors.
7. **Smoothing reactor / choke:** Smoothen out the ripples in the DC output current of rectifier.
8. **Traction motors:** Operates as per the requirement to take the traction load.

½ Mark for each of any four part function = 2 Marks

3. Attempt any THREE of the following: 12 Marks

a) A small assembly shop 16 m long; 10 m wide and 3 m up to trusses is to be illuminated to a level of 200 lux. The utilization and maintenance factors are 0.74 and 0.8 respectively. Calculate number of lamps required to illuminate whole area if the lumen output of the lamp selected is 3000 lumens.

Ans:

Given Data:

Area of working Plane = 16 x 10 m = 160 m^2

E or I = 200 lux = 200 lumens/$meter^2$

Utilization Factor (U.F) = 0.74

Maintenance Factor (M.F.) = 0.8

Lumens output of each lamp = 3000 lumens

$$N = \frac{\text{Illumination Level} \times \text{Area}}{\text{Lumens output of each lamp} \times \text{U.F} \times \text{M.F}}$$

$$N = \frac{200 \times 160}{3000 \times 0.74 \times 0.8}$$

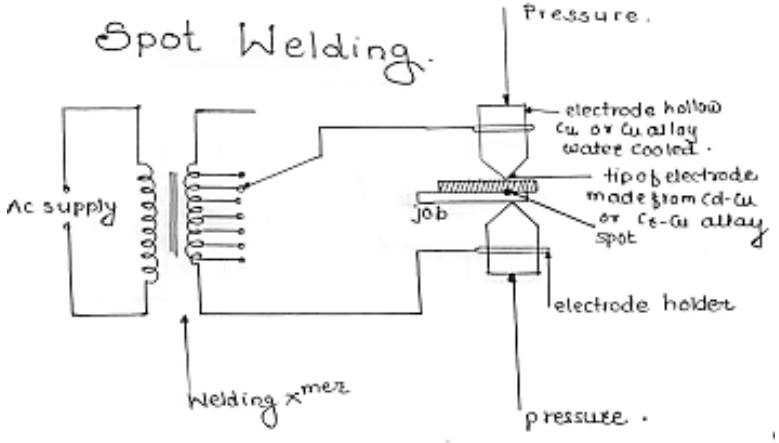
$$\mathbf{N = 18.018 \cong 18\ lamps}$$

2 Marks Stepwise solution 2 Marks

b) Describe with neat sketch; the working principle of spot welding and state its application.

Ans:

Spot Welding:



1 Mark for diagram

Working Principle:

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

It consists of:

- Transformer which is designed for low voltage and high current secondary.
- Transformer which is oil cooled and portable
- Two electrodes: one is fixed and other is movable
- The electrodes which are hollow and water cooled.
- Electrodes made from copper or copper alloys and tips are made from Cd-Cu or Cr-Cu.

2 Marks for working principle

As shown in fig. jobs to be welded are placed over one another between two electrodes under pressure and sufficiently heavy current at low voltage is passed directly through two metal jobs 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 the 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 sheets (job) to be welded.

Applications of spot welding:-

1 Mark for two applications

1) Joining of automobile body section.
2) Joining sheet metal structure.
3) It is used for automatic welding process.
4) For spot welding to GI sheets, MS sheet, tinned, lead-coated sheets.
5) For spot welding to non-ferrous material such as brass, bronze, nickel, Cu, Al etc.
6) In fabrication workshop for different applications.

c) Explain with neat sketch, Rheostatic braking for D. C. series motor.

