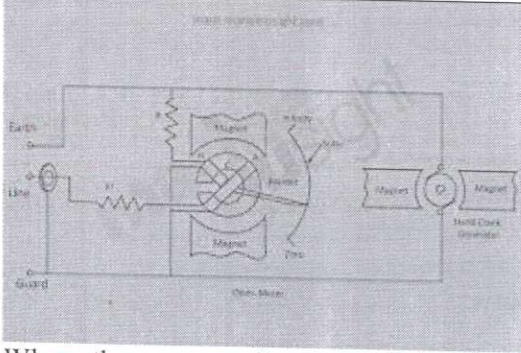
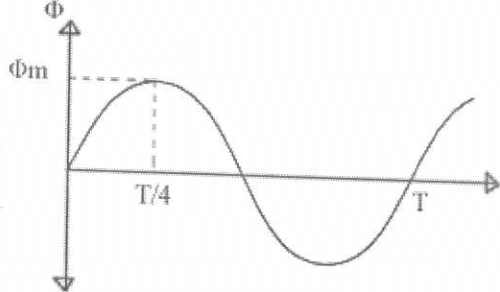


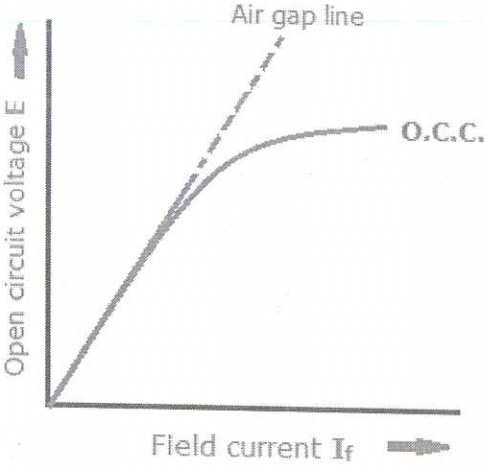
# Scheme of Evaluation

## Scoring Indicator

Revision 2015 Electrical Technology				
Ques t No:	Scoring Indicator	Split up score	Sub Tota l	Tota l
1.	$X_C = j\omega L$ and $X_L = 1/j\omega C$ , $\omega = 2\pi f$ .	1+1	2	2
2.	Keeping the first finger, second finger and the thumb of right hand at right angles to each other similar to the three axes, if the first finger points out in the direction of magnetic field, the thumb in the direction of motion of conductor, then the second finger points out in the direction of induced emf.	2	2	2
3.	10 A, according to Ohm's law. $I = V/R$	2	2	2
4.	Two main parts- 1. Stator- producing flux 2. Armature – generating electromotive force	1+1	2	2
5.	It is simple and rugged in construction. It is reliable. It is low cost Its starting arrangements are simple	2x1 (Any two)	2	2
Part B				
II 1.	 <p>When the current flows from the generator through the pressure coil, the coil tends to set itself at right angle to the field of the permanent magnet. When the test terminals are open and current flows through the deflecting coil. Thus the pressure coil governs the movement of the needle causing it to move to the extreme counter clockwise position indicating infinite resistance. When the terminals are shorted, current flows through the deflecting coil producing enough torque to overcome the counter clockwise torque moving the pointer in the clockwise direction indicating zero resistance. For any other value of resistance, the opposing torque of the coil balance each other and the pointer comes to rest at a point indicating the value of resistance calibrated on the scale. The resistance under test is connected between the terminals and the handle is rotated at a uniform speed until the pointer gives a steady reading.</p>	3+3	6	6

