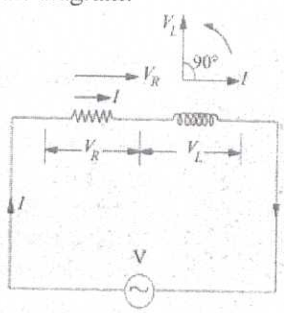
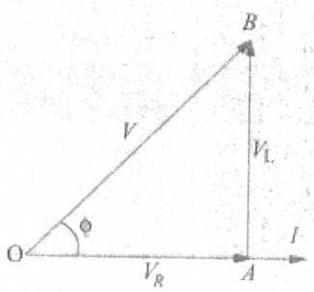
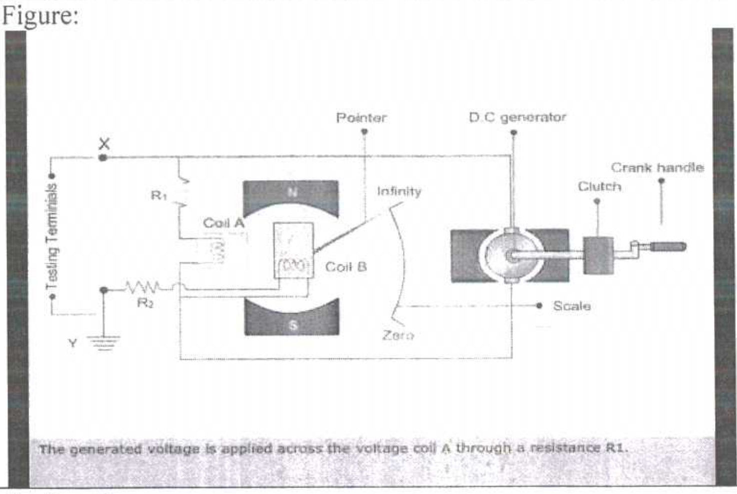
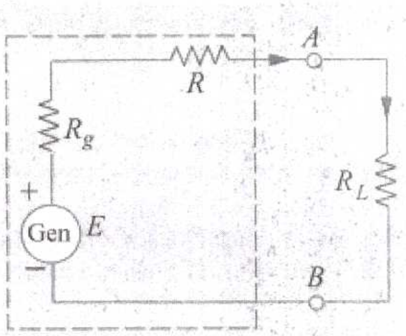
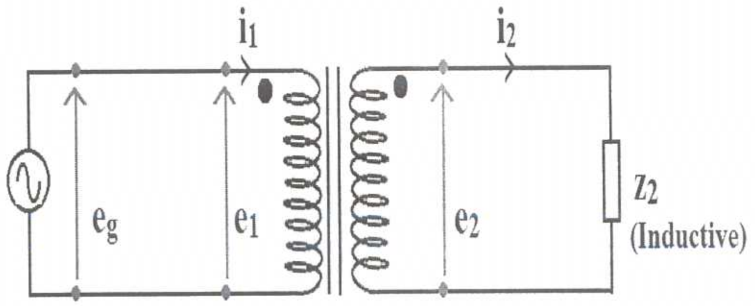
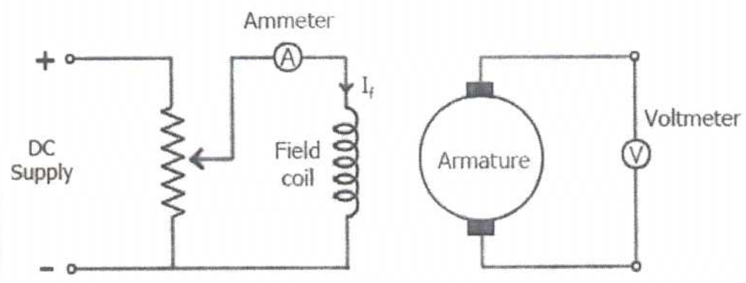
SCHEME OF VALUATION
(Scoring Indicators)