Ans:

Rheostatic Braking of D. C. Series Motor:

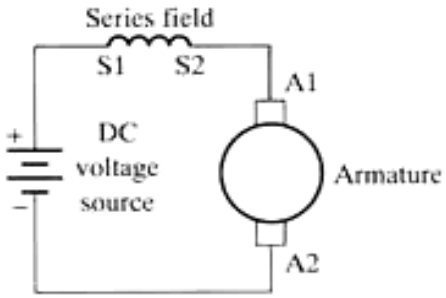


Fig. 1 Under Normal Condition

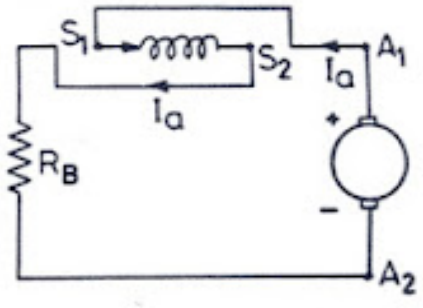


Fig. 2 Under Rheostatic Braking

2 Mark for diagram

Explanation:

- Under normal running condition, the armature winding and series field winding are connected in series with each other and then supplied from DC supply. This is "motoring" operation. The motor takes electrical power from DC vopltage source. The motor current flows through series field winding (from S_1 to S_2) and armature winding (from A_1 to A_2). The back emf induced in armature winding has polarity such that A_1 is positive and A_2 is negative.
- When braking is required, two changes are made in circuit configuration:
  i) Input DC source is disconnected and replaced by external resistance R_B, as shown in Fig. 2.
  ii)To maintain the polarity of back emf induced in armature winding same, the series field winding connections are reversed. Such connection maintains field current supplied by armature winding in the same direction as before during motoring.
  In absence of input DC source, now the kinetic energy stored in mechanical load drives the motor to operate it as generator and generated electrical power is supplied to external resistance R_B. In this way, the stored kinetic energy in mechanical load is converted to electrical energy and supplied to external resistance R_B. During every energy conversion process, an opposition is always there. Here also during braking, the current carrying armature conductors in magnetic field experience force opposing the motion and speed is therefore reduced.
- Value of external resistance connected in armature circuit must be less than the critical value otherwise there will be no excitation.

2 Marks for Explanation

d) A factory which has a maximum demand of 200 kW at a power factor of 0·8 lagging is charged at Rs. 720 per kVA per annum. If the phase advancing equipment costs Rs. 1200 per kVAR, find the most economical power factor at which the factory should operate. Interest and depreciation total 10% of the capital investment on the phase advancing equipment.

Ans:

Given Data:

Power factor of the factory, $\cos\emptyset = 0.8$ lagging

Max. demand charges, x = Rs. 720 per kVA per annum

1 Mark for x

Expenditure on interest and depreciation

y = 10% of Capital investment on phase advancing equipment,

= Rs 1200 × 0·1 = Rs 120/kVAR/annum

1 Mark for y

Most economical p.f. at which factory should operate is:

$$\cos \emptyset_2 = \sqrt{1 - \left(\frac{y}{x}\right)^2}$$

$$\cos \emptyset_2 = \sqrt{1 - \left(\frac{120}{720}\right)^2}$$

$$= \mathbf{0.98\ Lagging}$$

2 Marks for Stepwise solution

4. Attempt any THREE of the following: **12 Marks**

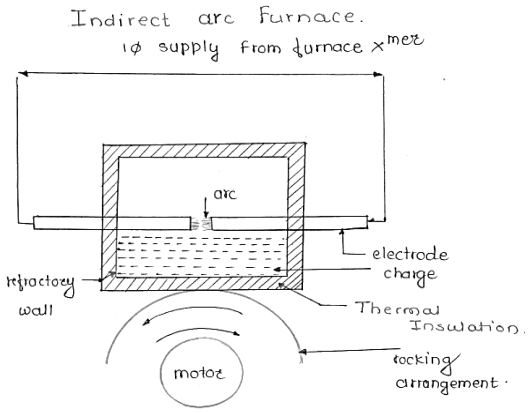
a) Explain with neat sketch; the construction and operation of indirect arc furnace.

Ans:

Indirect arc furnace:

The furnace in which, the heat is transferred to the charge by radiations is known as indirect arc furnace.