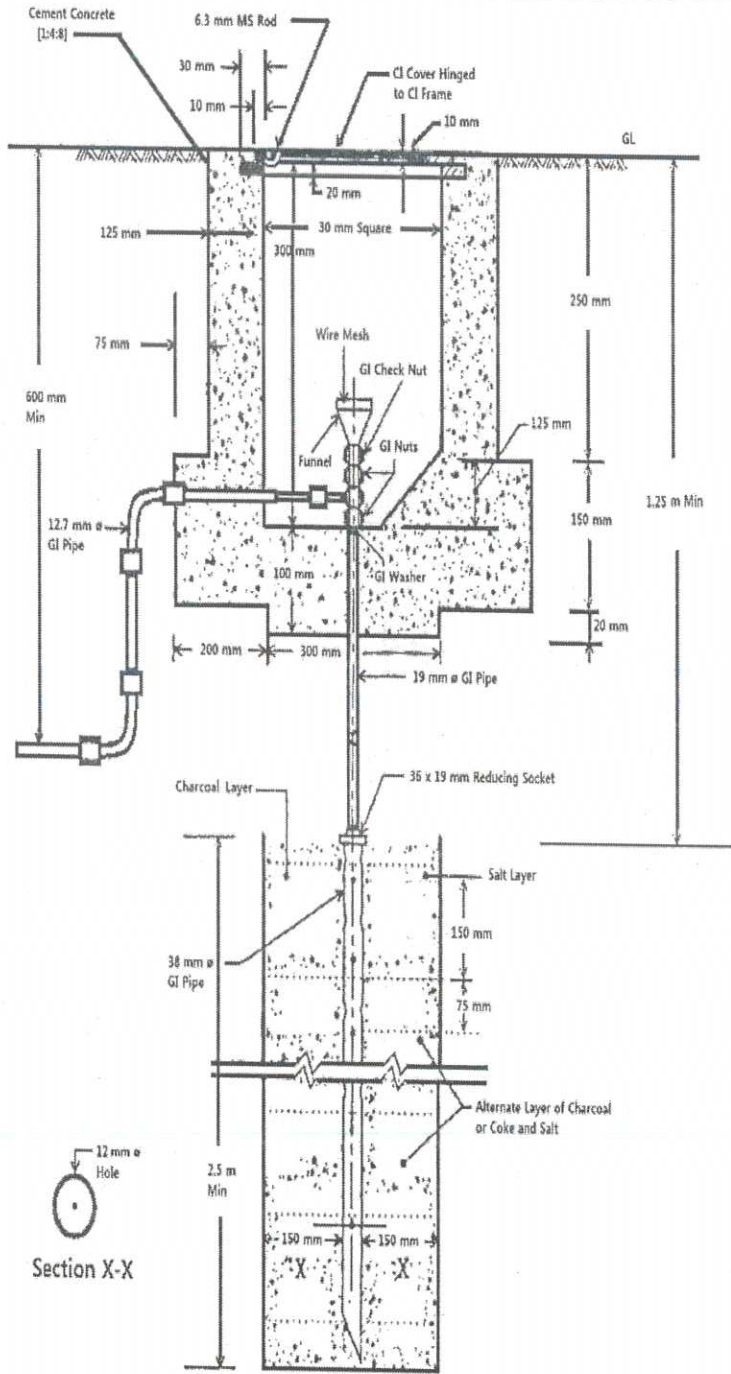
<p>2.</p>	<p>Let,  <math>N_1</math> = Number of turns in primary winding  <math>N_2</math> = Number of turns in secondary winding  <math>\Phi_m</math> = Maximum flux in the core (in Wb) = <math>(B_m \times A)</math>  <math>f</math> = frequency of the AC supply (in Hz)</p>  <p style="text-align: center;">electricaleasy.com</p> <p>average rate of change of flux = <math>\Phi_m / (T/4) = \Phi_m / (1/4f)</math>  average rate of change of flux = <math>4f \Phi_m</math> ..... (Wb/s).  Induced emf per turn = rate of change of flux per turn  Therefore, average emf per turn = <math>4f \Phi_m</math> .....(Volts).  RMS value of emf per turn = <math>1.11 \times 4f \Phi_m = 4.44f \Phi_m</math>.  RMS value of induced emf in whole primary winding (<math>E_1</math>) =  <math>E_1 = 4.44f N_1 \Phi_m</math> ..... eq 1  Similarly, RMS induced emf in secondary winding (<math>E_2</math>) can be given as  <math>E_2 = 4.44f N_2 \Phi_m</math>. ..... eq 2</p>	<p>6</p>	<p>6</p>	<p>6</p>
<p>3.</p>	<p>The superposition theorem states that in any linear bilateral network that consisting of two or more independent sources, current through (or voltage across) an element is the algebraic sum of the currents through (voltages across) that element caused by each independent source acting alone with all other sources are replaced by their internal resistances.</p> <p>Steps to Analyse Superposition Theorem</p> <ol style="list-style-type: none"> <li>1. Consider the various independent sources in a given circuit.</li> <li>2. Select and retain one of the independent sources and replace all other sources with their internal resistances or else replace the current sources with open circuits and voltage sources with short circuits.</li> <li>3. To avoid confusion re-label the voltage and current notations suitably.</li> <li>4. Find out the desired voltage/currents due to the one source acting alone using various circuit reduction techniques.</li> <li>5. Repeat the steps 2 to 4 for each independent source in the given circuit.</li> <li>6. Algebraically add all the voltages/currents that are obtained</li> </ol>	<p>2+4 ( 2 for statement and 4 for steps)</p>	<p>6</p>	<p>6</p>

