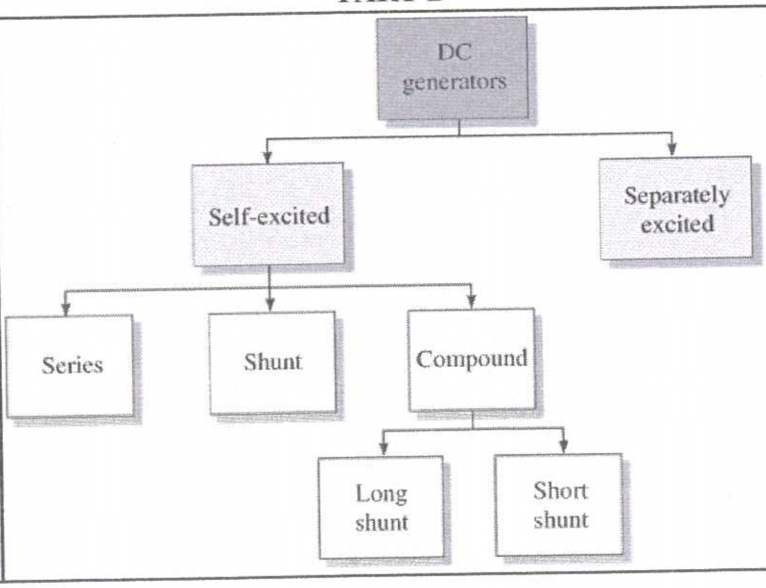
82 10/11/23

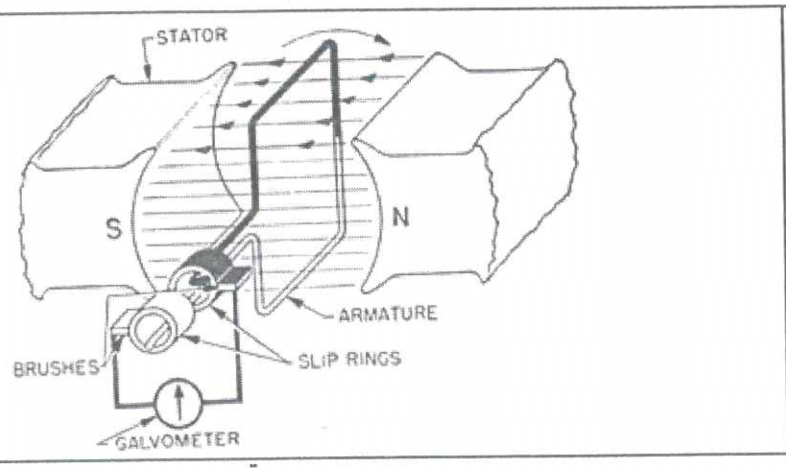
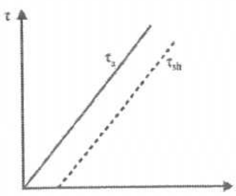
11 Nov-23

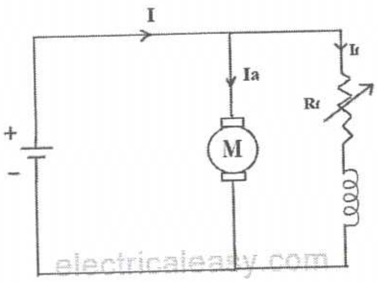
Scoring Indicators

COURSE NAME :

