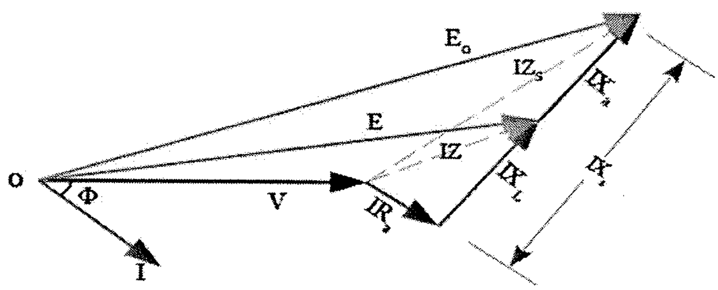
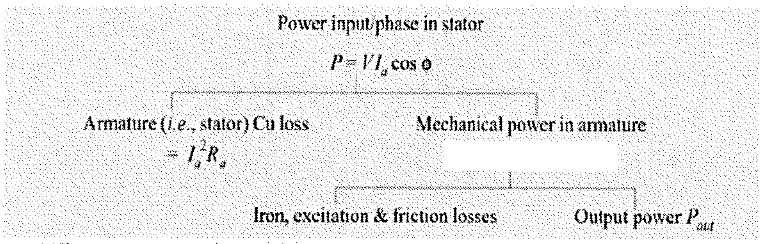
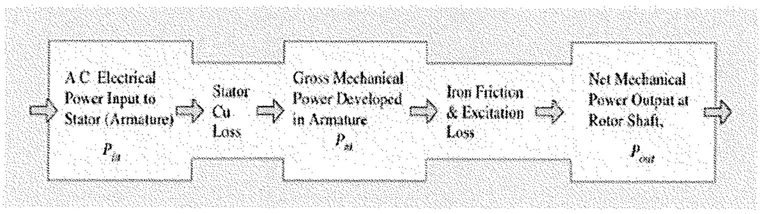
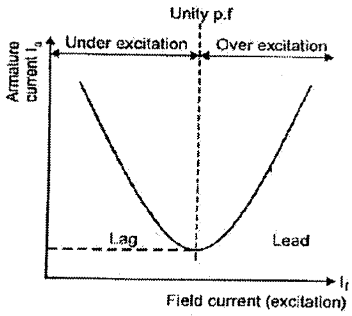
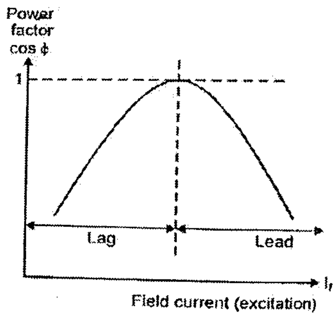
Scoring Indicators

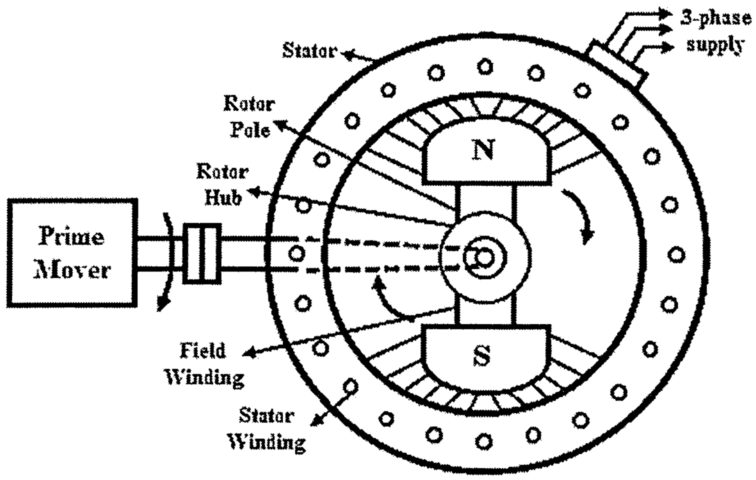
COURSE NAME : Synchronous Machines & FHP Motors