	obtained from each individual source (Consider the voltage signs and current directions while adding).			
4.	<p>Power factor : The ratio of the actual electrical power dissipated by an AC circuit to the product of the r.m.s. values of current and voltage. The range is from 0 to 1. It is given by <math>PF = \cos \phi</math>, where <math>\phi</math> is the phase lead or lag caused by the reactive loads.</p> <p>Reactive Power : reactive power is the imaginary power or apparent power, which does not do any useful work. It is a byproduct of AC systems and produced from inductive and capacitive loads. It exists when there is phase displacement between voltage and current. It is measured in units of volt-ampere reactive (VAR). It is given by <math>VI \sin \phi</math>.</p> <p>Idle Current: Current through pure 'L' or pure 'C' which consumes no power for its maintenance in the circuit is called Idle Current. It is also called wattles current</p>	2  2  2	6	6
5.	<p>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 a magnetic 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 Fleming's left hand rule.</p> <p>If the supply is DC, the polarity never reverses. So we get the field and the current in the same direction always and hence a net force in a particular direction on the conductors due to which the rotor rotates.</p> <p>If the supply is AC, the polarity changes between +ve and -ve, 50 times per second. So, the direction of current as well as the Magnetic Field changes and hence we get the Resultant Force in different directions.</p>	6	6	6
6.	<p>Consider a DC generator with the following parameters,</p> <p>P = number of field poles  <math>\Phi</math> = flux produced per pole in Wb (weber)  Z = total no. of armature conductors</p>	6	6	6

	<p>A = no. of parallel paths in armature  N = rotational speed of armature in revolutions per min. (rpm)  Now,  Average emf generated per conductor is given by <math>d\Phi/dt</math> (Volts) ... eq. 1  Flux cut by one conductor in one revolution = <math>d\Phi = P\Phi</math> ....(Weber),  Number of revolutions per second (speed in RPS) = <math>N/60</math>  Therefore, time for one revolution = <math>dt = 60/N</math> (Seconds)  From eq. 1, emf generated per conductor = <math>d\Phi/dt = P\Phi N/60</math> (Volts) .....(eq. 2)  which is the emf generated in one conductor of the generator.  The conductors are connected in series per parallel path, and the emf across the generator terminals is equal to the generated emf across any parallel path.  Therefore, <b><math>E_g = P\Phi NZ / 60A</math></b>  For simplex lap winding, number of parallel paths is equal to the number of poles (i.e. <math>A=P</math>),  Therefore, for simplex lap wound dc generator, <b><math>E_g = P\Phi NZ / 60P</math></b>  For simplex wave winding, number of parallel paths is equal to 2 (i.e <math>P=2</math>),  Therefore, for simplex wave wound dc generator, <b><math>E_g = P\Phi NZ / 120</math></b></p>			
7.	<p>It is the BH curve of the magnetic circuit of the alternator  It is determined by inserting resistance in the field circuit and measuring the corresponding value of the terminal voltage.</p> 	3+3	6	6

PART C				
III a.	$X_L = \omega L$ $= 2 \times 3.14 \times 50 \times 0.05 = \underline{\underline{15.7 \Omega}}$	2 x 4	8	8
i)	Impedance; $Z = \sqrt{R^2 + X_L^2} = \sqrt{50^2 + (15.7)^2}$ $= \underline{\underline{52.4 \Omega}}$			
ii)	Power factor $\cos \phi = R/Z$ $= 50/52.4 = \underline{\underline{0.99}}$			
iii)	Current $= V/Z = \frac{250}{52.4} = \underline{\underline{4.77 A}}$			
iv)	Active power $= VI \cos \phi$ $= 250 \times 4.77 \times 0.99$ $= 1180 W$ $= \underline{\underline{1.18 kW}}$			

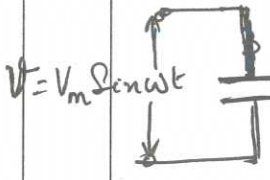
b.



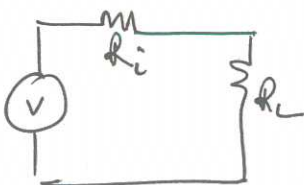
3+4

7

It is the most common type of earthing system. In this type of earthing system, a perforated pipe made of galvanized steel/iron of approved length and diameter is buried vertically. The size of the pipe used depends on the magnitude of current and the amount of moisture content in the soil. The diameter of the pipe is usually 40mm and length

