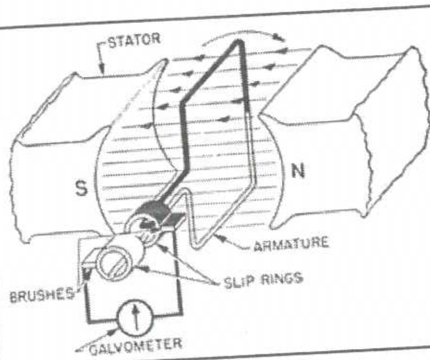
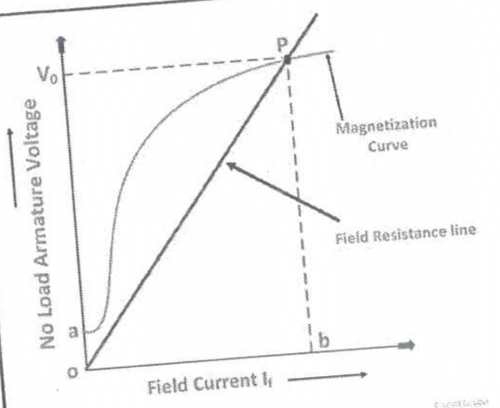
Scoring Indicators

COURSE NAME :

COURSE CODE : **QID :**

Q No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			**9**
I. 1	Collect the current from the commutator		1	
I. 2	Fleming's right hand rule		1	
I. 3	• Compensation winding • Interpoles	½ *2	1	
I. 4	Residual Magnetism		1	
I. 5	DC series generator		1	
I. 6	Swinburne's test		1	
I. 7	Three/Four point starter		1	
I. 8	Armature resistance method flux control method	½ *2	1	
I. 9	Inversely Proportional		1	
	PART B			24
II. 1	• Magnetic frame or Yoke • Pole core and pole shoes • Pole coils • Armature core (any six) • Armature windings • Comutator • Brushes and bearings	½ *6	3	
II. 2	An electrical generator is a machine which converts mechanical energy into electrical energy .The energy conversion is based on the principle of the production of dynamically induced e.m.f.whenever a conductor cuts magnetic flux, dynamically induced e.m.f. is produced in it according to Faraday's Laws of Electromagnetic Induction. This e.m.f. causes a current to flow if the conductor circuit is closed. Hence, two basic *essential parts of an electrical dc generator are (i) a magnetic field and (ii) a conductor or conductors* which can so move as to cut the flux.	1 2	3	

<table>
<tr><td></td><td>
</td><td></td><td></td><td></td></tr>
<tr><td>II. 3</td><td>Generated voltage E= 240 V
Number of conductors Z = 792
Speed N = 750
Number of poles P = 4
for wave winding , A =2
$E = \frac{N\phi Z}{60} \times \frac{P}{A}$
$240 = \frac{\phi \times 792 \times 750}{60} \times \frac{4}{2}$
$\phi = 0.0121\, Wb$</td><td></td><td>3</td><td></td></tr>
<tr><td>II. 4</td><td><table>
<tr><th>Lap Winding</th><th>Wave Winding</th></tr>
<tr><td>The numbers of the parallel path are equal to the total number of poles.</td><td>The number of parallel paths is equal to two.</td></tr>
<tr><td>Another name of lap winding is multiple winding otherwise Parallel Winding</td><td>Another name of wave winding is Series Winding otherwise Two-circuit</td></tr>
<tr><td>The e.m.f of lap winding is Less</td><td>The e.m.f of wave winding is More</td></tr>
<tr><td>The efficiency of the lap winding is Less</td><td>The efficiency of the wave winding is High</td></tr>
<tr><td>The winding cost of the lap winding is High</td><td>The winding cost of the wave winding is Low</td></tr>
<tr><td>The lap winding used for high current, low voltage machines.</td><td>The applications of wave winding include low current and high voltage machines.</td></tr>
</table></td><td>1*3</td><td>3</td><td></td></tr>
</table>