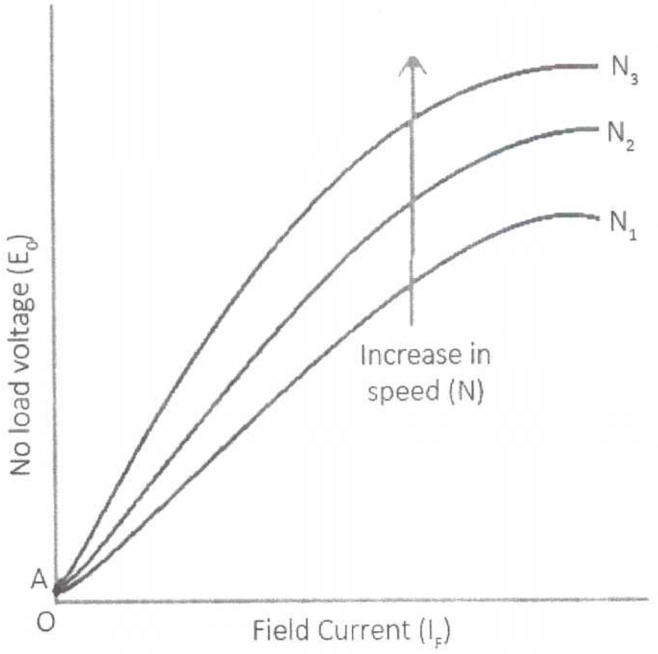
Rivision: 2015 — Course Code: 3043

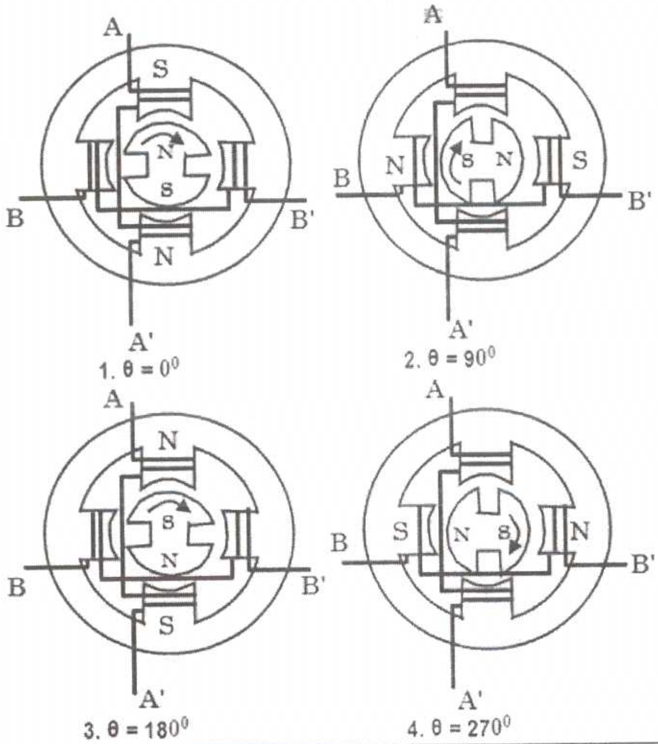
Course Title: ELECTRICAL TECHNOLOGY

Qn.No:	Scoring Indicator	Split up score	Sub total	Total
I	PART A			
1	Definition of Amplitude : Max value of a sinusoidal waveform	1	2	10
	Definition of Frequency: No: of cycles per second (Unit : Hz)	1		
2	greater length to insert earth pin first	1	2	
	greater cross-sectional area to reduce resistance (R α 1/A)	1		
3	**Superposition theorem** states that in any linear, active, bilateral network having more than one source, the response across any element is the sum of the responses obtained from each source considered separately and all other sources are replaced by their internal resistance.	2	2	
4	two comparisons Shunt Motor: 1. Field winding connected in parallel to armature 2. Low starting Torque Series Motor: 1. Field winding connected in series to armature 2. High starting Torque	2	2	
5	Synchronous speed: The speed at which the rotating magnetic field rotates is known as Synchronous speed. Synchronous speed , $N_s = 120f/P$	2	2	
II	PART B			
1	Circuit diagram:  	1	6	42
	phasor diagram:  	3		
	Derivation:	2		

	$\therefore \; V = \sqrt{(V_R^2 \quad V_L^2)} \quad \sqrt{[(IR)^2 \quad (I.X_L)^2]} \quad I\sqrt{R^2 \quad X_L^2} . \frac{V}{\sqrt{(R^2 \quad X_L^2)}} \quad I$ The quantity $\sqrt{(R^2 + X_L^2)}$ is known as the ***Impedance*** (Z) of the circuit. As seen from the impedance triangle ABC (Fig. 13.3) $Z^2 = R^2 + X_L{}^2$. *i.e.* $(\textit{Impedance})^2 = (\textit{resistance})^2 + (\textit{reactance})^2$		
2	Figure:  	3	6
	Explanation: Megger is an instrument used to measure high resistance. It has two coils. The pointer deflects with a resultant force produced by both coils. There is a hand driven generator which acts as a voltage source for the working of megger. If no external testing elements are connected, there will be current in coil A and zero current in coil B. The force dur to coil A moves the pointer to indicate infinity. If a test element is connected at XY terminal then according to the external resistance a current will also flow through coil B. Coil B produces a force opposite to the coil A. So the pointer settles at a point less than infinity which is the indication of external resistance.	3	
3	MPTT statement ***A resistive load will abstract maximum power from a network when the load resistance is equal to the resistance of the network as viewed from the output terminals, with all energy sources removed leaving behind their internal resistances.***	2	6
	Figure  	1	
	Derivation ($R_L = R_i$)	3	

	Proof. Circuit current $I = \dfrac{E}{R_L + R_i}$ Power consumed by the load is $P_L = I^2 R_L = \dfrac{E^2 R_L}{(R_L + R_i)^2}$ ...(i) For P_L to be maximum, $\dfrac{dP_L}{dR_L} = 0$. Differentiating Eq. (i) above, we have $\dfrac{dP_L}{dR_L} = E^2\left[\dfrac{1}{(R_L + R_i)^2} + R_L\left(\dfrac{-2}{(R_L + R_i)^3}\right)\right] = E^2\left[\dfrac{1}{(R_L + R_i)^2} - \dfrac{2R_L}{(R_L + R_i)^3}\right]$ $\therefore \quad 0 = E^2\left[\dfrac{1}{(R_L + R_i)^2} - \dfrac{2R_L}{(R_L + R_i)^3}\right]$ or $2R_L = R_L + R_i$ or $R_L = R_i$			
4	Ideal transformer equivalent circuit 	2	6	
	six assumptions and their explanation 1. **No Hysteresis loss.** 2. **μ (Permeability) → ∞** 3. **Bsat (Saturation Flux density) → ∞→ Core never Saturates** 4. **Resistivity of core is ∞ → Eddy current losses →0** 5. **Winding Resistance is 0 → Copper loss →0** 6. **No Leakage flux**	4		
5	OCC circuit 	2	6	
	OCC characteristics (E Vs If)	2		

	 Open Circuit Characteristic (O.C.C.)			
	Explanation Now, from the emf equation of the generator, we know that Eg = kϕ. Hence, the generated emf should be directly proportional to field flux (and hence, also directly proportional to the field current). However, even when the field current is zero, some amount of emf is generated (represented by OA in the figure below). This initially induced emf is due to the fact that there exists some residual magnetism in the field poles. Due to the residual magnetism, a small initial emf is induced in the armature. This initially induced emf aids the existing residual flux, and hence, increasing the overall field flux. This consequently increases the induced emf. Thus, O.C.C. follows a straight line. However, as the flux density increases, the poles get saturated and the ϕ becomes practically constant. Thus, even we increase the I_f further, ϕ remains constant and hence, Eg also remains constant. Hence, the O.C.C. curve looks like the B-H characteristic.	2		
6	Figure	3	6	