COURSE CODE : 5031

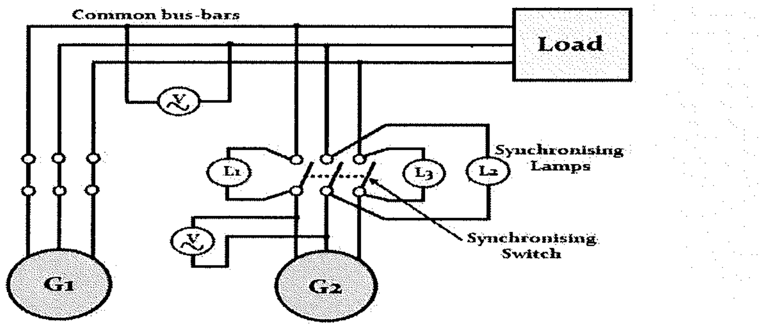
QID : 2109230048

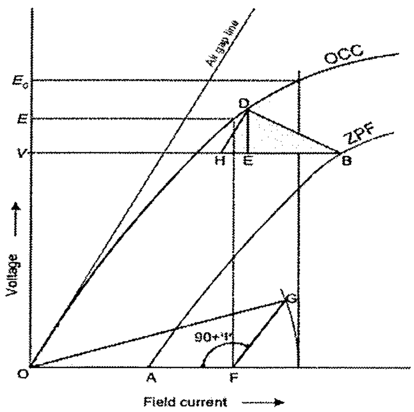
Q No	Scoring Indicators	Split score	Sub Total	Total Score
	PART A			
I. 1	$N = \frac{120F}{P}$	1	1	1
I. 2	Distribution factor	1	1	1
I. 3	Eddy current loss	1	1	1
I. 4	EMF Method (or) MMF method (or) ZPF method	1	1	1
I. 5	Damper winding (or) Externally coupled Pony Motor (or) DC motor	Any one 1	1	1
I. 6	Prevents hunting (or) Provides starting torque .	Any one 1	1	1
I. 7	(c) Single phase induction motor	1	1	1
I. 8	It creates a rotating magnetic field(for starting)	1	1	1
I. 9	Universal motor	1	1	1
	PART B			
II. 1		3	3	3
II. 2	$\delta = \frac{2}{9} \times 180^\circ = 40^\circ$ $K_p = \cos(\delta/2) = 0.94$	1 2	3	3

II. 3	Synchronizing Power is defined as the difference between input power to alternator at power angle δ and input power to alternator at power angle $\delta + \delta'$.	1.5 marks each	3	3
II. 4	Dark lamp method Bright lamp method Synchroscope	1 mark each	3	3
II. 5	 Different power stages in a synchronous motor are as under : 	3	3	3
II. 6	Constant-speed, constant-load drives Power factor correction	1.5 marks each	3	3
II. 7	 V-Curves  Inverted V-Curves	1.5 marks each	3	3
II. 8	• Good speed control. • Precise positioning. • Repeatability of movement. • Highly reliable since there are no contact brushes in the motor. • Minimum mechanical failure • Maximum operation lifespan of the motor.	Any 3 1 mark each	3	3
II. 9	FHP motors are being used to drive pumps and compressors in refrigerators, coffee machines, and washing machines, and they provide suction in vacuum cleaners and a variety of other switching and motion tasks across the ever-increasing variety of domestic products.	Any 3 1 mark each	3	3

II. 10	• High starting torque • Can run at high speed • lightweight and compact	1 mark each	3	3
	PART C			
III	 Explanation	Fig : 4 marks 3	7	7
IV	The emf equation of Synchronous Generator or Alternator is given as Let, Φ = Flux per pole, in Wb P = Number of poles N = Synchronous speed in rpm f = Frequency of induced emf in Hz Z = Total number of conductors Z_{ph} = Conductors per phase connected in series $=2T_{ph}$, T_{ph} - No.of turns per phase Consider a single conductor placed in a slot. The average value of emf induced in a conductor = dΦ/dt. For one revolution of a conductor, E_{avg} per conductor = (Flux cut in one revolution/Time taken for one revolution). Total flux cut in one revolution is Φ x P. Time taken for one revolution is $60/N_s$ seconds. $\therefore e_{avg}$ per conductor $= \frac{\phi P}{\left(\frac{60}{N_s}\right)} = \frac{\phi N_s P}{60}$ But, $f = \frac{PN_s}{120}$ $\frac{PN_s}{60} = 2f$	2 2	7	7