Construction: -



1 Mark for diagram or equivalent

- Heating chamber is Cylindrical in shape for providing minimum refractory material and for easy rocking.
- It has two openings, one is for pouring the charge and another is for taking out molten metal. Both openings are closed during operation.
- The wall of heating chamber is made from refractory material to withstand heating chamber high temperature and also to reduce heat loss.
- The electrodes are placed in horizontal position. These electrodes enter the furnace from side wall.
- The Entire assembly is supported on rocking wheels at the bottom. These wheels gives stirring action to furnace melt

2 Marks for construction

Operation:

- The Charge is put inside from furnace door.
- The Electrodes are made to touch each other and supply is turn on.
- The electrodes are slowly separated till is act struck between them.
- The arc transfers heat to the charge through radiations.
- The stirring action is obtained by rocking wheels these wheel cause a rhythmic movement of furnace.
- The molten charge is taken out from outlet

1 Mark for operation

b) A motor used for mines has following type of duty cycle: -

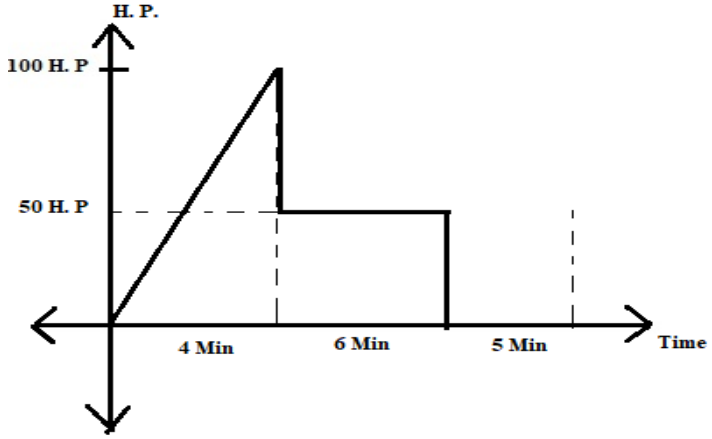
(i) Power demand increases from zero to 100 H. P. in 4 minutes.
(ii) Constant running for 50 H. P. for 6 minutes.
(iii) Remains at rest for another 5 minutes.

Estimate the size of motor.

Ans:-

i) Load rising from 0 to 100 H. P. :- 4 min

ii) Constant running 50 H. P. :- 6 min
iii) Remain at rest : 5 min



1 Mark for diagram

Here, $H_1 = 100$, $H_2 = 0$, $H_3 = 50$, $H_4 = 0$

$$\text{H. P. Rating} = \sqrt{\frac{\frac{1}{3}\left(H_1{}^2 + H_1H_2 + H_2{}^2\right)t_1 + H_3{}^2t_2 + H_4{}^2t_3}{T}}$$

2 Marks for stepwise solution

Where $T = t_1+t_2+t_3$
$= 4 + 6 + 5$
$= 15$

$$\text{H. P.} = \sqrt{\frac{\frac{1}{3}(100^2 + 100 \times 0 + 0^2) \times 4 + 50^2 \times 6 + 0}{15}}$$