	2.75m for normal soil. The amount of soil moisture determines the length of the pipe			
IV a	<p>Time period: The time required to complete one oscillation is known as time period. Unit is Seconds</p> <p>Frequency: No ; of wave cycles per second. Unit is Hz</p> <p>Phase : Phase is a particular point in time on the cycle of a waveform, measured as an angle in degrees. A complete cycle is 360°. Units is radians or degree.</p> <p>RMS value: That steady current which, when flows through a resistor of known resistance for a given period of time than as a result the same quantity of heat is produced by the alternating current when flows through the same resistor for the same period of time is called R.M.S or effective value of the alternating current. The unit can be Volt or Ampere depending on whether the quantity is voltage or current.</p>	(1+1) * 4	8	8
b	<p>Consider a pure capacitive ckt given below.</p>  <p>The current through such a circuit can be written as</p> $i = I_m \sin(\omega t + \pi/2)$ <p>Since <math>i</math> leads by <math>\pi/2</math> in a pure capacitive circuit.</p> <p>where <math>i = \frac{V}{X_c} = \frac{V}{1/\omega C} = \omega V C</math></p> <p>Now the instantaneous power <math>P = i \cdot V = I_m \sin(\omega t + \pi/2) \cdot V_m \sin \omega t</math></p> $= I_m \cdot \omega \cos \omega t - V_m \sin \omega t \quad (\because \sin(\omega t + \pi/2) = \cos \omega t)$ $= \underline{\underline{I_m \cdot \omega \cos(2\omega t)}}$ <p>Integrating both sides for the whole cycle <math>\omega t</math> dt with in the limits <math>0 \rightarrow 2\pi</math> we get, <math>P = \int_0^{2\pi} \frac{V_m I_m}{2} \sin 2\omega t dt = \underline{\underline{0}}</math></p>	7	7	7
Va	<p>In a dc network, for maximum transfer of power from source to load, the load resistance must be equal to the source resistance. with all voltage and current sources replaced by their internal resistances.</p> <p><u>Proof</u>:-</p> <p>Consider the ckt given below. Let the</p>			

internal resistance be  $R_i$  and load  $R_L$ .



$$I_L = \frac{V}{R_i + R_L}$$

$$\therefore \text{Power } P_L = I_L^2 \cdot R_L$$

$$= \frac{V^2}{(R_i + R_L)^2} \cdot R_L$$

For this power to be maximum

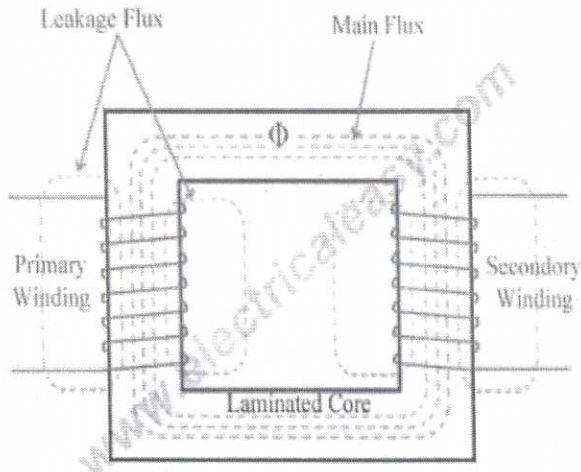
$$\frac{d(P_L)}{dR_L} = 0$$

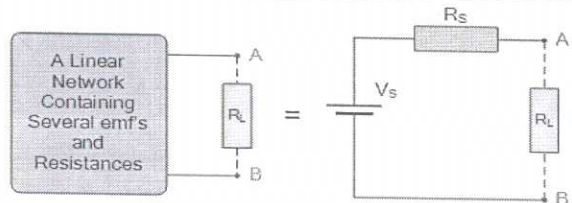
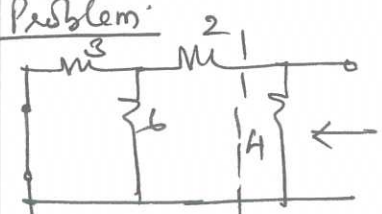
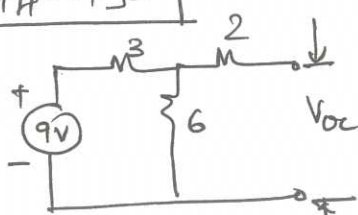
diff. and equating to 0;

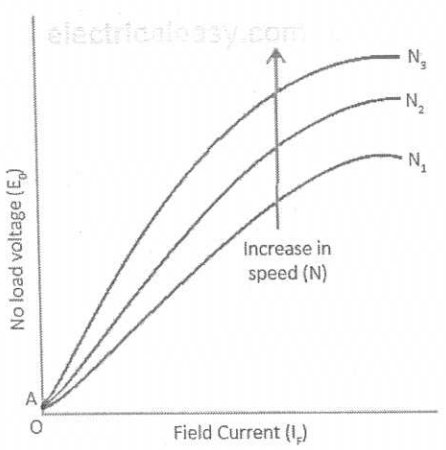
we get  $R_L = R_i$  and hence the proof