1. θ = 0^0 2. θ = 90^0 3. θ = 180^0 4. θ = 270^0

	Working principle of stepper motor: When the excitation is switched to B phase and switching off phase A, the rotor further adjusts to magnetic axis of phase B, and thus rotates through 90 degrees in clockwise direction. Next, if the phase A is energized with a negative current with respect to A', the formation of stator poles causes the rotor to move through another 90 degrees in clockwise direction. In the same way, if the phase B is excited with negative current by closing phase A switch, the rotor rotates through another 90 degrees in the same direction. Next, if the phase A is excited with positive current, the rotor comes to the original position thus making a 360 degrees complete revolution. This implies that, whenever the stator is excited, the rotor tends to rotate through 90 degrees in clockwise direction. The step angle of this 2-phase 2-pole permanent magnet rotor motor is expressed as, 360/ (2 × 2) = 90 degrees. The step size can be reduced by energizing two phases simultaneously or a sequence of 1-phase ON and 2-phase ON modes with a proper polarity.	3		
7	Derivation step	4	6	

EMF EQUATION OF ALTERNATOR

Let Z = No. of conductors or coil sides in series per phase
ϕ = Flux per pole in webers
P = Number of rotor poles
N = Rotor speed in r.p.m.

In one revolution (i.e., 60/N second), each stator conductor is cut by $P\phi$ webers i.e.,

$$d\phi = P\phi; \quad dt = 60/N$$

$\therefore$ Average e.m.f. induced in one stator conductor

$$= \frac{d\phi}{dt} = \frac{P\phi}{60/N} = \frac{P\phi N}{60} \text{ volts}$$

Since there are Z conductors in series per phase.

$$\therefore \text{ Average e.m.f./phase} = \frac{P\phi N}{60} \times Z$$

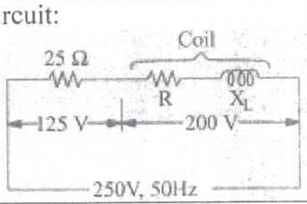
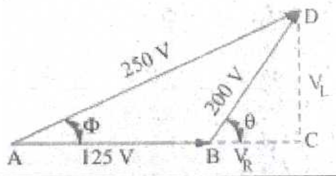
$$= \frac{P\phi Z}{60} \times \frac{120 f}{P} \qquad \left(\because N = \frac{120 f}{P}\right)$$

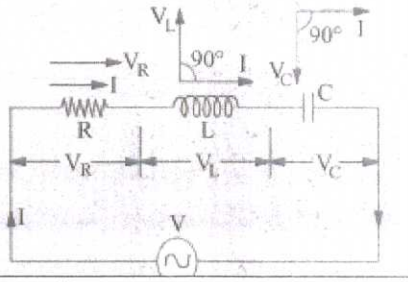
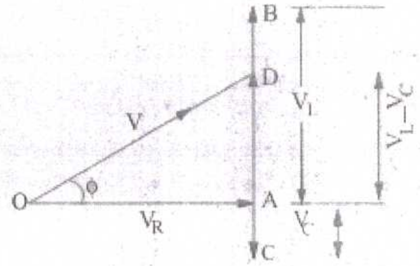
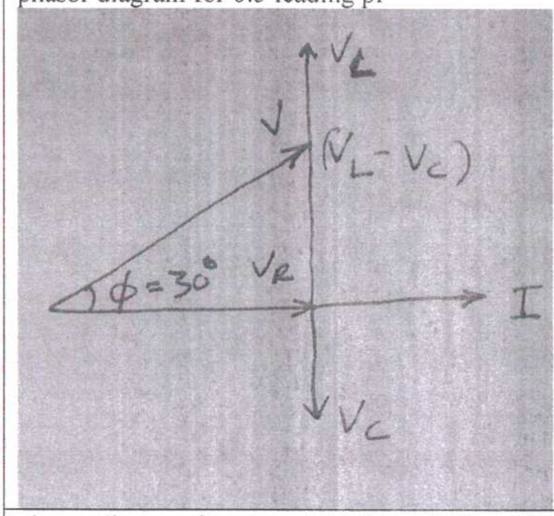
$$= 2f\phi Z \text{ volts}$$

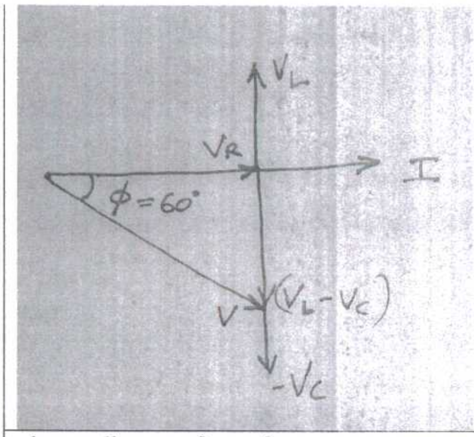
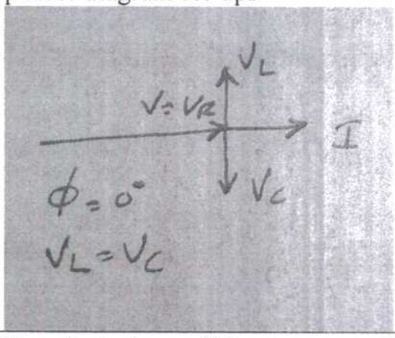
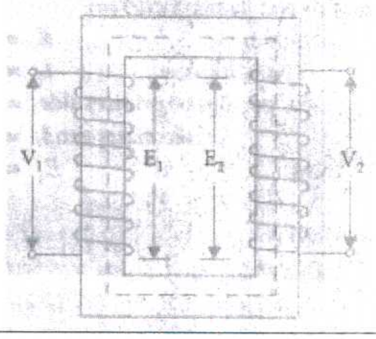
R.M.S. value of e.m.f./phase = Average value/phase x form factor

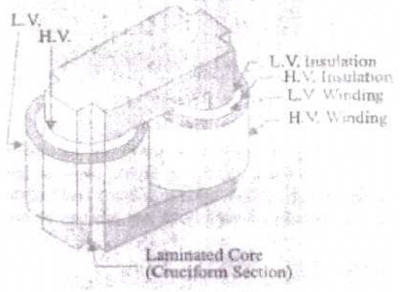
$$= 2f\phi Z \times 1.11 = 2.22 f\phi Z \text{ volts}$$