II. 5	 OCC plotted when the machine work with no load. The generator is run at its normal speed. The field current (If) is increased gradually from zero and the corresponding values of generated EMF at no-load (E0) is noted. and the shape obtained	2 1	3	
II. 6	If the speed of the dc machine is reduced to a value such that the field resistance line does not pass through the O.C.C then the machine fails to induce i.e., it may not generate any appreciable voltage. The speed at which the generator fails to build up the voltage is known as the critical speed. Below this speed, the field resistance line does not cut the O.C.C. Hence fails to build up the voltage. Therefore the machine should not be operated below the critical speed as it fails to induce. Hence, it should always be operated above the critical speed.	1.5 1.5	3	
II. 7	1. Continuity of service 2. High Efficiency 3. Maintenance and repair is easy 4. Increasing plant capacity 5. Non-availability of a single large unit	1*3	3	
II. 8	Amture torque is given by $T_a = 9.55 \times \frac{E_b I_a}{N}$ speed N = 800r.p.m. Armature current $I_a = 40\ A$ Back emf $E_b = V - I_a(R_a + R_{se})$ E_b = 220- 40(0.2+0.1) = 208 V Armature torque $T_a = 9.55 \times 208 \times 40/800$= 99.3 N-M	1 1 1	3	
II.9	DC Shunt Motor: • Instant speed applications • Centrifugal pump • Lathes • Blowers	1	3	

<table>
<tr><td></td><td>DC series motor
• For traction work
• trolley
• cranes
• Electric locomotives
Compound motor
• Elevators
• conveyers
• Heavy planners</td><td>1

1</td><td></td><td></td></tr>
<tr><td>II. 10</td><td>Regenerative Braking

It is a form of braking in which the kinetic energy of the motor is returned to the power supply system. This type of braking is possible when the driven load forces the motor to run at a speed higher than its no-load speed with a constant excitation.

The motor back emf Eb is greater than the supply voltage V, which reverses the direction of the motor armature current. The motor begins to operate as an electric generator.

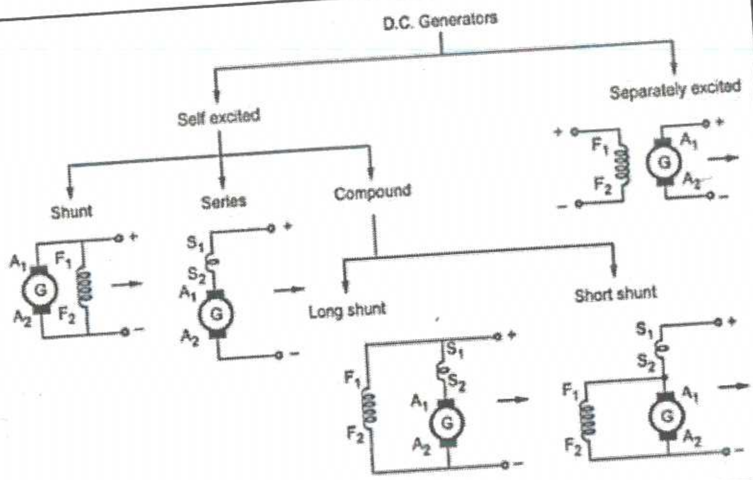
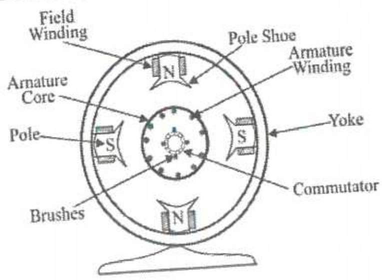
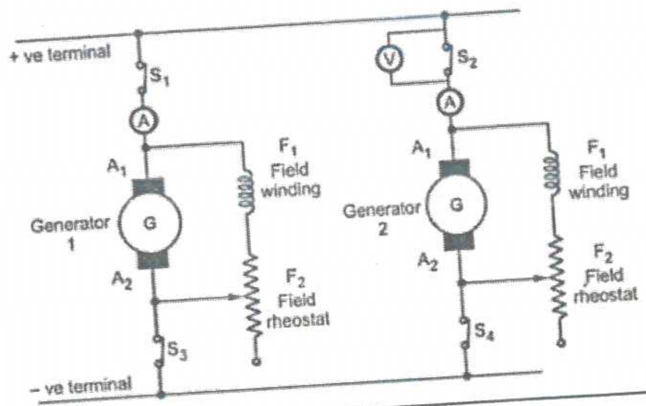
It is very interesting to note that regenerative braking cannot be used to stop a motor but to control its speed above the no-load speed of the motor driving the descending loads.</td><td></td><td>3</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>42</td></tr>
<tr><td></td><td>PART C</td><td></td><td>7</td><td>7</td></tr>
<tr><td>III. 1</td><td>
</td><td>Classification (3)

