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THIRD SEMESTER DIPLOMA EXAMINATION IN ENGINEERING AND TECHNOLOGY

ELECTRIC CIRCUIT AND NETWORK THEORY

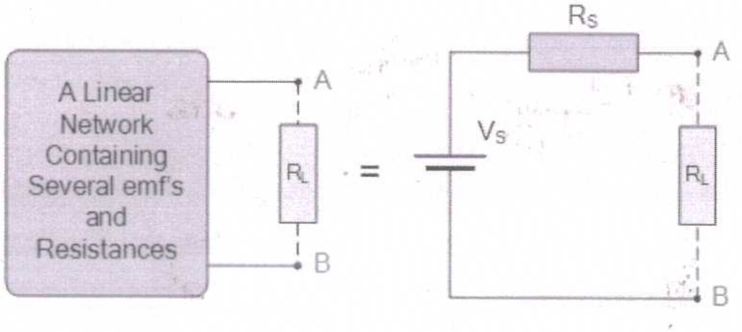
Answer Key- Set 1

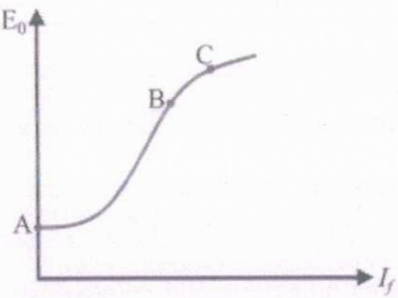
Time: 3 hours Maximum Marks:75

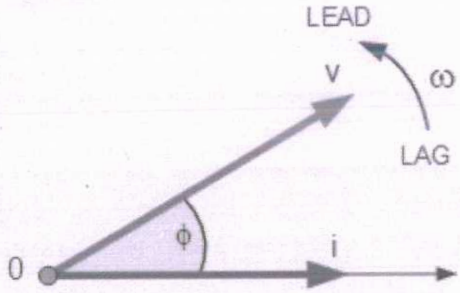
PART A

Question No:	Answer	Marking Scheme	
		Sub Total	Total
1.	1.11	1	1
2.	0 and 1	1	1
3.	Quality factor	1	1
4.	Kirchhoffs Voltage Law or KVL, states that “in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop” which is also equal to zero. In other words the algebraic sum of all voltages within the loop must be equal to zero.	1	1
5.	decreases	1	1
6.	Faraday’s law of electromagnetic induction	1	1
7.	0V	1	1
8.	zero	1	1
9.	Wb/m^2	1	1

PART B

1.	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. The resistance is called resistance , called Thevinin’s resistance and Voltage is called Thevinin’s Voltage 	Stmnt:2 + Fig:1	3

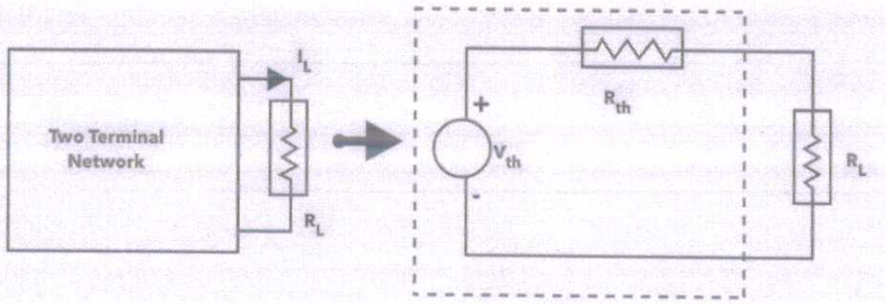
2.	• impedance matching. • isolate two circuits electrically. • Iused to increase or decrease the alternating voltages in electric power applications. • used in voltmeter, ammeters, protective relay etc. • step up low voltage in case of measurement. • step down high voltage for safety. • used in rectifier. • Iused in voltage regulators, voltage stabilizers, power supplies etc.	1x3	3
3.	When the armature of a DC motor rotates under the influence of the driving torque, the armature conductors move through the magnetic field and hence emf is induced .The induced emf acts in opposite direction to the applied voltage V (Lenz's law) and is known as Back EMF or Counter EMF (Eb). The presence of back emf makes the d.c. motor a self-regulating machine i.e., it makes the motor to draw as much armature current as is just sufficient to develop the torque required by the load.	3	3
4.	*The* open circuit characteristics (O.C.C) *or* magnetization characteristics *is the curve that shows the relationship between the generated EMF at no-load (E0) and the field current (If) at constant speed. It is also known as* no-load saturation curve.  	Exp :2 Fig :1	3