COURSE CODE : **QID :**

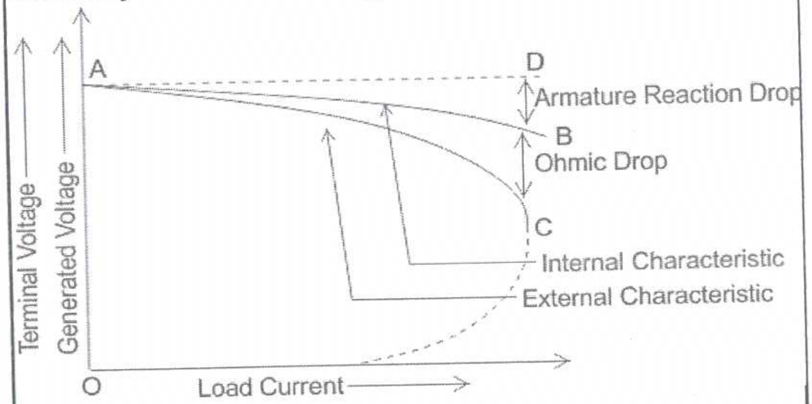
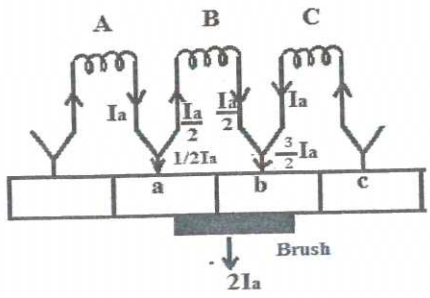
Q No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			9
I. 1	Faraday's law of electromagnetic induction		1	
I. 2	Iron loss and copper loss		1	
I. 3	Resistance Commutation (any two) EMF Commutation Compensation winding Interpoles		1	
I. 4	Cross Magnetisation and Demagnetisation		1	
I. 5	Lathes, Printing press, Centrifugal pump, Reciprocating pump,etc		1	
I. 6	Iron loss = copper loss		1	
I. 7	$N \propto \frac{E_b}{\phi} \propto \frac{V-I_aR_a}{\phi}$ Back emf, field flux, armature resistance		1	
I. 8	DC series motor		1	
I. 9	DC series motor control or Rheostat control series parallel control (any two) Metadyne control Multiple unit control		1	
	PART B			24
II. 1			3	

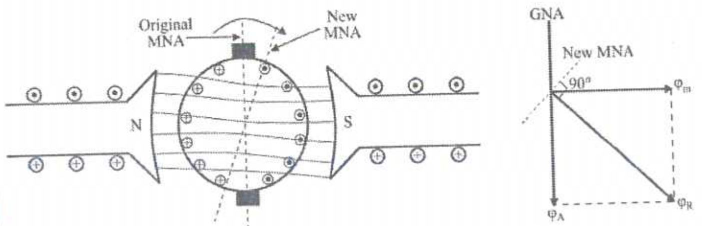
<table>
<tr><td>II. 2</td><td>
</td><td></td><td>3</td><td></td></tr>
<tr><td>II. 3</td><td>Flux cut by one conductor in one revolution of the armature,
$d\phi = P\phi$ webers
Time taken to complete one revolution,
$dt = 60/N$ second
e.m.f. generated/conductor $= \frac{d\phi}{dt} = \frac{P\phi}{60/N} = \frac{P\phi N}{60}$ volts
e.m.f. of generator, E_g = e.m.f. per parallel path
= (e.m.f./conductor) × No. of conductors in series per parallel path
$= \frac{P\phi N}{60} \times \frac{Z}{A}$
$\therefore \quad E_g = \frac{P\phi Z N}{60 A}$
where $A = 2$ ... for wave winding
$= P$ ... for lap winding</td><td></td><td>3</td><td></td></tr>
<tr><td>II. 4</td><td>Power output = 25000 W, Voltage = 500 V
Current I= 25000/500 = 50 A
Field current $I_{sh} = 500/200 = 2.5\,A$
Armature current $I_a = 50 + 2.5 = 52.5\,A$
Series field drop = 52.5× $0.04 = 2.1\,V$
Armature drop = 52.5× $0.03 = 1.575\,V$
Brush drop = $2 \times 1 = 2V$
Generated emf = 500+2.1+1.575+2 = 505.67 V</td><td></td><td>3</td><td></td></tr>
<tr><td>II. 5</td><td>Shunt Generator
• for general lighting.
• used to charge battery
• giving the excitation to the alternators
Series Generator
• field excitation in DC locomotives for regenerative braking.
• used as boosters
• series arc lightening</td><td></td><td>3</td><td></td></tr>
<tr><td>II. 6</td><td>
It is the graph plotted between the speed (N) and the armature current (Ia) of a DC motor.
In case of a shunt motor, the flux is also constant. Therefore,
$T_a \alpha I_a$
he shaft torque is less than the armature torque which is</td><td></td><td>3</td><td></td></tr>
</table>