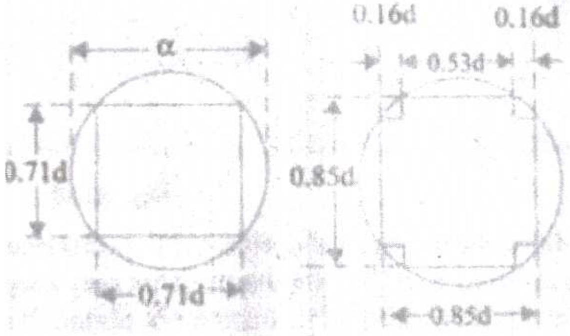
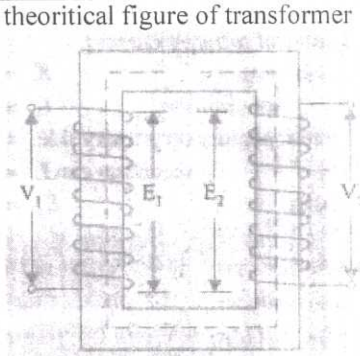
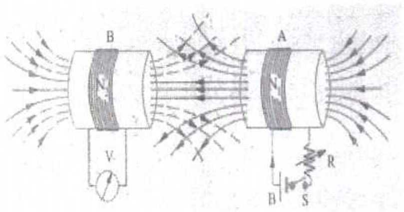
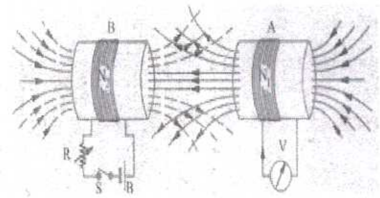
$$\therefore E_{r.m.s.}/\text{phase} = 2.22 f\phi Z \text{ volts} \qquad (1)$$

	final equation ,E= 4.44 ø f T Kp Kd Z=2T Kp – pitch factor Kd- Distribution factor	2		
	PART C			
III	Circuit: 	2	15	120
	phasor diagram: 	5		
	Impedance of coil, Zc = 200/5=40 Ω	2		
	Inductive reactance of coil, Xc= 39.62 Ω	2		
	Coil Resistance, Rc = 5.5 Ω	2		
	Active Power absorbed by coil , Pc = 137.5 W	1		
	total power Active Power , P = 762.5 W	1		
IV	Circuit diagram:	2	15	

				
	phasor diagram: 	2		
	Derivation of Impedance, Z: The applied voltage V is represented by OD and is the vector sum of OA and AD $\therefore \;\; OD = \sqrt{OA^2 \;\; AD^2}$ or $V \;\; \sqrt{(IR)^2 \;\; (IX_L \;\; IX_C)^2} \;\; I\sqrt{R^2 \;\; (X_L \;\; X_C)^2}$ or $I = \dfrac{V}{\sqrt{R^2 + (X_L - X_C)^2}} = \dfrac{V}{\sqrt{R^2 + X^2}} = \dfrac{V}{Z}$ The term $\sqrt{R^2 + (X_L - X_C)^2}$ is known as the impedance of the circuit. Obviously, $(\textit{impedance})^2 = (\textit{resistance})^2 + (\textit{net reactance})^2$	3		
	Derivation of phase angle, ø : Its phase angle is $\Phi = \tan^{-1} [X_L - X_C/R]$	2		
	phasor diagram for 0.5 leading pf 	2		
	phasor diagram for 0.866 lagging pf	2		

				
	phasor diagram for upf 	2		
V.a	Faraday's law of Electromagnetic induction : **First Law.** It states : Whenever the magnetic flux linked with a circuit changes, an e.m.f. is always induced in it. *or* Whenever a conductor cuts magnetic flux, an e.m.f. is induced in that conductor. **Second Law.** It states : The magnitude of the induced e.m.f. is equal to the rate of change of flux-linkages. **Explanation.** Suppose a coil has *N* turns and flux through it changes from an initial value of Φ_1 webers to the final value of Φ_2 webers in time *t* seconds. Then, remembering that by flux-linkages mean the product of number of turns and the flux linked with the coil, we have Initial flux linkages = $N\Phi_1$, add Final flux linkages = $N\Phi_2$ $\therefore$ induced *e.m.f.* $e = \frac{N\Phi_2 - N\Phi_1}{t}$ Wb/s or volt or $e = N\frac{\Phi_2 - \Phi_1}{t}$ volt Putting the above expression in its differential form, we get $e = \frac{d}{dt}(N\,\Phi) = N\frac{d}{dt}$ volt Usually, a minus sign is given to the right-hand side expression to signify the fact that the induced e.m.f. sets up current in such a direction that magnetic effect produced by it opposes the very cause producing it (Art. 7.5). $e = -N\frac{d\Phi}{dt}$ volt	4	8	
	theoritical figure of transformer 	2		

	Statically induced emf Induced e.m.f. can be either (*i*) **dynamically induced** or (*ii*) **statically induced.** In the first case, usually the field is stationary and conductors cut across it (as in d.c. generators). But in the second case, usually the conductors or the coil remains stationary and flux linked with it is changed by simply increasing or decreasing the current producing this flux (as in transformers).	2		
V.b	Seven comparisons Core Type: • 2 Limbs • 1 window • Windings on both limbs • Core is covered by Windings • No mechanical protection to Wdgs • More Leakage flux • Requires more copper • Requires less insulation material • Used for HV low current • Less Power transfer capability • Eg; Distribution Transformer Shell type: • 3 Limbs • 2 windows • Windings on central limb only • Windings are covered by core • Provides good mechanical protection to Wdgs • Less Leakage flux • Requires less copper • Requires more insulation material • Used for LV high current • More Power transfer capability • Eg; Transmission(Power) Transformer	7	7	
VI.a	Practical figure of core type transformer  Fig. 32.8 (a)	3	8	
	Material selection of core (CRGO) • Ferromagnetic material • High permiability (So low magnetization current) • Low hysteresis loss	1		
	Material selection of Winding (Copper or Aluminium) • Annealed Cu for Power T/f (η = 99%) • Annealed Al for Distribution T/f (η = 95%) • Annealing ➔ heat treatment➔ reduce brittleness	1		