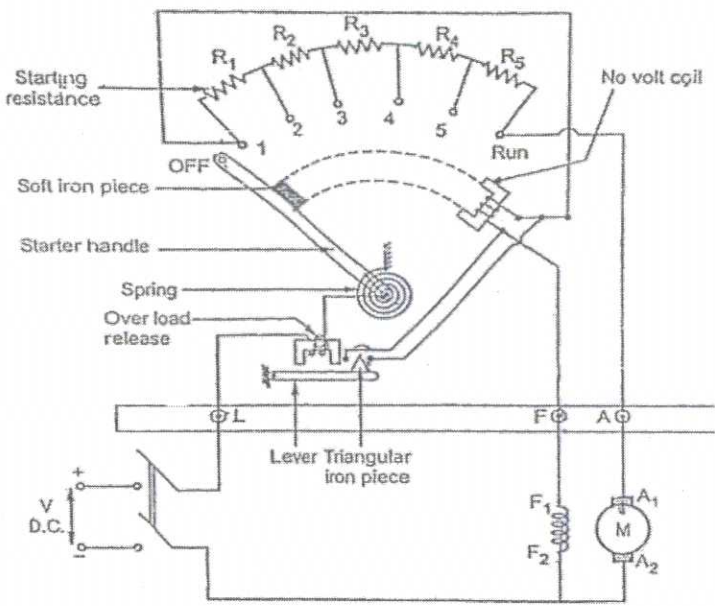
Max power is given by

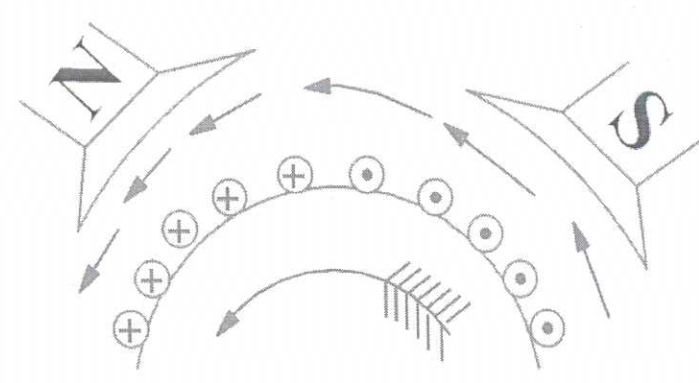
$$P_{\max} = \frac{V^2 \cdot R_L}{(2R_L)^2} = \frac{V^2}{4R_L}$$

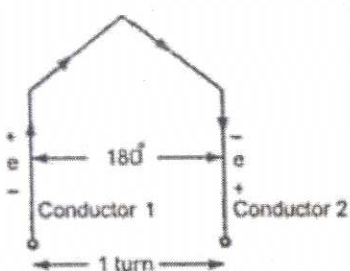
	<p>we get <math>R_L = R_i</math> and hence the proof</p> <p>Max power is given by</p> $P_{\max} = \frac{V^2 \cdot R_L}{(2R_L)^2} = \frac{V^2}{4R_L}$	8	8	8
b	<p>Basically a transformer consists of two inductive windings and a laminated steel core. The coils are insulated from each other as well as from the steel core. A transformer also consists of a container for winding and core assembly (called as tank), suitable bushings to take our the terminals, oil conservator to provide oil in the transformer tank for cooling purposes etc. Laminated sheets of steel are used to reduce eddy current loss.</p>  <p>The diagram shows a rectangular laminated core with two windings: a Primary Winding on the left vertical leg and a Secondary Winding on the right vertical leg. A dashed line labeled 'Main Flux' (Φ) shows the magnetic path circulating through the core. Another dashed line labeled 'Leakage Flux' shows magnetic field lines that do not follow the core path but instead loop through the air around the windings.</p>	Diagram - 3 Exp - 4	7	7
VI a.	<p><b>Thevenin's Theorem</b> states that "Any linear circuit containing several voltages and resistances can be replaced by just one single voltage in series with a single resistance connected across the load". In other words, it is possible to simplify any electrical circuit, no matter how complex, to an equivalent two-terminal circuit with just a single constant voltage source in series with a resistance (or impedance) connected to a load as shown below.</p>	Theorem - 3 Problem -6	3+	9

<p><math>R_{TH}</math></p> <p><math>V_{TH}</math></p>	<p>A Linear Network Containing Several emfs and Resistances</p>  <p>Problem:</p>  <p><math>R_{TH} = 4 \Omega</math></p>  <p>Applying voltage division, <math>V_{oc} = \frac{9 \times 6}{9} = 6V</math></p> <p>Applying Thevenin's theorem to find voltage across <math>4 \Omega</math>, <math>\Rightarrow</math> Voltage across <math>4 \Omega = 3V</math></p>	<p><math>= 6 \parallel 3 + 2</math></p> <p><math>= 2 + 2 = 4 \Omega</math></p>	
<p>b</p>	<p>There are two types of losses in a transformer- Copper Loss and Core loss in Transformer</p> <p>Copper loss is <math>I^2R</math> loss, in primary side it is <math>I_1^2 R_1</math> and in secondary side it is <math>I_2^2 R_2</math> loss, where <math>I_1</math> and <math>I_2</math> are primary and secondary current of transformer and <math>R_1</math> and <math>R_2</math> are resistances of primary and secondary winding. As the both primary &amp; secondary currents depend upon load of transformer, copper loss in transformer vary with load.</p> <p>Hysteresis loss and eddy current loss, both depend upon magnetic properties of the materials used to construct the core of transformer and its design. So these losses in transformer are fixed and do not depend upon the load current</p> <p>Hysteresis loss in transformer is due to the extra energy consumed for nullifying the residual magnetism which prevails in iron core and is denoted as,</p> <p><math>W_h = K_h f (B_m)^{1.6}</math> watts</p> <p>Eddy current loss: is due to locally induced back emf and the resulting currents in transformer. This is dissipated as heat. Energy loss due to this is called eddy current loss and is denoted as,</p>	<p>3+3</p>	<p>6</p>