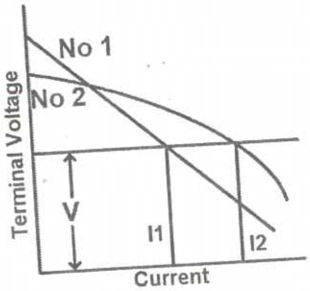
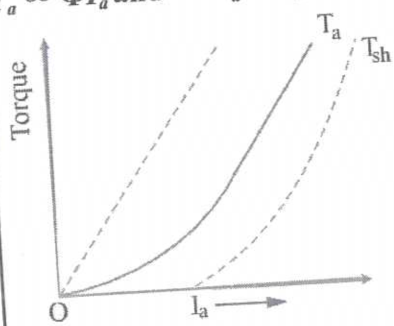
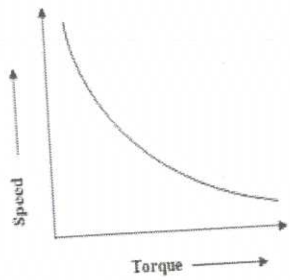
	represented by the dotted line.			
II. 7	• Only speeds below the rated value can be obtained. • Range of speeds available is limited because efficiency is reduced drastically • Speed regulation of the method is poor as for a fixed value of series armature resistance, • needs expensive arrangements • Maximum power developed is diminished		3	
II. 8	We know, $\frac{N_1}{N_2} = \frac{E_{b1}}{E_{b2}} \times \frac{\phi_2}{\phi_1}$ E_{b1}=220 − (2 × 0.4) = 219.2 V E_{b2}=220 − (50 × 0.4) = 200 V $\phi_1 = \phi_2$ $\frac{N_1}{1500} = \frac{200}{219.2}$ N_1=1368 rpm		3	
II.9	• High starting torque • Easy speed control • Can withstand with high temperature • high overload capacity (any three) • electric braking ability • Good commutation • ability to withstand voltage regulations		3	
II.10	• In this method, speed variation is accomplished by means of a variable resistance inserted in series with the shunt field. • An increase in controlling resistances reduces the field current with a reduction in flux and an increase in speed. • This method of speed control is independent of load on the motor. • Power wasted in controlling resistance is very less as field current is a small value. 		3	

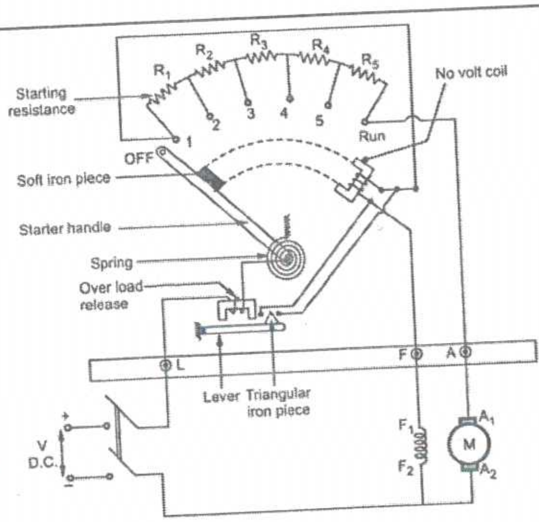
	PART C			42
III. 1	Terminal voltage = 20× 10 = 200 V Field current I_{sh} = 200/50 = 4 A Armature current I_a = 20 + 4 = 24 A resistance drop, $I_a R_a$ = 24 × 0.5 = 12 V		7	7

<table>
<tr>
<td></td>
<td>Brush drop = $2\times\ 1\ =\ 2\,V$
Generated voltage $E_g\ =\ 200\ +\ 12\ +\ 2\ =\ 214\,V$
Total power generated in armature = $214\ \times\ 24\ =\ 5136\,W$
Use full output = $200\ \times\ 20\ =\ 4000\,W$
efficiency = $\frac{Output}{Input}\ =\ 4000/5136\ =\ 0.799$
Percentage efficiency = 79.9 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III. 2</td>
<td>
<table>
<tr><th>Lap Winding</th><th>Wave Winding</th></tr>
<tr><td>The connection of the lap winding is, the armature coil end is connected to the nearby section on the commutators.</td><td>The connection of the wave winding, the armature coil end connected to commutator sections some distance apart.</td></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 no. of brushes in lap winding is Equivalent to the no. of parallel paths.</td><td>The no. of brushes in wave winding is Equivalent toTwo</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>Any 5</td>
<td>7</td>
<td>7</td>
</tr>
</table>

