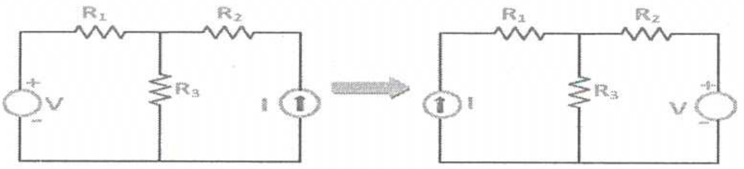
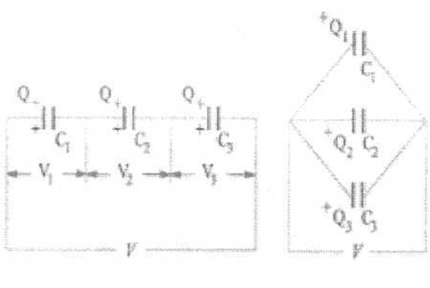
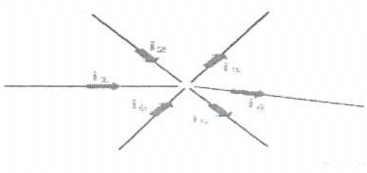
SCHEME OF VALUATION
(Scoring Indicators)

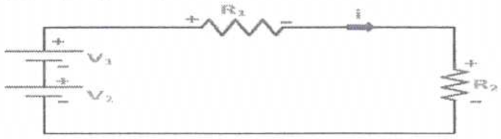
Revision:2015 Course Code: 2031

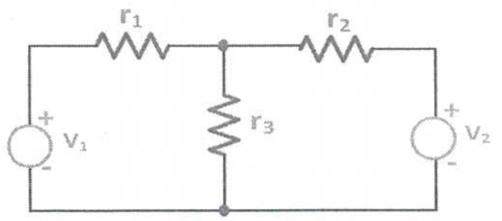
Course Title: Basic Electrical Engineering

Qst. no	Scoring Indicator	Split up score	Sub Total	Total
	PART A			
1.	The temperature coefficient of a material may be defined as the increase in resistance per ohm original resistance per °C rise in temperature. Unit of temperature coefficient of resistance is per degree centigrade	2	2	
2.	In d.c circuits, maximum power is transferred from a source to load when the load resistance is made equal to the internal resistance of the source as viewed from the load terminals with load removed and all e.m.f sources replaced by their internal resistances.	2	2	
3.	The change of potential per unit distance is called potential gradient i.e. Potential gradient = $\frac{V_2-V_1}{s}$	2	2	10
4.	Capacitors are used for power factor improvement. They are used in starting motors Capacitiors are used in electronics for various applications such as wave shaping , filtering ,coupling, decoupling etc	Any 2 2×1	2	
5	The opposition offered to the magnetic lines force in a magnetic circuit is called reluctance. The unit of reluctance is Ampere-turn/weber and is denoted by letter S. $S = \frac{mmf}{flux}$	2	2	
II	PART B			
1	Laws of Resistance The resistance R offered by a conductor depends on the following factors: (i) It varies directly as its length, l (ii) It varies inversely as the cross-section A of the conductor. (iii) It depends on the nature of the material. (iv) It also depends on the temperature of the conductor. Neglecting the last factor for the time being, $R \propto \frac{l}{A}$ or $R = \rho\frac{l}{A}$ where ρ is a constant depending on the nature of the material of the conductor and is known as its specific resistance or resistivity.	1½ 1½ 1 2	6	
2.	1. Same current flows through all parts of the circuit. 2. Different resistors have their individual voltage drops. 3. Voltage drops are additive. 4. Applied voltage equals the sum of different voltage drops. 5. Resistances are additive. 6. The total resistance in the series circuit is more than the largest resistance in the circuit. 7. Powers are additive	Any 6 6×1	6	