Diagram (4)</td><td></td><td></td></tr>
<tr><td>III. 2</td><td>

Yoke</td><td>4</td><td>7</td><td>7</td></tr>
</table>

	indicated by voltmeter V2 (iii) Now the generator 2 is ready to be **paralleled with generator** 1. The main switch S is closed, thus putting generator 2 in **parallel with generator** 1. Note that generator 2 is not supplying any load because it's generated e.m.f. is equal to bus-bars voltage. The generator is said to be "floating" (i.e., not supplying any load) on the bus-bars. (iv) If **generator** 2 is to deliver any current, then it's generated voltage E should be greater than the bus-bars voltage V. In that case, the current supplied by it is I = (E − V)/Ra, the generator 2 can be made to supply the proper amount of load. (v) The load may be shifted from one shunt generator to another merely by adjusting the field excitation. Thus if **generator** 1 is to be shut down, the whole load can be shifted onto generator 2 provided it has the capacity to supply that load. 	3	7	7
III. 5	V= applied voltage E_b = Back emf I_a = Armature current Then the applied voltage V= $E_b + I_a R_a$ When multiplied with current , equation becomes $VI_a = E_b I_a + I_a^2 R_a$ Condition for Maximum Mechanical Power The mechanical power developed by the motor is given by, $P_m = E_b I_a$ $P_m = VI_a - I_a^2 R_a$ Since, the V and Ra are constant for a given machine, hence the mechanical power developed by the motor depends upon the armature current.The condition for maximum power is given by,			

The outer frame of a DC generator is a hollow cylinder made up of cast steel or rolled steel is known as yoke. The yoke serves following two purposes

- It supports the field pole core and acts as a protecting cover to the machine.
- It provides a path for the magnetic flux produced by the field winding.

Magnetic Field System

3

The magnetic field system of a DC generator is the stationary part of the machine. It produces the main magnetic flux in the generator. It consists of an even number of pole cores bolted to the yoke and field winding wound around the pole core. The field system of DC generator has salient poles

- It provides support to the field coils.
- It reduces the reluctance of magnetic circuit by increasing the cross-sectional area of it.

Armature Core

The armature core of DC generator is mounted on the shaft and rotates between the field poles. It has slots on its outer surface and the armature conductors are put in these slots. The armature core is a made up of soft iron laminations which are insulated from each other and tightly clamped together. In small machines, the laminations are keyed directly to the shaft, whereas in large machines, they are mounted on a spider. The laminated armature core is used to reduce the eddy current loss.

Armature Winding

The insulated conductors are put into the slots of the armature core. The conductors are suitably connected. This connected arrangement of conductors is known as armature winding. There are two types of armature windings are used – wave winding and lap winding.

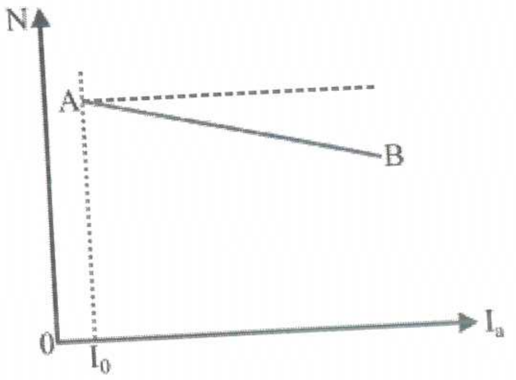
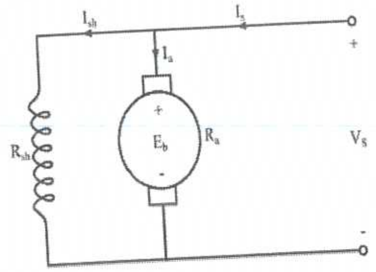
Commutator

A commutator is a mechanical rectifier which converts the alternating emf generated in the armature winding into the direct voltage across the load terminals. The commutator is made of wedge-shaped copper segments insulated from each other and from the shaft by mica sheets. Each segment of commutator is connected to the ends of the armature coils.