5.	$$u_{RMS}^2 = \frac{1}{T}\int_0^T u(t)^2 \cdot dt = \frac{a_1^2}{T}\int_0^T [\sin(\omega t)]^2 \cdot dt$$ $$[\sin(\omega t)]^2 = \frac{1}{2} - \frac{\cos(2\omega t)}{2}$$ $$u_{RMS}^2 = \frac{a_1^2}{T}\int_0^T \left(\frac{1}{2} - \frac{\cos(2\omega t)}{2}\right) \cdot dt = \frac{a_1^2}{2}\left(1 - \frac{1}{2T}\sin(2\omega t)\Big\vert_0^T\right) = \frac{a_1^2}{2}$$ $$u_{RMS} = \frac{a_1}{\sqrt{2}} = 0.707 a_1$$	3	3
6.	Active Power: The power which is actually consumed or utitilized in an AC Circuit is called True power or Active power or Real power. Reactive Power:The power which flows back and forth that means it moves in both the directions in the circuit or reacts upon itself, is called **Reactive Power** Apparent Power: The product of root mean square (RMS) value of voltage and current is known as **Apparent Power**. This power is measured in kVA or MVA.	1x3	3
7.	Phasor is a rotating vector, is a scaled line whose length represents an AC quantity that has both magnitude and direction. A complete sine wave can be constructed by a single vector rotating anti-clockwise at an angular velocity of ω = 2πf, where f denotes the frequency of the waveform.  	Exp :2 Fig:1	3
8.	**Iron Losses** in a Transformer are of two types – Eddy current loss and hysteresis loss. Iron losses mainly occur through the alternating flux within the transformer's core. Once this loss occurs within the core then it is called core loss.	3	3

	Copper losses occur because of the Ohmic resistance in the windings of the transformer. **Stray Losses** can occur because of the occurrence of the leakage field. As compared with copper and iron losses, the percentage of stray losses are less, so these losses can be neglected. Dielectric Loss mainly occurs within insulating material of the transformer. Eg .oil is an insulating material.		
9.	• It is used in applications requiring rapid variations in speed without the motor getting overheated. • Used in Industries performing packaging, factory automation, material handling, printing converting, assembly lines. • Used in many other demanding applications robotics, CNC machinery or automated manufacturing. • used in radio controlled airplanes to control the positioning and movement of elevators. • In robots because of their smooth switching on and off and accurate positioning. • In the aerospace industry to maintain hydraulic fluid in their hydraulic systems. • used in many radio controlled toys. • used in electronic devices such as DVDs or Blue ray Disc players to extend or replay the disc trays. • used in automobiles to maintain the speed of vehicles	1x3	3
10.	A *three phase induction motor* has a stator and a rotor. When the stator winding is connected to a balanced three phase supply, a rotating magnetic field (RMF) is setup which rotates around the stator at synchronous speed (Ns). Where, The RMF passes through air gap and cuts the rotor conductors, which are stationary at start. Due to relative motion between RMF and the stationary rotor, an EMF is induced in the rotor conductors. Since the rotor circuit is short-circuited, a current starts flowing in the rotor conductors. Now, the current carrying rotor conductors are in a magnetic field created by the stator. As a result of this, mechanical force acts on the rotor conductors. The sum of mechanical forces on all the rotor conductors produces a torque which tries to move the rotor in the same direction as the RMF.	3	3