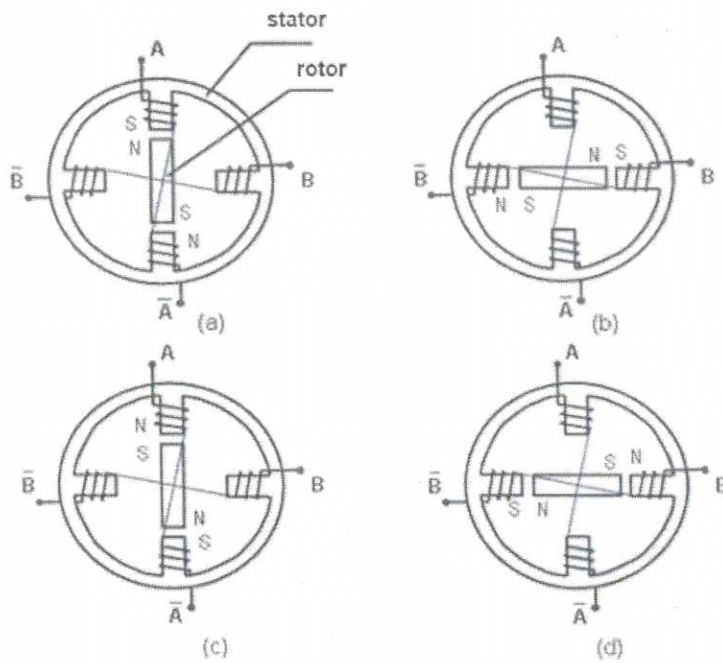
	$W_e = K_e f^2 K_f^2 B_m^2 \text{ watts}$ <p>Where, Kh = Hysteresis constant. Ke = Eddy current constant. Kf = form constant.</p>			
VII a.	<p>The no-load characteristics or the OCC is obtained by operating the generator at no load and keeping a constant speed. Field current is gradually increased and the corresponding terminal voltage is recorded.</p>  <p style="text-align: center;">Open Circuit Characteristic (O.C.C.)</p> <p><math>E_g = k\phi</math>, which means that 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, which is due to residual magnetism in the field poles. This 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 <math>\phi</math> becomes practically constant. Thus, even we increase the I further, <math>\phi</math> remains constant and hence, <math>E_g</math> also remains constant.</p>	Dia - 3 Exp - 3	6	6
b	<p>Starters are used to protect DC motors from damage that can be caused by very high current and torque during startup. Usually the armature coil has a very small resistance and the starting current will be very high. In order to reduce the starting and thereby reduce the damage due to this, an external resistance is provided to the motor, which is connected in series to the motor's armature winding. As the speed develops, back emf also increases. The resistance can be varied in steps and restricts the current to an acceptable level</p>	3	3	3

c	 <p>The handle is in OFF position:  When power is switched on to the motor. The handle is slowly moved to stud '1' against the spring force, the following will happen:  Field winding will get supply via parallel path provided through stud 1 and NVC.  Entire starting resistance is in series with the armature and limits the starting current. As the motor picks up speed, the back emf develops and the armature current drops down.  As the handle moves further to stud 2, it cuts the resistance between 1 and 2 and so the armature current increases. As the motor gains speed, again back emf raises which lowers the current. The handle is then moved to points 3,4,5 and finally RUN position, where it gets locked magnetically by the holding coil. It bypasses the starting resistance and the motor rotates at normal speed.  The handle comes back to the initial starting position with the help of the helical spring.</p>	6	6	6
VIII a	<p>A machine that converts DC electrical power into mechanical power is known as a Direct Current motor. DC motor working is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force. The direction of this force is given by <b>Fleming's left-hand rule</b> and magnitude is given by;</p> $F = BIL \text{ Newtons}$	Dia - 4 Exp - 4	8	8