	Core stepping  ***Advantages*** 1. ***Amount of insulation reduced*** 2. ***Length per turn decreased*** 3. ***Amount of copper less*** 4. ***More volume of core in same space*** 5. ***Size, weight & cost of t/f reduces***	3	
	theoritical figure of transformer 	2	
VI.b	Mutually induced emf **7.8. Statically Induced E.M.F.** It can be further sub-divided into (*a*) ***mutually induced e.m.f.*** **and** (*b*) ***self-induced e.m.f.*** (*a*) **Mutually-induced e.m.f.** Consider two coils *A* and *B* lying close to each other (Fig. 7.9).  **Fig. 7.9** Coil *A* is joined to a battery, a switch and a variable resistance *R* whereas coil *B* is connected to a sensitive voltmeter *V*. When current through *A* is established by closing the switch, its magnetic field is set up which partly links with or threads through the coil *B*. As current through *A* is changed, the flux linked with *B* is also changed. Hence, mutually induced e.m.f. is produced in *B* whose magnitude is given by Faraday's Laws (Art. 7.3) and direction by Lenz's Law (Art. 7.5).  **Fig. 7.10** If, now, battery is connected to *B* and the voltmeter across *A* (Fig. 7.10), then the situation is reversed and now a change of current in *B* will produce mutually-induced e.m.f. in *A*. It is obvious that in the examples considered above, there is no movement of any conductor, the flux variations being brought about by variations in current strength only. Such an **e.m.f.** induced in one coil by the influence of the other coil is called (statically but) mutually induced e.m.f.	2	7

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Mutually induced emf Derivation, E = 4.44 ø f T

32.6. E.M.F. Equation of a Transformer

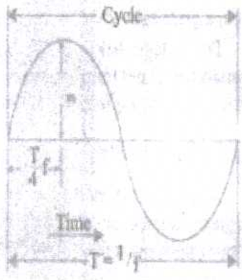

Fig. 32.14

Let N_1 = No. of turns in primary
N_2 = No. of turns in secondary
Φ_m = Maximum flux in core in webers
= $B_m \times A$
f = Frequency of a.c. input in Hz

As shown in Fig. 32.14, flux increases from its *zero* value to maximum value Φ_m in one quarter of the cycle *i.e.* in 1/4 f second.

∴ Average rate of change of flux = $\frac{\Phi_m}{1/4f}$
= $4f\Phi_m$ Wb/s or volt

Now, rate of change of flux per turn means induced e.m.f. in volts.

∴ Average e.m.f./turn = $4f\Phi_m$ volt

If flux Φ varies *sinusoidally*, then r.m.s. value of induced e.m.f. is obtained by multiplying the average value with form factor.

Form factor = $\frac{\text{r.m.s. value}}{\text{average value}} = 1.11$

∴ r.m.s. value of e.m.f./turn = $1.11 \times 4f\Phi_m = 4.44 f\Phi_m$ volt

Now, r.m.s. value of the induced e.m.f. in the whole of primary winding
= (induced e.m.f./turn) × No. of primary turns

$E_1 = 4.44 f N_1 \Phi_m = 4.44 f N_1 B_m A$ ...(i)
</td>
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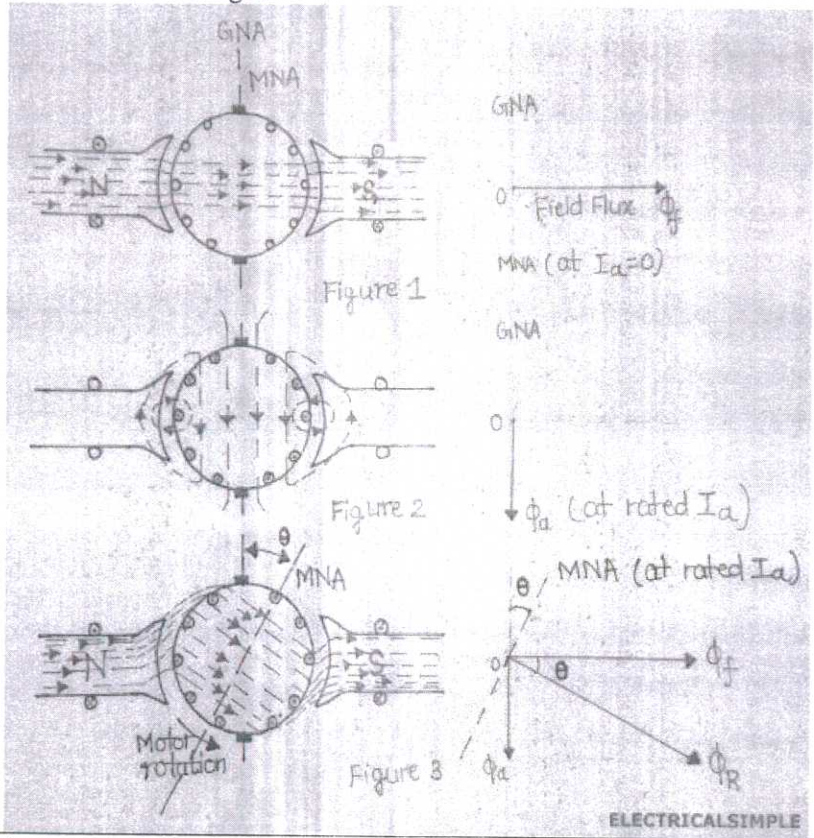
<tr>
<td>VII.a</td>
<td>
Armature reaction figure