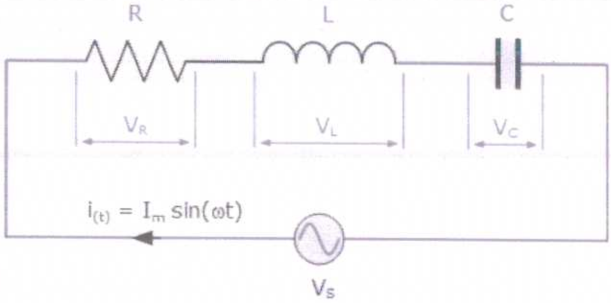
PART C

1.	Solution. $X_L = 2\pi fL = 2\pi \times 50 \times 0.2 = 62.8\Omega$; $X_C = 1/2\pi fC$ $= 10^{6}\, 2\pi \times 50 \times 150 = 21.2\,\Omega$; $X = (X_L - X_C) = 41.6\,\Omega$; $Z = \sqrt{R^2 + X^2} = \sqrt{20^2 + 41.6^2} = 46.2\,\Omega$; $I = V/Z = 230/46.2 = 4.98\,A$ Also, $Z = R + jX = 20 + j\,41.6 = 46.2 \angle 64.3°$ ohm $\therefore$ $Y = 1/Z = 1/46.2 \angle 64.3° = 0.0216 \angle -64.3°$ siemens p.f. $= \cos 64.3° = 0.4336$ (lag) Active power $= VI\cos\phi = 230 \times 4.98 \times 0.4336 = 497$ W Reactive power $= VI\sin\phi = 230 \times 4.98 \times \sin 64.3° = 1031$ VAR	3+2+2	7
2.	$P = V \times I$ $P = V_m \text{Sin}\omega t \times I_m \text{Sin}(\omega t + 90)$ $P = V_m I_m \text{Sin}\omega t\ \text{Sin}(\omega t + 90)$ $P = V_m I_m \text{Sin}\omega t\ \text{Cos}\omega t$ [$\text{Sin}(\omega t + 90) = \text{Cos}\omega t$] $P = \frac{V_m I_m}{2}\ 2\,\text{Sin}\omega t\ \text{Cos}\omega t$ $P = \frac{V_m I_m}{2}\ \text{Sin}\,2\omega t$ [$2\text{Sin}\theta\text{Cos}\theta = \text{Sin}2\theta$] Taking integration for one cycle $P = \frac{V_m I_m}{4\pi}\int_0^{2\pi} \text{Sin}2\omega t$ $P = \frac{V_m I_m}{4\pi}\left[\frac{\text{Cos}2\omega t}{2}\right]_0^{2\pi}$ $P = \frac{V_m I_m}{8\pi}\left[-\text{Cos}4\pi + \text{Cos}0\right]$ $P = \frac{V_m I_m}{8\pi}\left[-1 + 1\right]$ $P = \frac{V_m I_m}{8\pi}\left[\,0\,\right]$ $\boxed{P = 0}$	7	7
3.	According to FLEMI average induced EMF in Primary coil is e1 (avg.) = -N1 (dϕ/dt) volt Secondary coil is e2 (avg.) = -N2 (dϕ/dt) volt where N1 & N2 are number of turns in primary and secondary winding respectively. (-) sign represents according to lenz's law. dϕ/dt means change in flux with time. dϕ/dt = ϕm/(T/4) = ϕm/ (1/4f) = 4f*ϕm e1 = -N1(4f*ϕm) volt e2 = -N2(4f*ϕm) volt This is the average value and in AC system we deal with with rms value. Form factor = (rms / avg.) = 1.11	7	7