III. 3	The internal characteristic curve represents the relation between the generated voltage Eg and the load current IL. When the generator is loaded then the generated voltage is decreased due to armature reaction. External characteristic is showing the variation of terminal voltage with the load current. Ohmic drop due to armature resistance gives lesser terminal voltage than the generated voltage. That is why the curve lies below the internal characteristic curve. Terminal Voltage $V = E_g - I_a R_a$ load current can be increased to a certain limit with the decrease of load resistance. Beyond this point, it shows a reversal in the characteristic. Any decrease of load resistance, results in current reduction and consequently, the external characteristic curve turns back as shown in the dotted line and ultimately the terminal voltage becomes zero.	3	7	7
	 	4		
III. 4	The em.f. induced in each coil on the armature of a DC. generator alternates with a frequency corresponding to the product of the speed and the number of pairs of poles. To obtain direct currents in the external circuit we need commutator and brushes. As conductors pass out of the influence of a N-pole and enters S-pole, the current in them is reversed. This reversal of current takes place along brush axis l.e. when the brush short circuits that particular coil undergoing reversal of current through it. This process by which current in a short- circuited coil is reversed while crossing the M.N.A. is called Commutation. The period during which the col remains short-circuited is called Commutation period and is represented by T_c	3	7	7
	 	4		

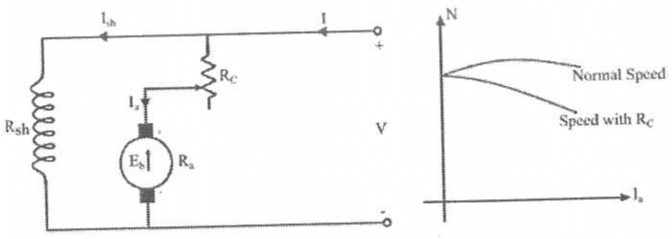
III. 5	The effect of armature flux on the main flux is known as armature reaction.This armature flux distorts and weakens the magnetic flux produced by the main poles. Consider a two pole generator on no-load. , the current in the armature conductors is zero. Under this condition, there is only the main flux (φ_m). This main flux is distributed symmetrically with respect to the polar axis Consider the case only having armature current, the direction of magnetic flux is given by cork screw rule.These conductors also produce a flux which is directed downward. Therefore, all the armature conductor produces a flux through the armature in the downward direction.  There are two fluxes inside the machine , armature flux and field flux. The main flux get distorted amd M.N.A. of the armature changes	Figure (4) Explanation (3)	7	7
III. 6	The **load sharing between shunt generators** in parallel can be easily regulated because of their drooping characteristics.The load may be shifted from one generator to another merely by adjusting the field excitation.Let us discuss the load sharing of two **generators** which have unequal no-load voltages. Let E_1, E_2 = no-load voltages of the two generators R_1, R_2 = their armature resistances V = common terminal voltage (Bus-bars voltage) then $I_1 = (E_1 - V)/R_1$ and $I_2 = (E_2 - V)/R_2$ Thus the current output of the **generators** depends upon the values of E_1 and E_2.These values may be changed by field rheostats.The common terminal voltage (or bus-bars voltage) will depend upon (i) the e.m.f.s of individual generators and (ii) the total load current supplied. It is generally desired to keep the bus bars voltage constant. This can be achieved by adjusting the field excitations of the **generators operating in parallel**.	4 3	7	7

	 			
III. 7	**Electrical Characteristic (T_a/I_a)** For a DC motor $T_a \propto \Phi I_a$. In a series motor, as field windings also carry the armature current, $\Phi \propto I_a$ up to the point of magnetic saturation. Hence, before saturation, $\boldsymbol{T_a \propto \Phi I_a}$ **and** $\boldsymbol{\therefore\ T_a \propto I_a^2}$  At light loads, I_a and hence Φ is small. But as I_a increases, T_a increases as the square of the current. Hence, T_a/I_a curve is a parabola as shown in the figure. **N/T_a Characteristic (Mechanical)**  It is clear that series motor develops high torque at low speed and vice-versa. It is because an increase in torque requires an increase in armature current, which is also the field current. The result is that flux is strengthened and hence the speed drops	4 3	7	7