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<td>3</td>
<td>7</td>
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Armature reaction definition & explanation:
Armature reaction is the effect of armature flux on main field flux. In other words, the armature reaction represents the impact of the armature flux on the main field flux. The armature field is produced by the armature conductors
</td>
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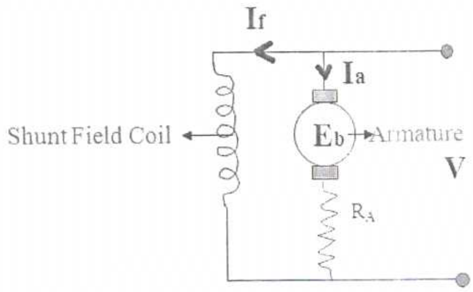
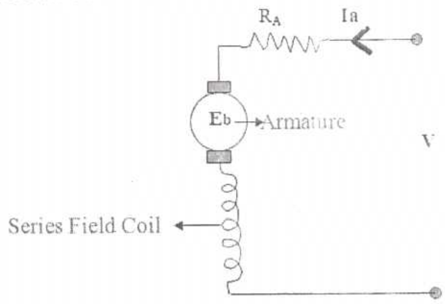
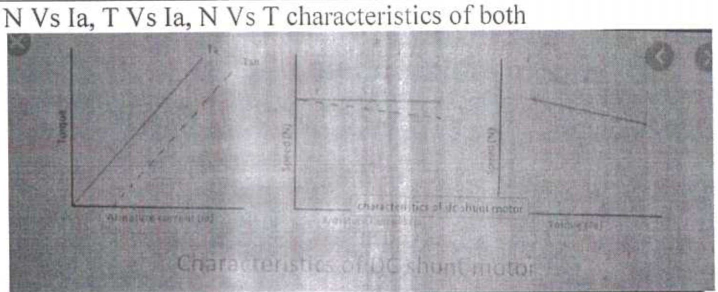
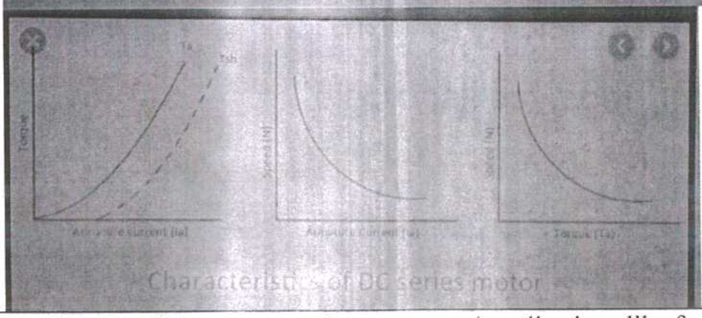
</table>

	when current flows through them. And the main field is produced by the magnetic poles.			
	Cross magnetization & Demagnetization: Because of the armature reaction the flux density of over one-half of the pole increases and over the other half decreases. The total flux produces by each pole is slightly less due to which the magnitude of the terminal voltage reduces. The effect due to which the armature reaction reduces the total flux is known as the demagnetising effect. 2. The resultant flux is distorted due to CROSS – MAGNETIZATION effect. The direction of the magnetic neutral axis is shifted with the direction of resultant flux in case of the generator, and it is opposite to the direction of the resultant flux in case of the motor.	2		
VII.b	Circuit of DC shunt  Circuit of DC series motor  	2	8	
	N Vs Ia, T Vs Ia, N Vs T characteristics of both   	4		
	Application of shunt motor: Constant speed applications like fan, blower, pump	2		

<table>
<tr><td></td><td>etc
Application of series Motor: High starting torque applications like Electric traction, Electric vehicles, crane, lift etc</td><td></td><td></td></tr>
<tr><td>VIII.a</td><td>theoritical figure with split ring and formation of DC signal

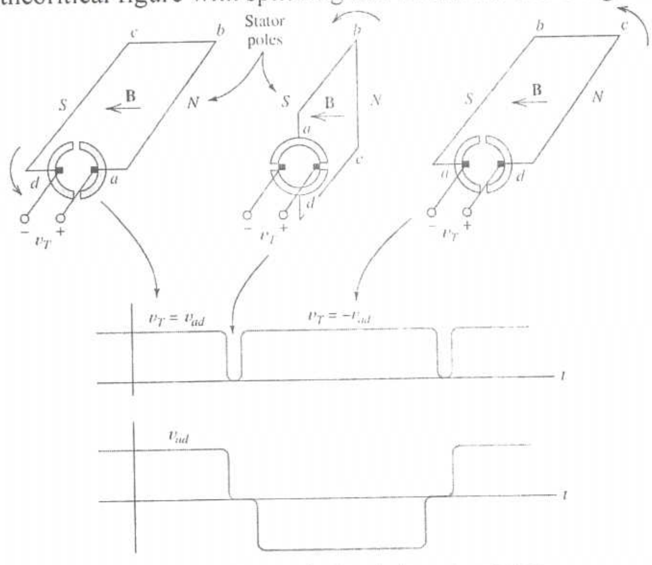
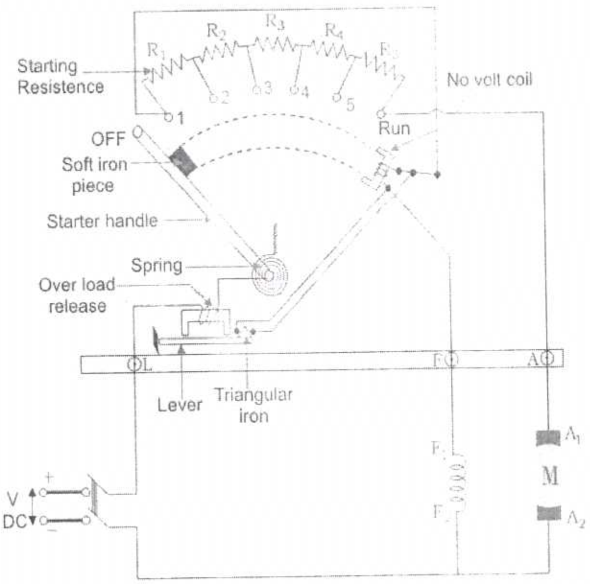
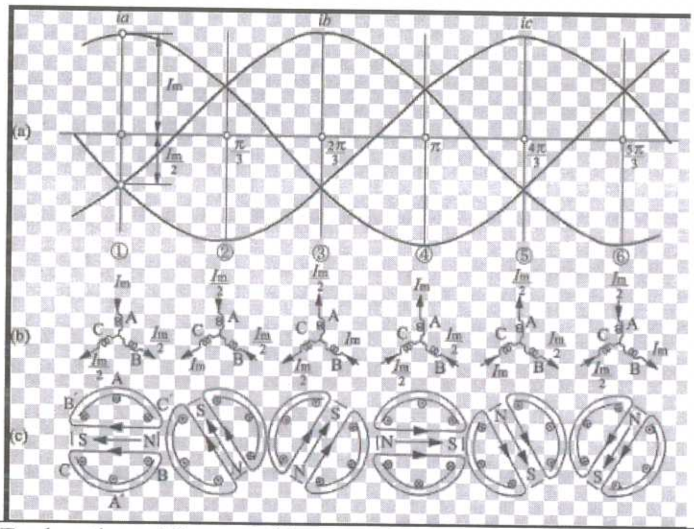
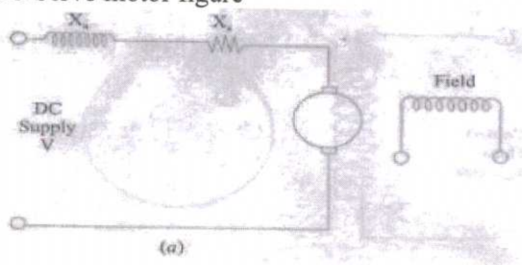
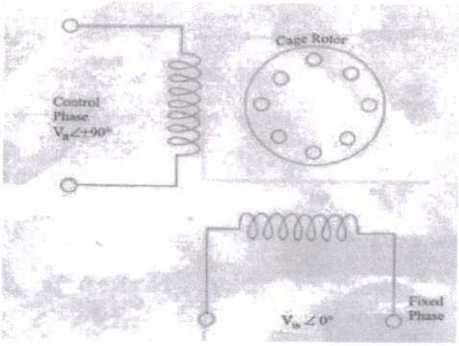