	So rms = 1.11*avg. Now e1 (rms) = -(4.44*N1*f*ϕm) volt e2 (rms) = -(4.44*N2*f*ϕm) volt This is the emf equation of transformer.		
4.	 Thevenin's Equivalent Circuit $$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$ The power absorbed by the load is $$P_L = I_L^2 \times R_L$$ $$= \left[\frac{V_{Th}}{R_{Th} + R_L}\right]^2 \times R_L$$ To find the exact value of RL, we apply differentiation to P_L with respect to R_L and equating it to zero	Fig : 3 Condition = 3 Power delivered : 1	7

	$$\frac{dP(R_L)}{dR_L} = V_{Th}^2 \left[\frac{(R_{Th}+R_L)^2 - 2R_L \times (R_{Th}+R_L)}{(R_{Th}+R_L)^4} \right] = 0$$ $$\Rightarrow (R_{Th}+R_L) - 2R_L = 0$$ $$\Rightarrow R_L = R_{Th}$$ The maximum power delivered to the load is, $$P_{max} = \left[\frac{V_{Th}}{R_{Th}+R_L} \right]^2 \times R_L \Big|_{R_L=R_{Th}}$$ $$= \frac{V_{Th}^2}{4R_{Th}}$$		
5.	the current flowing through the 20 Ω resistor to due 20 V voltage source is 0.4 A. the current flowing through the circuit when only 4 A current source is 1.6 A. $I = I_1 + I_2$ Substituting the values of I_1 and I_2 in the above equation, we get $I = 0.4+1.6 = 2$ A Therefore, the current flowing through the resistor is 2 A.	3 3 1	7

6.	See below	Series circuit : 3 Phasor: 2 Triangle :2	7

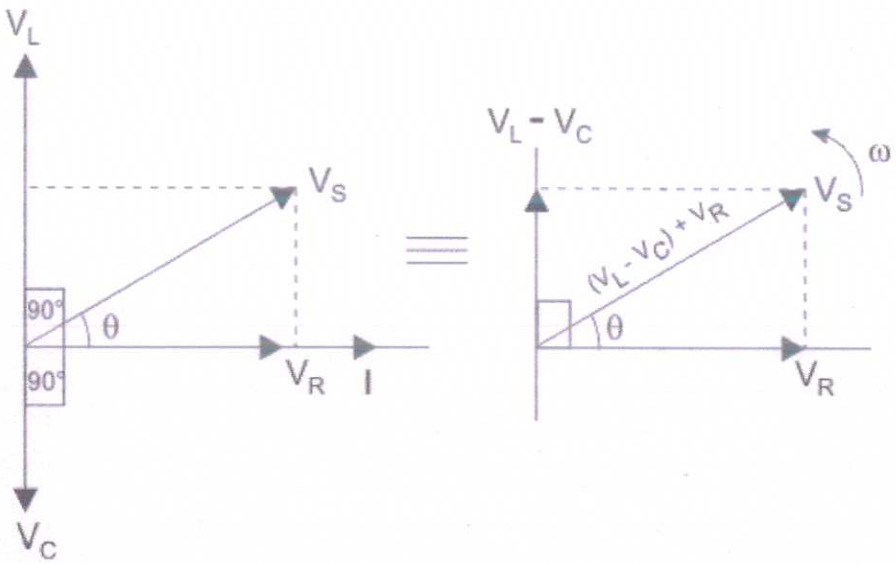


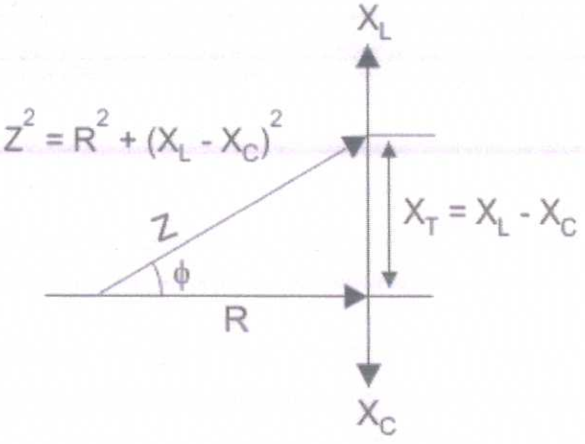
$V_R = I.R \quad V_L = I.X_L \quad V_C = I.X_C$