III. 8		4	7	7
	To start with, the handle is in the OFF position when the supply to the DC motor is switched on. Then the handle is slowly moved against the spring force to make contact with stud No. 1. At this point, field winding of the shunt or the compound motor gets supply through the parallel path provided to start the resistance, through No Voltage Coil. While entire starting resistance comes in series with the armature. As the handle is moved further, gradually cutting off the series resistance from the armature circuit as the motor gathers speed. Finally, when the starter handle is in 'RUN' position, the entire starting resistance is eliminated, and the motor runs with normal speed. This is because back emf is developed consequently with speed to counter the supply voltage and reduce the armature current.	3		
III. 9	Significance of Back EMF in DC Motor The armature current drawn by the DC motor is given by, $I_a = \frac{V-E_b}{R_a}$ I_a - Amature current V - terminal Voltage R_a - Armature resistance E_b - Báck emf Hence, the back emf makes the DC motor a self-regulating machine i.e. it makes the motor to draw as much armature current as is needed to develop the torque required by the load. Therefore, it automatically changes the armature	3	7	7

	current to meet the load requirement as follows • When the motor is running at no-load, a small torque is required to overcome the mechanical losses. Hence, the Ia is small and back emf is nearly equal to the applied voltage. • Now, if the load is connected to the motor, it causes the armature to slow down and hence, the back emf decreases. The decreased back emf causes the larger current to flow through the armature and the large armature current means increased developed torque by the motor. Hence, the torque is increased when the motor slows down. The motor will stop slowing down when the armature current is sufficient to produce the increased torque required by the load • When the load on the motor is decreased, then the torque is momentarily more than the requirement so that the armature is accelerated. As the speed of the armature increases, the back emf also increases and causes the armature current is decrease. The motor will stop accelerating when the armature current is sufficient to develop the torque required by the load.	4		
III. 10	Iron or Core Losses The *iron losses* occur in the armature core of the DC machine since the armature core is subjected to the magnetic field reversal i.e. changing magnetic field. The core losses are of two types viz. · Hysteresis Loss · Eddy Current Loss	1	7	7
	Hysteresis Loss The armature core of DC machine is subjected to magnetic field reversal when it passes under successive poles. An energy loss takes place due to molecular friction in the material of the armature core i.e. the domains of the core material resist being turned first in one direction and then in the other. Thus, some energy is expanded in the material of the armature core in overcoming this opposition and appears in the form of heat. This loss is known as hysteresis loss. The empirical formula of hysteresis loss is, HysteresisLoss,Ph=ηBmax $^{1.6}$ maxfVWatt Where,	2		

	η = Steinmetz hysteresis co-efficient, B_{max} = Maximum flux density in the core, f = frequency of magnetic reversal, V = volume of the core. In order to reduce the hysteresis loss, the armature core is made of materials having narrower B-H curve such as silicon steel. Eddy Current Loss When the armature of DC machine rotates in the magnetic field produced by the poles, an emf is induced in the core and due to this induced emf, eddy currents are circulated in the armature core. The power loss due to these eddy currents is termed as *eddy current loss*. The eddy current loss is given by, Eddycurrentloss,Pe=KeBmax ^{2} f ^{2} t ^{2} VWattsEddycurrentloss,Pe=KeBmax2f2t2VWatts In order to reduce the eddy current loss, the armature core is built up of thin laminations which insulated from each with a coating of varnish. Copper Losses The *copper losses* in a DC machine occur in the various windings of the machine due to currents flowing in them. In a typical DC machine, following copper losses occur	2 2		
III. 11	**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 E_b 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 b) • Advantages of electric braking • Maintenance free • No replacement of brake shoe	4 3	7	7

	• Capacity of the system can be increased to heavy loads • No wasting of energy • Smooth and jerkless • Passengers are comfortable			
III. 12	The *armature resistance control method* is based on the principle that by varying the voltage available across the armature, the back EMF of the motor can be changed, which in turn changes the speed of the shunt motor. In this method, a variable resistance RC (called *controller resistance*) is inserted in series with the armature. The speed of DC shunt motor is given by, $N \propto Eb$ Also, $Eb=V-Ia(Ra+RC)$ $Eb=V-Ia(Ra+RC)$ Thus, due to the voltage drop in the controller resistance, the back EMF is decreased and hence the speed of the motor. The maximum speed that can be obtained using armature resistance control method is the speed corresponding to R_C = 0, i.e., the normal speed. Therefore, by this method only speed below the normal speed can be obtained. 	4 3	7	7