$$\text{H. P.} = \sqrt{\frac{\frac{1}{3}(10000) \times 4 + 2500 \times 6}{15}}$$

$$\mathbf{H.\,P. = 43.46\ H.\,P.}$$

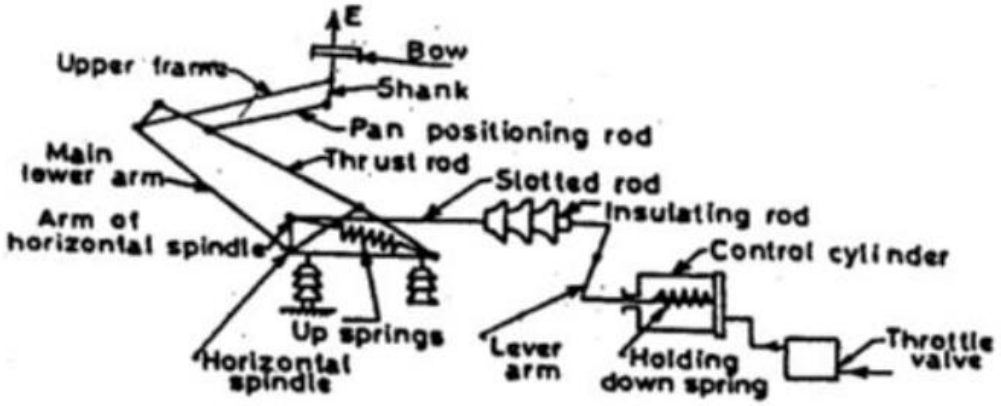
1 Mark

Nearest standard rating of motor is to be selected.

c) Explain with neat sketch; the construction and working of pantograph collector.

Ans:

Faiveley type pantograph collector:



2 Marks for fully labeled diagram

1 Mark for partially labeled diagram

Construction of Faiveley type pantograph collector :

- It consists of
  i) sub frame or base, ii) Articulated system, iii) Pneumatic control system including throttle valve, iv) Two raising springs v) Four insulators.
- The base is made up of welded sections and houses two ball bearings on which is carried the articulated system.
- Rubber stops are provided to limit the folding of the articulated system at the lower part.
- Articulated system consists of:
  a) Horizontal spindle turning into two ball bearings which are part of the base.
  b) Lower arm integral with horizontal spindle and supporting at the upper end bearing on which are fitted two tubes of the upper frame.
  c) Thrust rod articulated at lower end on fixed point of the base frame and on upper end on bearing housed in the yoke casting at upper end of lower arm.
  d) Transversal tube rotating in the sleeves fitted on the tube ends of upper frame.
  e) Positioning rod articulated on a pin fitted on the thrust rod and on one side & on the crank pin fitted to the shank as shown in the figure.
  f) Bow consists of frame on which are bolted two connecting strips.
  g) Whole pantograph is fitted on the roof of the vehicle by means of four insulators.

1 Mark for construction

Working of Faiveley type pantograph collector:

- When compressed air is admitted in the central cylinder, piston compresses the holding down springs and slotted rod gets translatory motion which permits horizontal spindle to rotate under the action of up springs.
- The pantograph then rises until collector touches the OHE.
- The articulated system then stops and piston complete its stroke.
- Piston remains stationary during normal operation.
- The pin of horizontal spindle is permitted to move freely in the slot of slotted rod & pantograph is operated purely by the up springs.

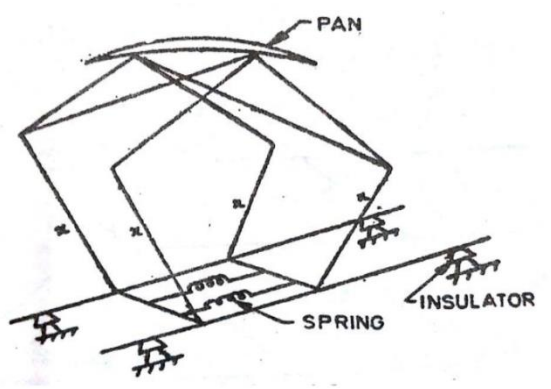
1 Mark for working

OR

Diamond Pantograph:

Construction:

1. Diamond Pantograph consist of pressed steel channel sectional fitted with renewable collector strips and supported at the apex of Pentagonal tubular frame work as shown in above figure.
2. Collector strips are forced against the contact wire by upward action pantograph springs.
3. These strips slide along the bare metal of the contact wire as the train moves.
4. The collector strip material and the contact pressure are such as to ensure the minimum wear of the contact wire.
5. Metalized carbon strips are used for high current collecting capacity and to



2 Marks for fully labeled diagram

1 Mark for partially labeled diagram

1 Mark for construction

avoid use of lubricant.