	But in ac circuits, RMS value of an alternating quantity is used for the analysis. The form factor is 1.11 of sinusoidal emf. $\therefore$ R.M.S. value of E_{ph} = Form factor × Average value $\therefore E_{ph} = 1.11 \times 4 f \phi T_{ph}$ $E_{ph} = 4.444 f \phi T_{ph}$ volts This is the general emf equation for an induced emf per phase for full pitch, concentrated type of winding. where, T_{ph} = Number of turns per phase $T_{ph} = Z_{ph}/2$ (as 2 conductors constitute 1 turn)	3		
V	$V_{ph} = \frac{415}{\sqrt{3}} = 239.6\ V$ $R_a = 0.35\ \Omega$; $X_L = 0.6\ \Omega$ Full load current, $I = \frac{20 \times 10^3}{\sqrt{3} \times 415} = 27.8A$ $\cos\phi = 0.7$; $\sin\phi = 0.71$ $E_0 = \sqrt{(V\cos\phi + IR_a)^2 + (V\sin\phi - IX_L)^2}$ $= 233\ V$	1 2 1 2 1	7	7
VI	$Z_{ph} = \frac{60 \times 6}{3} = 120$; $T_{ph} = \frac{Z_{ph}}{2} = 60$ $\beta = \frac{180^\circ}{n} = 12^\circ$; $\alpha = 12^\circ \times 2 = 24^\circ$ $K_p = \cos(\alpha/2) = 0.97$ $K_d = \frac{\sin(m\beta/2)}{m \sin(\beta/2)} = 0.95$ $E_{ph} = 4.44\, K_p K_d f \phi T_{ph}$ $= 613.7\ V$ $E_L = \sqrt{3}\, E_{ph} = 1063\ V$	2 2 2 1	7	7

VII	 1. Consider alternator-1 is supplying power to load at rated voltage and rated frequency which Means alternator-1 is already in synchronism with bus-bar, 2. Now we need to connect alternator-2 in parallel with alternator-Across the 3 switches of alternator-2 three lamps are connected as shown in the figure. 3.To match the frequency of alternator-2 with the bus-bar frequency we need to run the prime mover of alternator-2 at nearly synchronous speed which is decided by the frequency of bus-bar and number poles present in alternator-2. 4. To match the terminal voltage of alternator-2 with bus-bar voltage we need to adjust the field current of alternator-2 until terminal voltage of alternator-2 matches with the bus-bar voltage. The required value of voltage can be seen in the voltmeter connected to the bus-bar. 5. To know whether the phase sequence of alternator 2 matches with the bus-bar phase sequence we have a condition. If all the three bulbs ON and OFF concurrently then we say the phase sequence of alternator-2 matches with the phase sequence of bus-bar. If the bulbs ON and OFF one after the other then the phase sequence is mismatching. 6. To change the connections of any two leads during the mismatch of phase sequence first off the alternator and change the connections. 7.ON and OFF rate of bulbs(flickering rate) depends upon frequency difference of alternator-2 voltage and bus-bar voltage. Rate of flickering of bulbs is reduced when we match the frequency of alternator-2 with bus-bar voltage by adjusting the speed of prime mover of alternator 2. 8. If all the conditions required for synchronization are satisfied then the lamps will become dark. 9. Now close the switches of alternator-2 to synchronize with alternator-1. 10.Now the alternators are in synchronism.	Fig :3 marks 4	7	7

VIII	$R_a = 0.2\,\Omega$ $Z_s = \frac{\text{O.C voltage}}{\text{S.C current}} = \frac{420}{100} = 4.2\,\Omega$ $X_s = \sqrt{Z_s^2 - R_a^2} = 4.19\,\Omega$ $\cos\phi = 0.7$; $\sin\phi = 0.71$. Full load current, $I = \frac{50\times10^3}{500} = 100A$ $E_0 = \sqrt{(V\cos\phi + IR_a)^2 + (V\sin\phi + IX_s)^2}$ $= 853.38\ V$ % Voltage Regulation $= \frac{E_0 - V}{V} \times 100$ $= 70.67\ \%$	2 2 2 1	7	7
IX	OC test diagram OC Characteristics SC test diagram SC Characteristics	2 2 2 1	7	7
X	 1. By suitable tests plot OCC and SCC 2. Draw tangent to OCC (air gap line) 3. Conduct ZPF test at full load for ratedvoltage and fix the point B. 4. Draw the line BH with length equal to field current required to produce full loadcurrent at short circuit. 5. Draw HD parallel to the air gap line so asto touch the OCC. 6. Draw DE parallel to voltage axis. Now, DE represents	Fig:3 marks 4	7	7