	<p>Consider a part of a <b>multipolar DC motor</b> as shown in the figure below. When the terminals of the motor are connected to an external source of DC supply:</p> <ul style="list-style-type: none"> <li>-the <b>field magnets</b> are excited developing alternate North and South poles</li> <li>-the <b>armature conductors</b> carry currents.</li> </ul> <p>All conductors under North-pole carry currents in one direction while all the conductors under South-pole carry currents in the opposite direction.</p>  <p style="text-align: center;">Part of a Multi-polar DC Motor</p>			
<p>b.</p>	<p>When the generator is loaded, the armature carries the current. The armature current sets up its own magnetic field. The effect of this armature flux on the distribution of main field flux is called <b>Armature Reaction</b>. It reduces the generated voltage by distorting the main flux and it causes sparking at the brushes.</p> <p><b><u>Effects of Armature Reaction</u></b></p> <ol style="list-style-type: none"> <li>1. The armature reaction will reduce the generated EMF due to decrease in value of flux per pole.</li> <li>2. The iron losses in the teeth and pole shoes are determined by the maximum value of flux density at which they work. Due to distortion in main field flux the maximum density at load increases above no load. Thus more iron losses are observed on load than no load.</li> <li>3. Due to this process the maximum value of gap flux density increases. This will increase the maximum voltage between adjacent commutator segments at load. If this voltage exceeds beyond 30V the sparking may take place between adjacent commutator segments.</li> <li>4. The armature reaction shifts brush axis from GNA. Thus flux density in the interpolar axis is not zero but having some value. Thus there will be an induced emf in the coil undergoing commutation which will try to</li> </ol>	<p><del>7</del> 7 1+6  <del>6 (Any three)</del></p>	<p><del>6</del> 7</p>	<p><del>6</del> 7</p>

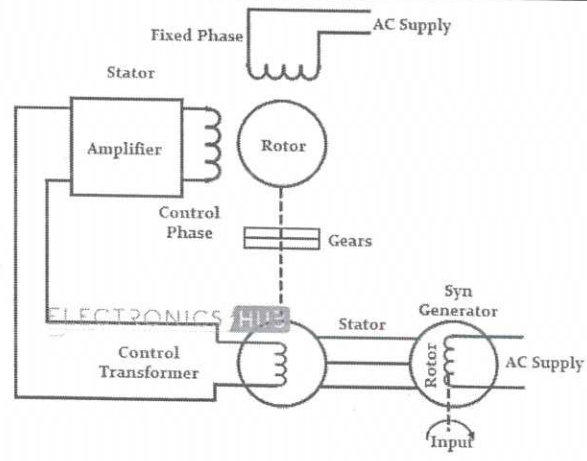
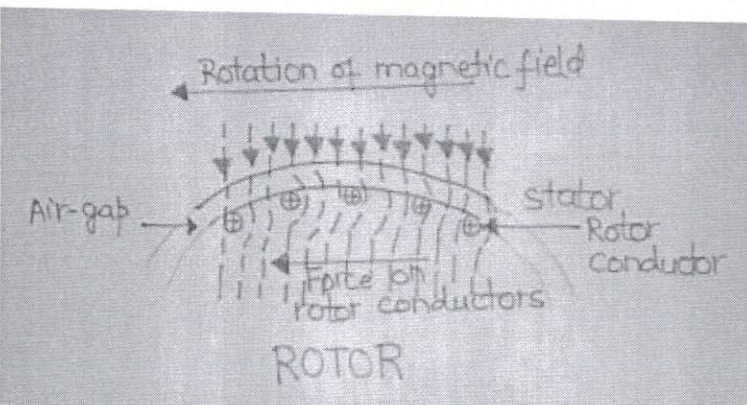
	maintain the current in original direction. This will make commutation difficult and will cause delayed commutation.			
IX a	<p>Let <math>\Phi</math> = Flux per pole, in Wb  <math>P</math> = Number of poles  <math>N_s</math> = Synchronous speed in r.p.m.  <math>f</math> = Frequency of induced e.m.f. in Hz  <math>Z</math> = Total number of conductors  <math>Z_{ph}</math> = Conductors per phase connected in series  ... <math>Z_{ph} = Z/3</math> as number of phases = 3.</p> <p>Consider a single conductor placed in a slot.  The average value of e.m.f. induced in a conductor  <math>= d\Phi/dt</math></p> <p>For one revolution of a conductor,  <math>e_{avg}</math> per conductor = (Flux cut in one revolution)/(time taken for one revolution)</p> <p>Total flux cut in one revolution is <math>\Phi \times P</math>  Time taken for one revolution is <math>60/N_s</math> seconds.</p> <p>... <math>e_{avg}</math> per conductor = <math>\Phi P / (60/N_s)</math>  <math>= \Phi (PN_s/60)</math> ..... (1)</p> <p>But <math>f = PN_s/60</math>  <math>PN_s/60 = 2f</math></p> <p>Substitution in (1),  <math>e_{avg}</math> per conductor = <math>2 f \Phi</math> volts</p> <p>Assume full pitch winding for simplicity i.e. this conductor is connected to a conductor which is 180° electrical apart. So there two e.m.f.s will try to set up a current in the same direction i.e. the two e.m.f. are helping each other and hence resultant e.m.f. per turn will be twice the e.m.f. induced in a conductor.</p> <p>... e.m.f. per turn = <math>2 \times</math> (e.m.f. per conductor)  <math>= 2 \times (2 f \Phi)</math>  <math>= 4 f \Phi</math> volts</p>  <p>Let <math>T_{ph}</math> be the total number of turn per phase connected in series. Assuming concentrated winding, we can say that all are placed in single slot per pole per phase. So induced e.m.f.s in all turns will be in phase as placed in single slot. Hence net e.m.f. per phase will be algebraic sum of the</p>	8	8	8