3	**Reciprocity Theorem** states that – In any linear bilateral network, if a source of e.m.f E in any branch produces a current I in any other branch, then the same e.m.f E acting in the second branch would produce the same current in the first branch. In other words E and I are mutually transferrable. The ratio E/I is known as transfer resistance. **Explanation of Reciprocity Theorem** The location of the voltage source and the current source may be interchanged without a change in current. However, the polarity of the voltage source should be identical with the direction of the branch current in each position. The Reciprocity Theorem is explained with the help of the circuit diagram shown below  various resistances R_1, R_2, R_3 is connected in the circuit diagram above with a voltage source (V) and a current source (I). It is clear from the figure above that the voltage source and current sources are interchanged for solving the network with the help of reciprocity Theorem.	State mt 2 Expla nation 4	6	
4.	Permittivity is the property of a medium and affects the magnitude of force between two point charges. The greater the permittivity of a medium, the lesser the force between the charged bodies placed in it. Air or vacuum has a minimum value of permittivity. The absolute permittivity ε_0 of air or vacuum is 8.854×10^{-12} F/m. The absolute permittivity ε of all other insulating materials is greater than ε_0. The ratio $\varepsilon/\varepsilon_0$ is called relative permittivity of the material and is denoted by ε_r i.e. $\varepsilon_r = \dfrac{\varepsilon}{\varepsilon_0}$ Where, ε= absolute permittivity of material ε_o = absolute permittivity of air or vacuum (8.854 x 10-12 F/m) ε_r = relative permittivity of material Obviously, ε_r for air would be $\varepsilon/\varepsilon_0 = 1$	2 2 2	6	
5.	**Capacitors in Series** With reference of Fig. 5.17, let C_1, C_2, C_3 = Capacitances of three capacitors V_1, V_2, V_3 = p.ds. across three capacitors. V = applied voltage across combination C = combined or equivalent or joining capacitance. In series combination, charge on all capacitors is the same but p.d. across each is different. $\therefore \quad V = V_1 + V_2 + V_3$ or $\quad \dfrac{Q}{C} = \dfrac{Q}{C_1} + \dfrac{Q}{C_2} + \dfrac{Q}{C_3}$ or $\quad \dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}$ For a changing applied voltage, $\dfrac{dV}{dt} = \dfrac{dV_1}{dt} + \dfrac{dV_2}{dt} + \dfrac{dV_3}{dt}$  	Fig-1 Deri.2		

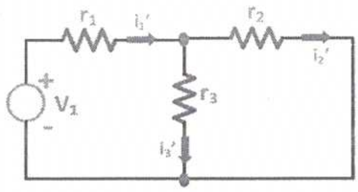
	We can also find values of V_1, V_2 and V_3 in terms of V. Now, $Q = C_1V_1 = C_2V_2 = C_3V_3 = CV$ where $C = \dfrac{C_1C_2C_3}{C_1C_2 + C_2C_3 + C_3C_1} = \dfrac{C_1C_2C_3}{\Sigma C_1C_2}$ $\therefore$ $C_1V_1 = CV$ or $V_1 = V\dfrac{C}{C_1} = V\dfrac{C_2C_3}{\Sigma C_1C_2}$ Similarly, $V_2 = V \cdot \dfrac{C_1C_3}{\Sigma C_1C_2}$ and $V_3 = V \cdot \dfrac{C_1C_2}{\Sigma C_1C_2}$ **Capacitors in Parallel** In this case, p.d. across each is the same but charge on each is different (Fig. 5.18) $\therefore$ $Q = Q_1 + Q_2 + Q_3$ or $CV = C_1V + C_2V + C_3V$ or $C = C_1 + C_2 + C_3$	Fig 1 Deri.2	3+3 (6)	
6.	i) <u>Magnetic flux density (B)</u> The flux passing per unit area through a plane at right angles to the flux. $B = \frac{\emptyset}{A}$ Wb/m^2 or tesla Where Φ (Wb) is the magnetic flux and A (m^2) is the area of cross section. ii) <u>Magnetomotive force (mmf)</u> Magnetomotive force is the cause producing flux in a magnetic circuit and so it is analogous to emf in an electric circuit. MMF = N I where N is the number of turns of the coil and I the current flowing through it. The unit of mmf is ampere-turns (AT) iii) <u>Magnetic field intensity or Magnetizing force (H)</u> Magnetic field intensity at any point in a magnetic field is the force experienced by a unit north pole placed at that point. It is denoted by the letter H. The unit of H is N/wb.	2 2 2	6	
7.	<u>Dynamically induced emf:</u> The emf induced in a coil due to relative motion of the conductor and the magnetic field is called dynamically induced emf. Example: dc generator works on the principle of dynamically induced emf in the conductors which are housed in a revolving armature lying within magnetic field. <u>Statically induced emf:</u> The emf induced in a coil due to change of flux linked with it (change of flux is by the increase or decrease in current) is called statically induced emf. Transformer is an example of statically induced emf. Here the windings are stationary, magnetic field is moving around the conductor and produces the emf. There are two types of statically induced emf - 1. Self induced emf 2. Mutually induced emf.	2 1 2 1	6	30
	PART- C			
III a)	**Kirchhoff's Current Law** states that" the algebraic sum of all the currents at any node point or a junction of a circuit is zero". $\Sigma I = 0$  Considering the above figure as per the Kirchhoff's Current Law **i1 + i2 – i3 – i4 – i5 + i6 = 0 ……… (1)**	2 1½		