6. Diamond Pantograph may be raised or lowered from cabin by following methods.
   a) Air raised gravity lowered.
   b) Air raised spring lowered
   c) Spring raised air lowered

Working:

The pantograph current collector is used in the railways for collection of current from the overhead system where the operating speed of the train is as high as 100 kmph to 130 kmph and the current to be collected are as large as 2 kA to 3 kA.

1 Mark for working

The pantograph is mounted on the roof of the vehicle and carry a sliding shoe for contact with the overhead trolley wire. It consists of a jointed frame usually of steel tubing. The contact shoe is usually about 1.2 meters long. The sliding shoe always make contact with the overhead line to collect the current.

d) Compare D.C. and A. C. system of railways electrification from the point of main line and suburban line railways service

Ans:

Comparison Between D. C. and A. C. system of Railways Electrification:

Sr.No	Points	A.C. System	D.C. System
1	Supply given to O/H condition	1-ph, 25KV, AC 50 Hz	600/750V-Tromways 1500/3000V- urban / suburban
2	Type of drive used	1-ph, AC series motor	DC series motor for tramways.
3	Weight of traction motor	1.5 times more than d.c. series motor.	1.5 times less than a.c series motor
4	Starting torque	Less starting torque than d.c series motor	High starting torque
5	Acceleration and retardation	Less than d.c series motor	High
6	Overload capacity	Less than d.c series motor	High
7	Method of speed control	Simple and smooth	Limited, except chopper method
8	Maintenance cost of traction motor	More	Less
9	Starting Efficiency	More	Less
10	Ridding quality	Less, better than d.c.	Smooth (Better)
11	Insulation cost	High	Low
12	Cross section of conductor	Less	More
13	Design of supporting structure	light	Heavy
14	Distance between two substation	More	Less
15	No. of substation	Less	More

1 Mark for each of any four points = 4 Marks

	required for same track distance.		
16	Size (capacity) of traction substation	More	Less
17	Capital & maintenance cost of substation	Less	More
18	Cost track electrification for same track distance	Less	More
19	Applications	Main line services	Urban and suburban area

e) It is desired that the correct power factor of 0.95 by means of static condensers is connected to each phase of 3- phase, 400 volt, 50 Hz motor having maximum load of 50 kVA at a p.f. of 0.75. Determine the capacity of each delta connected condenser.

Ans:

Given Data:

V = 400V, f = 50Hz, $\cos\emptyset_1 = 0.75$, $\cos\emptyset_2 = 0.95$,

$P = 50\text{kVA} = 50 \times 0.75 = 37.5\text{kW}$

$$\tan\emptyset_1 = 0.88$$ ½ Mark

$$\tan\emptyset_2 = 0.33$$ ½ Mark

$$Q_1 = P\tan\emptyset_1$$

$$Q_1 = 37.5 \times 0.88$$

$$\mathbf{Q_1 = 33\ kVAR}$$ ½ Mark

$$Q_2 = P\tan\emptyset_2$$

$$Q_2 = 37.5 \times 0.33$$

$$\mathbf{Q_2 = 12.37kVAR}$$ ½ Mark

KVAR Rating of the capacitor Bank

$$Q_C = Q_1 - Q_2$$

$$Q_C = 33 - 12.37$$

$$\mathbf{Q_C = 20.63kVAR}$$ 1 Mark

Capacitor when connected in delta :-

$$C_{per\ phase} = \frac{Q_C \times 10^3}{3\omega V^2}$$

$$C_{per\ phase} = \frac{20.63\times10^3}{3\times2\times\pi\times50\times400^2} \quad \ldots\ldots\ldots\omega = 2\pi f$$

$C_{per\ phase} = 1.36 \times 10^{-4}$ F = 136.82 μF — 1 Mark

5 Attempt any TWO of the following: 12 Marks

5 a) A 20kW single phase 220V resistance oven has Nichrome wire heating elements. The wire is designed for maximum temperature of 1150°C and temperature of charge to be 600°C. If radiating efficiency is 0.55; Emissivity is 0.9 and specific resistance is 1.09×10^{-6} ohm-m, estimate the diameter and length of wire.