	<p>e.m.f.s per turn.  ... Average <math>E_{ph} = T_{ph} \times (\text{Average e.m.f. per turn})</math>  ... Average <math>E_{ph} = T_{ph} \times 4 f \Phi</math>  But in a.c. circuits R.M.S. value of an alternating quantity is used for the analysis. The form factor is 1.11 of sinusoidal e.m.f.  <math>K_f = (\text{R.M.S.})/\text{Average} = 1.11</math> ..... for sinusoidal  ... R.M.S. value of <math>E_{ph} = K \times \text{Average value}</math>  <math>E = 4.44 \times f \Phi T_{ph}</math> volts  The above equation is valid if the windings are full pitched and concentrated. But most of the windings are short pitch and distributed. So considering the pitch factor <math>K_p</math> and distribution factor <math>K_d</math>,  RMS value of emf per phase = <math>4.44 \times f \Phi T_{ph} K_p K_d</math> volts.  Since the alternator winding are connected in star the line voltage is <math>\sqrt{3}</math> times the phase voltage.  Ie, RMS value of emf between lines = <math>\sqrt{3} \times 4.44 \times f \Phi T_{ph} K_p K_d</math> volts</p>			
b	<p>The stepper motor rotor is a permanent magnet, when the current flows through the stator winding, the stator winding to produce a vector magnetic field. The magnetic field drives the rotor to rotate by an angle so that the pair of magnetic fields of the rotor and the magnetic field direction of the stator are consistent. When the stator's vector magnetic field is rotated by an angle, the rotor also rotates with the magnetic field at an angle. Each time an electrical pulse is input, the motor rotates one degree further. The angular displacement it outputs is proportional to the number of pulses input and the speed is proportional to the pulse frequency. Change the order of winding power, the motor will reverse. Therefore, it can control the rotation of the stepping motor by controlling the number of pulses, the frequency and the electrical sequence of each phase winding of the motor.</p>	<p>Working -  4;  Application  Classification  0- 3</p>	<p>4+3  =7</p>	<p>7</p>



### Applications:

1. **Industrial Machines** – Stepper motors are used in automotive gauges and machine tooling automated production equipments.
2. **Security** – new surveillance products for the security industry.
3. **Medical** – Stepper motors are used inside medical scanners, samplers, and also found inside digital dental photography, fluid pumps, respirators and blood analysis machinery.
4. **Consumer Electronics** – Stepper motors in cameras for automatic digital camera focus and zoom functions.

<p>X a</p>	 <p>The reference input is given to the rotor of synchro generator as mechanical input. This rotor is connected to the electrical input at rated voltage at a fixed frequency. The three stator terminals of a synchro generator are connected correspondingly to the terminals of control transformer. The angular position of the two-phase motor is transmitted to the rotor of control transformer through gear train arrangement. Initially, there exist a difference between the synchro generator shaft position and control transformer shaft position. This error is reflected as the voltage across the control transformer. This error voltage is applied to the servo amplifier and then to the control phase of the motor. With the control voltage, the rotor of the motor rotates in required direction till the error becomes zero. This is how the desired shaft position is ensured in AC servo motors.</p>	<p>Diagram -4 Exp - 4</p>	<p>4+4 = 8</p>	<p>8</p>
<p>b</p>	<p>When the 3 phase stator winding is energised from a 3 phase supply, a rotating magnetic field is produced which rotates around the stator at synchronous speed.</p> 	<p>Dia- 3 Exp - 4</p>	<p>3+4 = 7</p>	<p>7</p>

<p>The rotating magnetic field cuts the rotor conductors, which are stationary. Due to this flux cutting, emfs are induced in the rotor conductors. As rotor circuit is short circuited, currents start flowing in it and the direction of induced current will be such that it opposes the very cause that produced it. Here, the cause of emf induction is the relative motion between the rotating field and the stationary rotor conductors. Hence, to reduce this relative motion, the rotor starts rotating in the same direction as that of the stator field and tries to catch it but, can never catch it due to friction and windage and therefore emf induction continues and motor keeps rotating.</p>			
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