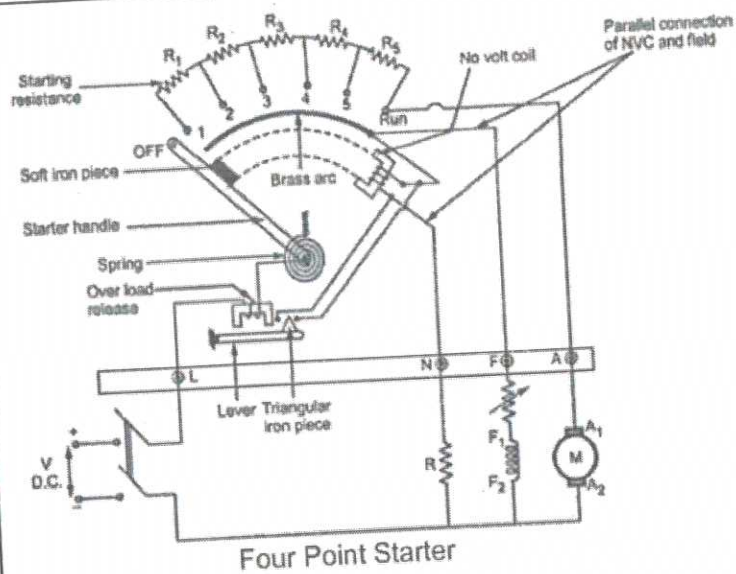
Brushes

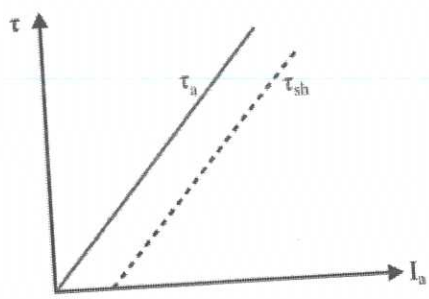
The brushes are mounted on the commutator and are used to collect the current from the armature winding. The brushes are made of carbon and is supported by a metal box called brush holder. The pressure exerted by the brushes on the commutator is adjusted and maintained at constant value by means of springs. The current flows from the armature winding to the external circuit through the commutator and carbon brushes.

III. 3	There are three main methods of improving commutation. These are 1. Resistance commutation 2. E.M.F. commutation 3. Compensating windings	1	7	7
	Resistance Commutation In this method of commutation we use high electrical resistance brushes for getting spark less commutation. This can be obtained by replacing low resistance copper brushes with high resistance carbon brushes. When high resistance brushes are used, then as the brush moves towards the commutator segments, the contact area of the brush and the segment b decreases and contact area with the segment a increases. Now, as the electrical resistance is inversely proportional to the contact area of then resistance will increase and the resistance of the new coil will decrease as the brush moves. Then the current will prefer the 2nd path to reach to the brush.	3		
	E.M.F. Commutation The main reason of the delay of the current reversing time in the short circuit coil during commutation period is the inductive property of the coil. In this type of commutation, the reactance voltage produced by the coil due to its inductive property, is neutralized by producing a reversing emf in the short circuit coil during commutation period. Reactance Voltage: The voltage rise in the short circuit coil due to inductive property of the coil, which opposes the current reversal in it during the commutation period, is called the reactance voltage.	3		
III. 4	The generators in a power plant are **connected in parallel through bus-bars**. The bus-bars are heavy thick copper bars and they act as +ve and -ve terminals.The positive terminals of the **generators** are connected to the +ve side of bus-bars and negative terminals to the negative side of bus-bars. When the load on the power plant increases beyond the capacity of this **generator**, the second shunt generator 2 is connected in parallel with the first to meet the increased load demand.The procedure for **paralleling generator** 2 with generator 1 is as under:		7	7
	(i) The prime mover of generator 2 is brought up to the rated speed. Now switch in the field circuit of the generator 2 is closed (ii) Next the excitation of **generator** 2 is adjusted till it generates a voltage equal to the bus-bars voltage. This is	4		