	voltage drop IX_L and BE represents the field current required toovercome the effect of armature reaction. ***Triangle BDE is called Potier triangle and X_L is the Potier reactance*** 7. Find E from V, IX_L and Φ. Consider R_a also if required. The expression to use is $E = \sqrt{(V\cos\Phi + IR_a)^2 + (V\sin\Phi + IX_L)^2}$ 8. Find field current corresponding to E. 9. Draw FG with magnitude equal to BE at angle (90+Ψ) from field current axis, where Ψ is the phase angle of currentfrom voltage vector E (internal phase angle). 10. The resultant field current is given byOG. Mark this length on field current axis. 11. From OCC find the corresponding E_0. 12. Then % Voltage regulation = $\frac{E_0 - V}{V}$ * 100 .			
XI	1. **Starting Torque:** Torque produced at the time of starting of synchronous motor is called starting torque. It is also called as breakaway torque. The starting torque of the synchronous motor is purely depending on the method of starting the motor. 2. **Running Torque:** Torque produced at running condition of motor is called running torque or load torque. Otherwise, the full load torque of the motor is called running torque. The running torque is defending on the motor specifications. 3. **Pull in Torque:** A synchronous motor is started as induction motor during starting condition and its speed is 2 - 5% below the synchronous speed. When the excitation to the field winding is applied, the rotor is pulled into synchronism. It results in rotation of rotor in same speed equal to synchronous speed. The amount of torque required for synchronous motor to pull into synchronism is called pull in torque. 4. **Pull Out Torque**: It is the maximum torque which the synchronous motor can develop without pulling out of synchronism.	2 2 2 1	7	7

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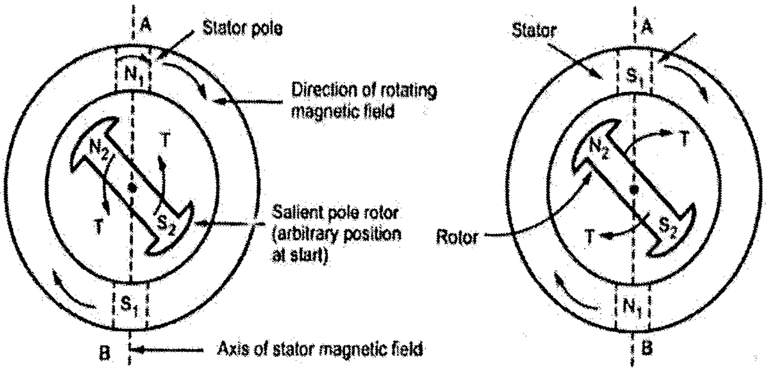
<td>

Explanation</td>
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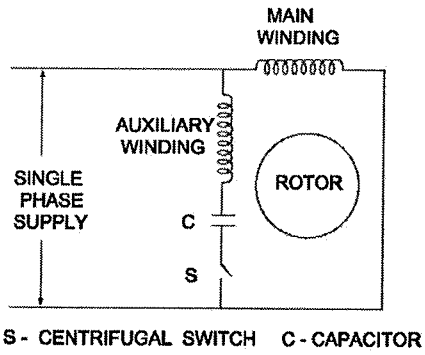
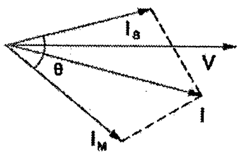
<td>



Explanation</td>
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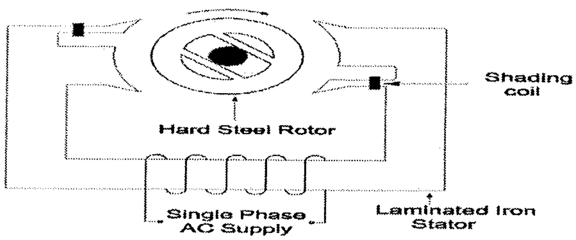
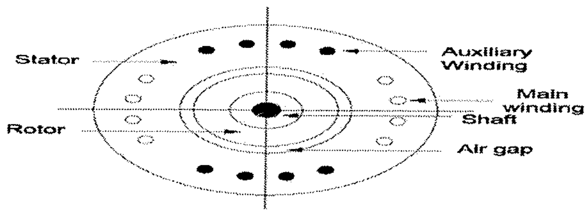
<td>



Explanation</td>
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