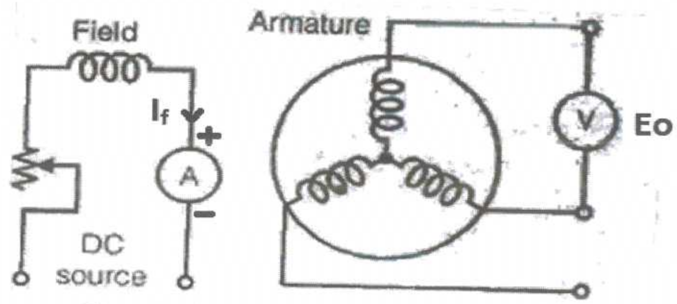
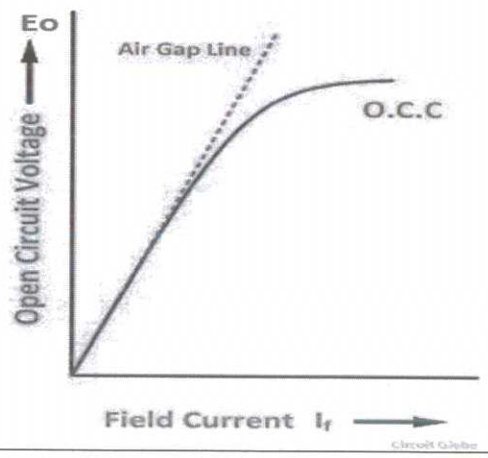
Figure 16.12 Commutation for a single armature winding.</td><td>4</td><td>7</td></tr>
<tr><td></td><td>Explanation of the figure</td><td>3</td><td></td></tr>
<tr><td>VIII.b</td><td>Three point starter figure

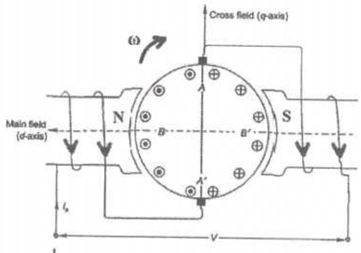


Three Point Starter</td><td>3</td><td>8</td></tr>
<tr><td></td><td>Working
To start with the handle is in the OFF position when the supply to DC motor is switched on. Then handle is slowly moved against the spring force to make contact with stud No. 1. At this point, field winding of the shunt or the compound motor gets supply through the parallel path provided to starting the resistance, through No Voltage Coil. While entire starting resistance comes in series with the armature. The high starting armature current thus gets limited as the current equation at this stage becomes:
Ia= (V-Eb)/(Ra+Rst) during starting N=0; Eb=0</td><td>2</td><td></td></tr>
</table>

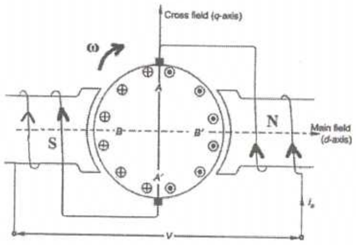
	after reaching full speed Rst=0 As the handle is moved further, it goes on making contact with studs 2, 3, 4, etc., thus gradually cutting off the series resistance from the armature circuit as the motor gathers speed. Finally, when the starter handle is in 'RUN' position, the entire starting resistance 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. So the external electrical resistance is not required anymore and is removed for optimum operation. The handle is moved manually from OFF to the RUN position with the development of speed. Now the obvious question is once the handle is taken to the RUN position how it is supposed to stay there, as long as the motor is running.				
	No voltage coil The supply to the field winding is derived through no voltage coil. So when field current flows, the NVC is magnetized. Now when the handle is in the 'RUN' position, a soft iron piece is connected to the handle and gets attracted by the magnetic force produced by NVC, because of flow of current through it. The NVC is designed in such a way that it holds the handle in 'RUN' position against the force of the spring as long as supply is given to the motor. Thus NVC holds the handle in the 'RUN' position and hence also called **hold on coil**. Now when there is any kind of supply failure, the current flow through NVC is affected and it immediately loses its magnetic property and is unable to keep the soft iron piece on the handle, attracted. At this point under the action of the spring force, the handle comes back to OFF position, opening the circuit and thus switching off the motor. So due to the combination of NVC and the spring, the starter handle always comes back to OFF position whenever there is any supply problem.	2			
	Over load release When the motor draws over current (due to over load) the OLR coil attracts the soft iron there by shorting the NVC. So the handle comes back to OFF position there by turning off the motor. Thus it also acts as a protective device safeguarding the motor from any kind of abnormality.	1			
IX.a	necessary condition for RMF 1. three windings arranged in space with a mutual displacement of 120^0 2. three currents should flow through the above windings such that the currents are displaced 120^0 with respect to time.	1	8		
	Pole formation figure and its rotation with 3-phase supply	4			