<table>
<tr>
<td></td>
<td>
</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III.7</td>
<td>The efficiency of a DC motor is defined as the ratio of output power to the input power.
Efficiency $= \frac{Outout}{Input} \times 100$
Efficiency $\eta = \frac{P_{out}}{P_{out} + losses} \times 100$
Condition for Maximum Efficiency of DC Motor
The efficiency of a DC motor is not constant but varies with the load. Consider a shunt motor drawing an armature current of Ia amperes and the back emf is Eb.


$P_m = E_b I_a$
$P_{in} = P_{in} + variable\ losses\ + fixed\ losses$
Efficiency $\eta = \frac{E_b I_a}{E_b I_a + I_a^2 R_a + W_c}$
$\eta = \frac{1}{1 + \frac{I_a R_a}{E_b} + \frac{W_c}{E_b I_a}}$
The efficiency of the motor will be maximum, if the denominator of the equation is minimum. Hence, to determine the condition for maximum efficiency, differentiating the denominator of the eqn. with respect to armature current and equating it to zero,
$\frac{R_a}{Eb} - \frac{W_c}{E_b I_a^2} = 0$
$W_c = I_a^2 R_a,\ Constant\ loss = Variable\ loss$</td>
<td></td>
<td>7</td>
<td>7</td>
</tr>
</table>

III. 8.	 Four Point Starter	4		
	A **4 point starter** protects the armature of a DC shunt motor or compound wound DC motor against the initially high starting current of the DC motor. The 4 point starter has a lot of constructional and functional similarity to a 3 point starter, but this special device has an additional point and coil in its construction . This brings about some difference in its functionality, though the basic operational characteristic remains the same. The basic difference in the circuit of a **4 point starter** as compared to 3 point starter is that the holding coil is removed from the shunt field current and is connected directly across the line with current limiting resistance in series.	3		
III. 9	V= 220 V, $R_a = 0.25\,\Omega$ $N_1 = 600rpm$ $I_{a1} = 50A$ $\phi_2 = 0.9\,\phi_1$ $E_{b1} = V - I_{a1}R_a = 220 - 50 \times 0.25$= 207.5 V As the torque remains constant $\phi_1 I_{a1} = \phi_2 I_{a2}$ $I_{a2} = \frac{\phi_1}{\phi_2} \times I_{a1}$ $= \frac{1}{0.9} \times 50$= 55.6A $E_{b2} = V - I_{a1}R_a = 220 - 56.5 \times 0.25$= 206.1 V $\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{\phi_1}{\phi_2}$ $\frac{N_2}{600} = \frac{206.1}{207.5} \times \frac{1}{0.9}$ N_2 =662 r.p.m.		7	7
III. 10	Field current I_{sh}= 250/250 = 1A $I_{a1} = 5 - 1 = 4A$ $I_{a2} = 50 - 1 = 49\,A$ $E_{b1} = V - I_aR_a = 250 - 4 \times 0.2$= 249.2 V		7	7

	$\frac{dp_m}{dI_a} = 0$ $\quad$ $V - 2I_aR_a = 0$ $I_aR_a = \frac{V}{2}$ applied it in V= $E_b + I_aR_a$ $E_b = \frac{V}{2}$ Hence, the mechanical developed by a DC motor being maximum, when the back EMF is equal to the half of the applied voltage.			
III. 6	Characteristics of DC Shunt Motor The shunt motors are the constant flux machines i.e. their magnetic flux remains constant because their field winding is directly connected across the supply voltage which is assumed to be constant. Torque and Armature Current Characteristics The armature torque in a DC motor is directly proportional to the flux and the armature current, i.e., $T_a \alpha\ \phi I_a$ In case of a shunt motor, the flux is also constant. Therefore, $T_a \alpha\ I_a$  Hence, the torque and armature current characteristics of DC shunt motor is straight line passing through the origin (see the figure). The shaft torque is less than the armature torque which is represented by the dotted line. From the characteristics, it can be seen that a very large current is required to start a heavy load. Thus, the shunt motor should not be started on heavy loads. Speed and Torque Characteristics This is the curve plotted between the speed and the torque for various armature currents. It can be seen that the speed of the shunt motor decreases as the load torque increases.	4	7	7