Ans:

Given Data:

Power rating of oven, P = 20kW = 20000W
Voltage rating, V = 220 V
T_1 = 1150°C = 1150+273 =1423°K
T_2 = 600°C = 500 +273 = 773°K
Radiation efficiency (k) = 0.55,
Specific resistance (ρ) = 1.09×10^{-6} ohm-m,
Emissivity (e) = 0.9.
Heat dissipation per unit area due to radiation is given by,

$$H = 5.72 \times k \times e\left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] \quad watt/m^2$$

$$H = 5.72 \times 0.55 \times 0.9\left[\left(\frac{1423}{100}\right)^4 - \left(\frac{773}{100}\right)^4\right] \quad watt/m^2$$

1 Mark for H

$$\mathbf{H = 105987.6985 \ watt/m^2}$$

Heat Dissipated in watt = Electrical Power Input in watt

$H \times \pi dl$ = P ……..Eq. No. 1

But, $P = \frac{V^2}{R} = \frac{V^2}{\left[\frac{\rho l}{a}\right]} = \frac{V^2}{\left[\frac{\rho l}{\left(\frac{\pi}{4}d^2\right)}\right]} = \frac{V^2}{\left[\frac{4\rho l}{\pi d^2}\right]}$

$$\therefore \frac{l}{d^2} = \frac{\pi V^2}{4P\rho}$$

$$\therefore \frac{l}{d^2} = \frac{3.142 \times 220^2}{4 \times 20 \times 1000 \times 1.09x\,10^{-6}}$$

1 Mark for Eq. 2

$\frac{l}{d^2} = 1743728.032$ …..……. ……..Eq. No. 2

$H \times \pi dl$ = P

$105987.6985 \times \pi \times dl = 20000$

$d\,l = 0.06$ …… Eq. No. 3

Squaring both sides

$d^2 l^2 = 0.00361$

1 Mark for Eq. 3

$$d^2 = \frac{0.00361}{l^2}$$

1 Mark for stepwise solution

Substituting this value in Eq. No. 2

$$\frac{l}{\left[\frac{0.00361}{l^2}\right]} = 1743728.032$$

$l^3 = 1743728.032 \times 0.00361 = 6294.86$

$\therefore \boldsymbol{l = 18.464}$ **m**

1 Mark for l

Substituting this value in Eq. No. 3

d (18.464) = 0.06 m
$\therefore$ **d = 3.25 mm**

1 Mark for d

5 b) Enumerate the factors governing selection of electric drives for a particular service / application.

Ans:

Factors governing selection of electric drives forparticular service / application:

1. **Nature of supply:**
   - AC,
   - Pure DC
   - Rectified DC
2. **Nature of Drive (Motor):**
   - Individual machine
   - Group of machines.
3. **Nature of load:**

   Whether load required light or heavy starting torque
   - Load having high inertia, require high starting torque for long duration.
   - Whether load torque increases with speed (Tα N)
   - Decreases with speed (T α 1/N)
   - Remains constant with speed (T = N)
   - Increases with square of speed (T α N^2)
4. **Electric Characteristics of drive:**
   - Starting,
   - Running,
   - Speed control
   - and braking characteristics
5. **Size and rating of motor:**
   - Whether motor is short time running
   - Continuously running
   - Intermittently running
   - Variable load cycle.
6. **Mechanical Considerations:**
   - Types of enclosure,
   - Types of bearing,
   - Transmission of mechanical power,
   - Noise
   - Load equalization
7. **Cost:**
   - Capital,
   - Running
   - Maintenance cost

1 Mark for each factor with at least two sub-points = 6 Marks

5 c) An electric train is to have acceleration and braking retardation of 1.2Km/hr/sec and 4.8 Km/hr/sec respectively. If the ratio of maximum to average speed is 1.6 and time for stops 35 seconds. Find schedule speed for a run of 3Km. Assume simplified trapezoidal speed-time curve.