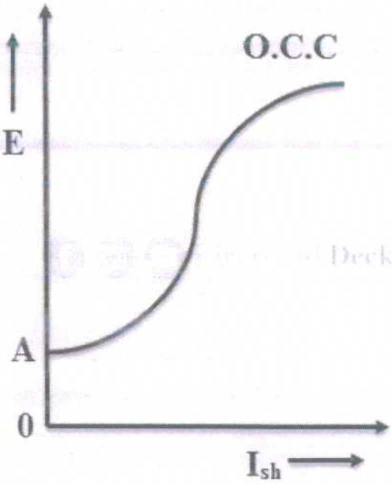
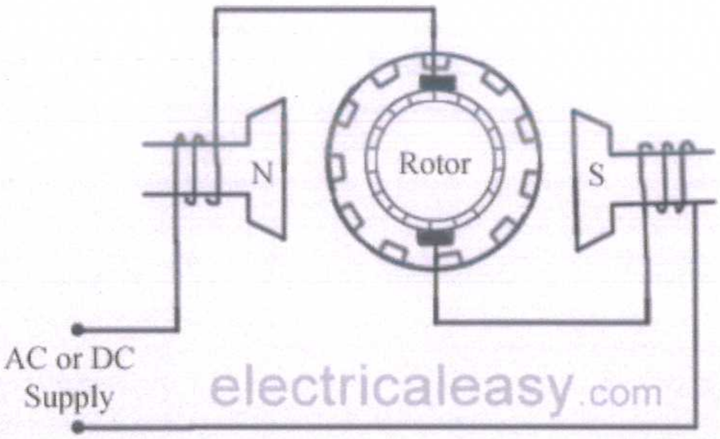
$$V_S = \sqrt{(I.R)^2 + (I.X_L - I.X_C)^2}$$

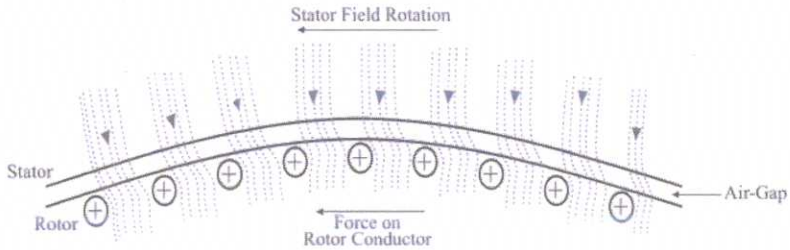
$$V_S = I.\sqrt{R^2 + (X_L - X_C)^2}$$

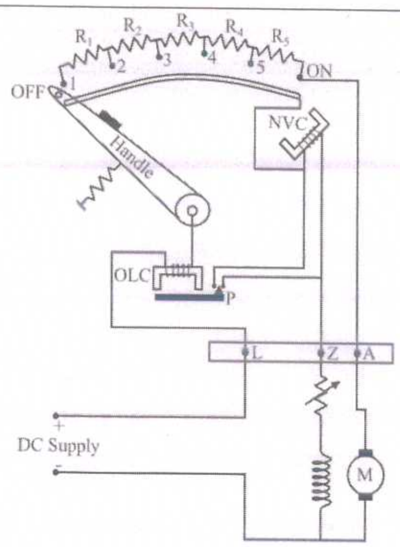
$$\therefore V_S = I \times Z \quad \text{where: } Z = \sqrt{R^2 + (X_L - X_C)^2}$$



			
7.	Time period: Time taken to complete one full cycle of a waveform **Frequency: No of cycles per second . Unit Hz** Indicate T and f in a sine wave The **RMS (Root Mean Square)** of an alternating current (AC) is the value of direct current (DC) when flowing through a circuit or resistor for the specific time period and produces same amount of heat which produced by the alternating current (AC) when flowing through the same circuit or resistor for a specific time. It has a value equal to .707 Im for a sine wave. The ratio of the root mean square value to the average value of an alternating quantity (current or voltage) is called **Form Factor. It is 1.11 for a sine wave.**	1 1 1 2 2	7
8.	No-load or open circuit characteristics of a shunt generator are obtained by plotting field current, Ish, versus generated voltage, E Under the no-load condition, the generator is said to be open-circuited and rotating at a constant speed. From the EMF equation of dc generator, generated voltage E is directly proportional to flux φ. As φ is directly proportional to field current Ish, an increase in Ish also increases E. voltage E for 0 Ish is mainly due to magnetism present in the field poles, known as residual magnetism. Now as the field current Ish, flux φ, increases with an increase in voltage E. But, after reaching certain current Ish the field gets saturated and therefore φ and E remain constant .	Exp : 4+ Fig: 3	7