<table>
<tr><td></td><td>

$E_{b2} = 250 - 49 \times 0.2 = 240.2$ V

$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{\phi_1}{\phi_2}$

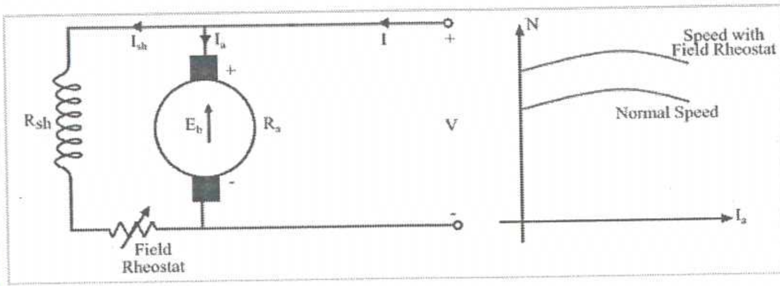
$\frac{N_2}{1000} = \frac{240.2}{249.2} \times \frac{\phi_1}{0.97\phi_1}$

N_2 =944 r.p.m.

</td><td></td><td></td><td></td></tr>
<tr><td>III. 11</td><td>

Flux Control Method

The *flux control method* is based on the principle that by varying the field flux ϕ, the speed of DC shunt motor can be changed.



$$N \propto \frac{1}{\phi}$$

In this method, a variable resistance (called *field rheostat*) is connected in series with the shunt field winding. By increasing the resistance of the field rheostat, the shunt field current Ish can be reduced and hence the field flux. Thus, by the flux control method, the speed of a DC shunt can only be increased above the normal speed.

The flux control method is frequently used for the speed control of DC shunt motors because it is simple and inexpensive method.

Advantages

The flux control method for the speed control of DC shunt motor has following advantages –

- It is a simple and convenient method.
- It is an inexpensive method as the small power loss in the field rheostat due to the small value of Ish.
- The speed control using flux control method is independent of the load on the machine.

Disadvantages

Following are the disadvantages of the flux control method –

- In flux control method, there is a limit to the maximum speed obtainable, because if the field flux is too much weakened, the commutation becomes poorer.

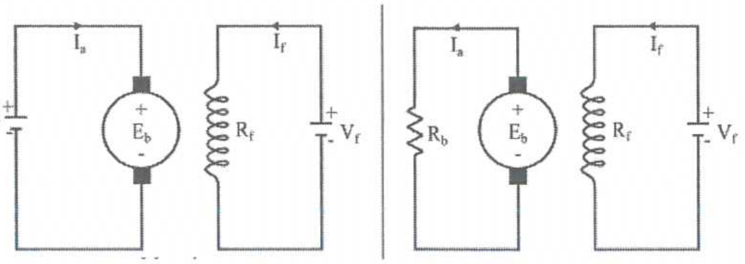
</td><td>3

2

2</td><td>7</td><td>7</td></tr>
<tr><td>III. 12</td><td>

Dynamic Braking (Rheostatic Braking)

</td><td></td><td>7</td><td>7</td></tr>
</table>

	In *dynamic breaking*, the armature of running DC motor is disconnected from the supply and is connected across a breaking resistance Rb. However, the field winding is left connected to the supply. Hence, the motor now works as a generator and producing a breaking torque. This method is also known as *rheostat breaking* since an external resistance Rb is connected across the armature for the electric breaking. During dynamic electric breaking when the motor works as a generator, the kinetic energy of moving parts of the motor is converted into electrical energy and is dissipated in the form of heat in the breaking resistance and the armature circuit resistance . As a result, the motor is brought to standstill quickly.	4		
	 Motoring Braking	3		