Ans:

Given:

Acceleration, α = 1.2Km/hr/sec

Retardation, β = 4.8 Km/hr/sec

Ratio of Max speed to average speed, $\frac{V_m}{V_a}$= 1.6 **,** stop time = 35sec**,**

Distance between stops, S = 3km

$$\text{Average speed(Va)in kmph} = \frac{\text{S in km}}{\text{Actual time of run in hrs}}$$ 1 Mark

$\text{Va} = \frac{3}{(\frac{T}{3600})}$, where T is the total time of travel in seconds.

$$\therefore \text{Va} = \frac{3 \times 3600}{T}$$

$$\text{Va} = \frac{10800}{T}\text{kmph}$$

$$\frac{V_m}{V_a} = 1.6$$

$\therefore \text{Vm} = 1.6\,\text{Va} = 1.6 \times \frac{10800}{T} = \frac{17280}{T}$ 1 Mark

For trapezoidal speed-time curve,

$$V_m^2\left[\frac{1}{2\alpha} + \frac{1}{2\beta}\right] - V_m T + 3600S = 0$$ 1 Mark

$$V_m^2\left[\frac{1}{2 \times 1.2} + \frac{1}{2 \times 4.8}\right] - V_m T + 3600S = 0$$

$$V_m^2[0.417 + 0.104] - V_m \times \frac{17280}{V_m} + 3600 \times 3 = 0$$

$$V_m^2[0.52] - 17280 + 10800 = 0$$

$$V_m^2[0.52] = 6480$$

$$V_m^2 = \frac{6480}{[0.52]} = 12461.54$$

$$\therefore V_m = \sqrt{12461.54} = \mathbf{111.63\ kmph}$$ 1 Mark

$$\frac{V_m}{V_a} = 1.6$$

$$\therefore V_a = \frac{V_m}{1.6} = \frac{111.63}{1.6} = \mathbf{69.77\ kmph}$$ 1 Mark

But, $\text{Va} = \frac{10800}{T}$ $\quad \therefore T = \frac{10800}{V_a}$

$$\therefore T = \frac{10800}{69.77} = 154.79 \text{ sec}$$

Schedule time = Actual time of run+ stop time
= 154.79 + 35= 189.79 sec

$\therefore$ Schedule speed $= \frac{S}{\left[\frac{189.79}{3600}\right]} = \frac{3\times3600}{189.79} = \mathbf{56.905\ kmph}$ 1 Mark

6 Attempt any TWO of the following: 12 Marks

6 a) Compare resistance welding and arc welding on the basis of
i) Supply requirement
ii) Voltage
iii) Power factor
iv) Additional material requirement
v) External pressure
vi) Temperature

Ans:

Comparison between Resistance welding and Arc welding:

Sr. No.	Parameters	Resistance Welding	Arc Welding
1	Supply requirement	Usually ACSupply is used	Metal arc welding – Both AC and DC supply are used. But generally AC Supply is preferred. Carbon arc welding - only DC supply is used
2	Voltage	Low voltage (2 to 20V AC)	Metal Arc welding Voltage- 70 to 100V AC Carbon arc welding voltage- 50 to 60V DC,
3	Power factor	Low	Poor
4	Additional material requirement	Required	Not required
5	External pressure	Required	Not required
6	Temperature	Temperature obtained is not very high (up to 1350^0C)	Temperature obtained is very high (up to 3500^0C to 6000^0C)

1 Mark for each point

6 b) Select the type of enclosures for the electric drives used in following places with justification.
(i) Drives used in petroleum station/chemical plants.
(ii) Electric drives used in damp situation.
(iii) Electric drives used in coal handling plant.