				
	Explanation of figure and how rotating magnetic field is produced by using above two conditions.	3		
IX.b	DC Servo motor figure  AC servo motor 	3	7	
	Working A **servo motor** is an electrical device which can push or rotate an object with great precision. Servo motors are used to rotate an object at some specific angles or distance. It is just made up of simple motor which run through **servo mechanism**. If motor is used is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor. We can get a very high torque servo motor in a small and light weight packages. Due to these features they are being used in many applications like toy car, RC helicopters and planes, Robotics, Machine etc. In DC servo (permanent magnet DC) motor the angle of rotation is controlled by the duration of the voltage applied and speed is controlled by the magnitude of applied voltage. A two phase AC squirrel cage induction motor is used as AC servo motor. Here the angle of rotation is controlled by the voltages in two coils.	3		

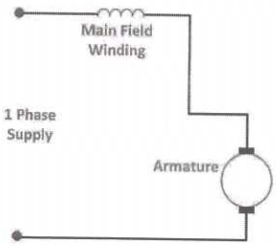
	Application : Due to these features they are being used in many applications like toy car, RC helicopters and planes, Robotics, Machine etc.	1	
X.a	 Circuit diagram for obtaining OCC	2	8
		2	
	Explanation: With the armature terminals open, Ia=0, so Eo = terminal voltage,It is thus possible to construct a plot of Eo vs If graph. This plot is called open-circuit characteristic (OCC) of a generator. With this characteristic, it is possible to find the internal generated voltage of the generator for any given field current. Initially OCC follows a straight-line relation with the field current as long as the magnetic circuit of the synchronous generator does not saturate. This straight line is appropriately called the ***air-gap line***. Practically due to saturation induced emf bend from the straight line.	4	
X.b	Universal motor figure	3	

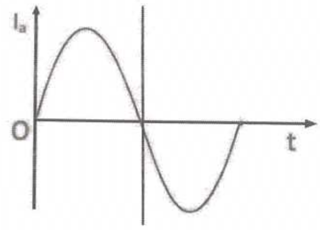


+ +ve half cycle of AC −



− -ve half cycle of AC +





7

Working

A universal motor works on either DC or single phase AC supply. When the universal motor is fed with a DC supply, it works as a DC series motor. When current flows in the field winding, it produces an electromagnetic field. The same current also flows from the armature conductors. When a current carrying conductor is placed in an electromagnetic field, it experiences a mechanical force. Due to this mechanical force, or torque, the rotor starts to rotate. The direction of this force is given by Flemming's left hand rule. When fed with AC supply, it still produces unidirectional torque. Because, armature winding and field winding are connected in series, they are in same phase. Hence, as polarity of AC changes periodically, the direction of current in armature and field winding reverses at the same time. Thus, direction of magnetic field and the direction of armature current reverses in such a way that the direction of force experienced by armature conductors remains same. Thus, regardless of AC or DC supply, universal motor works on the same principle that DC series motor works.

3

Application

- in various home appliances like vacuum cleaners, drink and food mixers, domestic sewing machine etc.
- The higher rating universal motors are used in portable drills, blenders etc.

1

CODE : 3043

COURSE : ELECTRICAL TECHNOLOGY **VERSION:2015**

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Sl.No	Module	Type of Question							
		Part A		Part B		Part C		Total	
		No. of Questions	Score	No. of Questions	Score	No. of Questions	Score	No. of Questions	Score
1	I	2	4	2	12	2	30	6	46
2	II	1	2	2	12	2	30	5	44
3	III	1	2	1	6	2	30	4	38
4	IV	1	2	2	12	2	30	5	44
Total		5	10	7	42	8	120	20	172

<u>**QUESTION WISE ANALYAIS**</u>

COURSE: ELECTRICAL TECHNOLOGY (3043)

VERSION: 2015

Qn No:	Specific outcome (*as per syllabus*)	Module	Content Details	Score	Time in minutes
I	PART A				
1	1.1.3	I	define frequency, amplitude etc	2	5
2	1.2.1	I	necessity of earthing of equipment	2	5
53	2.1.2	II	Superposition theorem	2	5
4	3.2.1	III	types of DC motors	2	5
5	4.1.3	IV	Synchronous speed	2	5
II	PART B				
1	1.1.6	I	To illustrate series AC circuits	6	10
2	1.2.2	I	test insulation resistance with megger	6	10
3	2.1.2	II	Maximum power transfer theorem	6	10
4	2.2.3	II	Ideal transformer	6	10
5	3.1.6	III	No load Characteristics	6	10
6	4.2.2	IV	working principle of stepper motor	6	10
7	4.1.2	IV	emf equation of an alternator	6	10
PART C					
III	1.1.6	I	solve simple series AC circuit problems	15	25
IV	1.1.5	I	AC series RLC circuit	15	25
V.a.	2.2.1	II	working principle of transformer	8	15
V.b	2.2.7	II	types of transformer	7	10
VI.a	2.2.2	II	Construction of transformer	8	15
VI.b	2.2.5	II	To derive emf equation of transformer	7	10
VII.a	3.1.5	III	Armature reaction	7	10
VII.b	3.2.5	III	Types of DC motor	8	15
VIII.a	3.1.1	III	working principle of DC generator	7	10
VIII.b	3.2.4	III	Three point starter	8	15
IX.a	4.2.5	IV	working principle of induction motor	8	15
IX.b	4.2.4	IV	Servo motor	7	10
X.a	4.1.4	IV	OCC of Alternator	8	15
X.b	4.2.3	IV	Universal motor	7	10
Total Time					175