			
9.	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. (see working of a DC series motor here). 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. 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. 	Exp : 4 Fig : 3	7
10.	A three phase induction motor has a stator and a rotor. The stator carries a 3-phase winding called as stator winding while the rotor carries a short circuited winding	Exp: 5 +	7

	called as rotor winding. The stator winding is fed from 3-phase supply and the rotor winding derives its voltage and power from the stator winding through electromagnetic induction. 3-phase induction motor is fundamentally based on electromagnetic induction. • When the stator winding is connected to a balanced three phase supply, a rotating magnetic field (RMF) is setup which rotates around the stator at synchronous speed (Ns). • The RMF passes through air gap and cuts the rotor conductors, which are stationary at start. Due to relative motion between RMF and the stationary rotor, an EMF is induced in the rotor conductors. Since the rotor circuit is short-circuited, a current starts flowing in the rotor conductors. • Now, the current carrying rotor conductors are in a magnetic field created by the stator. As a result of this, mechanical force acts on the rotor conductors. The sum of mechanical forces on all the rotor conductors produces a torque which tries to move the rotor in the same direction as the RMF.  	Fig:2	
11.	The handle of the 3 point starter can be moved from one stud to another stud positions.At first when a DC supply is turned ON by H-handle in the OFF position, then the handle will move CLK wise direction to the stud1. The winding of the shunt field is directly associated across the voltage supply as the total resistance, in the beginning, is included in series with the armature circuit. If the voltage supply is unexpectedly disrupted, then the no-volt discharge coil is demagnetized as well as the H-handle goes back to the OFF location in the pull of the spring. If no-volt coil were not utilized, then there will be a supply failure. The H-handle would stay on the last stud. If the voltage supply is returned, then the DC motor will be openly allied across the supply, resulting in an extreme armature current.	Exp : 4+ Fig: 2	7

	 If the DC motor is overloaded, it will draw extreme current from the current supply, NVC coil is demagnetized as well as the H-handle is pulled near the OFF location by the S-spring. Hence the electric motor is automatically detached from the current		
12.	Consider a single loop DC generator (as shown in the figure), in this a single turn loop 'ABCD' is rotating clockwise in a uniform magnetic field with a constant speed. When the loop rotates, the magnetic flux linking the coil sides 'AB' and 'CD' changes continuously. This change in flux linkage induces an EMF in coil sides and the induced EMF in one coil side adds the induced EMF in the other. The EMF induced in a DC generator can be explained as follows • When the loop is in position-1, the generated EMF is zero because, the movement of coil sides is parallel to the magnetic flux. • When the loop is in position-2, the coil sides are moving at an angle to the magnetic flux and hence, a small EMF is generated. • When the loop is in position-3, the coil sides are moving at right angle to the magnetic flux, therefore the generated EMF is maximum. • When the loop is in position-4, the coil sides are cutting the magnetic flux at an angle, thus a reduced EMF is generated in the coil sides. • When the loop is in position-5, no flux linkage with the coil side and are moving parallel to the magnetic flux. Therefore, no EMF is generated in the coil. • At the position-6, the coil sides move under a pole of opposite polarity and hence the polarity of generated EMF is reversed. The maximum EMF will generate in this direction at position-7 and zero when at position-1. This cycle repeats with revolution of the coil.	Exp : 5 + Fig :2	7

It is clear that the generated EMF in the loop is alternating one. It is because any coil side (say AB) has EMF in one direction when under the influence of N-pole and in the other direction when under the influence of S-pole. Hence, when a load is connected across the terminals of the generator, an alternating current will flow through it. Now, by using a commutator, this alternating emf generated in the loop can be converted into direct voltage. We then have a DC generator.