Ans:

Drive Application	Type of Enclosure	Justification
1. Drives used in petroleum station/chemical plants.	Explosion-proof enclosure	The explosion proof motor is a totally enclosed machine and is designed to withstand an explosion of specified gas or vapor (usually present in chemical plant or petroleum station) inside the motor casing and prevent the ignition outside the motor by sparks, flashing or explosion.
2. Electric drives used in damp situation	Drip-proof type enclosure	In such machines openings provided for ventilation are so protected by overhanging cowls that liquid drops or dust particles falling on the machine vertically cannot enter the machine. Such motors are used in damp situations such as for pumping sets.
3. Electric drives used in coal handling plant	Totally enclosed type enclosure	Such machines have solid frames and end shields but no opening for ventilation. They get cooled by surface radiation only. In such machines no dirt or foreign matter can enter the motor and clog the air passage. These machines are used in situations like coal handling plant where dust, water, oil, chemicals, gases or other injurious substances are likely to enter the machine but natural cooling is sufficient.

For each application
1 Mark for type of enclosure
+
1 Mark for justification
= 2 Marks

(For 3 applications total six marks)

6 c) Draw speed-time curve and label its various parts for the following services.
(i) Main line service
(ii) Urban line service
And describe the main features of above train services.

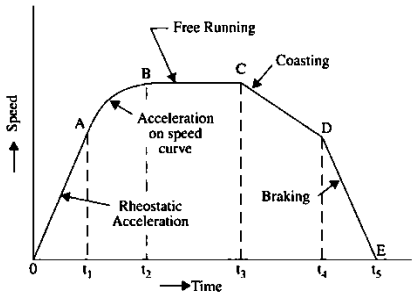
Ans:

I) Speed-Time Curve for Main Line Service:

In main line service, the distance between two stops is considerably more (usually more than 10 km). Speed-time curve mainly consists of :

1) Constant Acceleration or Acceleration during Notching Up or Rheostatic Acceleration (OA): During this, the current is maintained approximately constant and the voltage across the motor is gradually increased by cutting out

the starting resistance. Thus tractive effort is constant and therefore the acceleration remains constant during this period.



2 Marks for diagram

2) Speed Curve Running or Acceleration on Speed Curve (AB): During this the voltage across the motor remains constant and current starts decreasing with the increase in speed according to the characteristics of the motor and finally the current taken by the motor becomes constant. During this period, the train accelerates, but acceleration decreases with increase in speed and finally becomes zero at the speed at which the tractive effort developed by the motor becomes exactly equal to the resistance to the motion of the train.
3) Free Run or Constant Speed Run (BC): At the end of speed curve running, the train attains the maximum speed. During this period, the train runs with constant speed attained at and constant power is drawn.
4) Coasting (CD): At the end of free running period (i.e at C) power supply is cut off and the train is allowed to run under its own momentum. The speed of the train starts decreasing on account of resistance to the motion of train. The rate of decrease of speed during coasting period is known as coasting retardation.

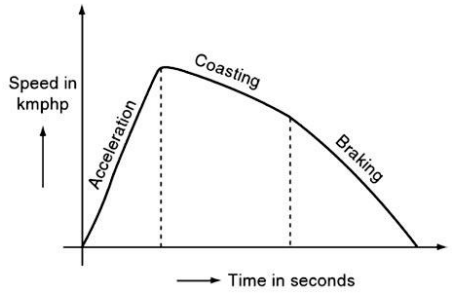
2 Marks for features

5) Retardation or Braking Period (DE): At the end of coasting period (i.e at D), the brakes are applied to bring the train to rest. During this period speed decreases rapidly and finally reduces to zero.

II) Speed-Time Curve for Urban Line Service:

In urban or city service, the distance between the two stops is comparatively very short (say 1 km or so). The time required for this run is very small (few minutes). The acceleration as well as retardation is required to be high so that high average speed and short time of run is obtained.

1 Mark for feature



Typical speed–time curve for urban service

1 Mark for diagram