	The direction of incoming currents to a node is taken as positive while the outgoing currents is taken as negative. The equation (1) can also be written as **i1 + i2 + i6 = i3 + i4 + i5** Sum of incoming currents = Sum of outgoing currents			
	Kirchhoff's Voltage Law states that the algebraic sum of the voltages (or voltage drops) in any closed path of network is zero or in other words, in a closed circuit, the algebraic sum of all the EMFs + the algebraic sum of all the voltage drops (product of current (I) and resistance (R)) is zero. **$\Sigma E + \Sigma V = 0$**	2	7	
	 	1½		
	As per the Kirchhoff's Voltage Law $-V_1 + (-V_2) + iR_1 + iR_2 = 0 \dots\dots\dots (2)$			15
b)	R_t =R$_0$ [1+α_0 t]	1		
	R_{-30} = R$_0$ [1+α_0 (-30)] = 100 [1+0.00427(-30)] =87.2 Ω	2½	8	
	R_{+35} = R$_0$ [1+α_0 (30)] = 100 [1+0.00427(35)] =115 Ω	2½		
	Change in resistance = 115 – 87.2 =27.8 Ω	2		
IVa	The effect of rise in temperature is: (i) to increase the resistance of pure metals. The increase is large and fairly regular for normal ranges of temperature. Hence, metals have a positive temperature coefficient of resistance. Eg. Cu, Al	2½		
	(ii) to increase the resistance of alloys. The increase is relatively small and irregular. Eg. Eureka, Manganin	2	7	
	(iii) to decrease the resistance of electrolytes, insulators, semiconductors. Hence, insulators are said to possess a negative temperature –coefficient of resistance. Eg. Rubber, glass, Carbon	2½		
b)	Total wattage of lamps = 5 ×100 =500 watts Wattage of electric press = 220× 2 =440 watts Total Wattage of fans = 4×110 =440 watts Wattage of heater = 1120 watts	2		15
	Total wattage of all the appliances = 500+440+440+1120 =2500 watts	1½	8	
	Energy consumed by all the appliances per day =2500×2 = 5000 wh =5 kWh	1½		
	Energy consumed by all the appliances in the month of Sept. =5×30 = 150 kWh	1½		
	Bill for the month of September = Rs 2×150 = Rs. 300	1½		
V (a)	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. The circuit diagram shown below consists of a two voltage sources V1 and V2.	Statemt 2		



First, take the source V1 alone and short circuit the V2 source as shown in the circuit diagram fig 2

Explanation 5 | 7



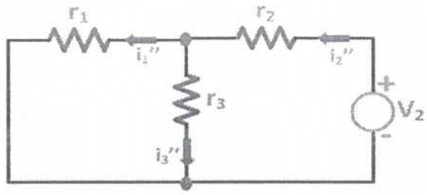


Fig 2 fig 3

Here, the value of current flowing in each branch, i.e. i1', i2' and i3' is calculated by the following equations.

The difference between the above two equations gives the value of the current i3'

the Now, activating voltage source V2 and deactivating the voltage source V1by short circuiting it, find the various currents, i.e. i1'', i2'', i3'' flowing in the circuit diagram fig 3. Here,

$$i_2'' = \frac{V_2}{\frac{r_1 r_3}{r_1 + r_3} + r_2} \quad \text{and} \quad i_1'' = i_2'' \frac{r_3}{r_1 + r_3}$$

And the value of the current i3'' will be calculated by the equation shown below

$$i_3'' = i_2'' - i_1''$$

As per the superposition theorem the value of current i1, i2, i3 is now calculated as

$$i_3 = i_3' + i_3''$$
$$i_2 = i_2' - i_2''$$
$$i_1 = i_1' - i_1''$$

b)

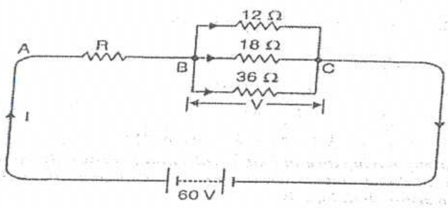


Fig 1 | 15

$$\frac{1}{R_{BC}} = \frac{1}{12} + \frac{1}{18} + \frac{1}{36} = \frac{6}{36}$$

∴ $R_{BC} = 36/6 = 6\ \Omega$ — 2

Now, Power in 12 Ω = 36 watts

or $V^2/12 = 36$ ∴ $V = \sqrt{36 \times 12} = 20\cdot8$ volts — 1 | 8

Current in R, $I = V/R_{BC} = 20\cdot8/6 = 3\cdot47$ A — 1

P.D. across R = $60 - 20\cdot8 = 39\cdot2$ volts

∴ Value of R = $39\cdot2/3\cdot47 = 11\cdot3\ \Omega$ — 1½

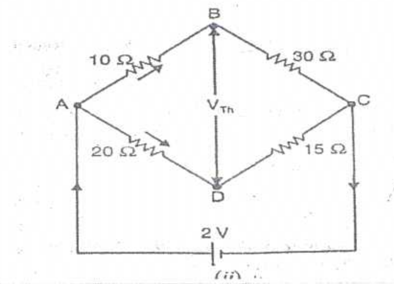
Power in parallel group = $I^2 \times R_{BC} = (3\cdot47)^2 \times 6 = 72\cdot24$ watts — 1½

VIa) Norton's theorem states that any two terminal linear bilateral networks can be replaced by an equivalent circuit consisting of a current source and a parallel resistance. 2

Procedure for Finding Norton Equivalent Circuit

- Open the two terminals (e. remove any load) between which we want to find Norton equivalent circuit. 7
- Put a short circuit across the terminals under consideration. Find the short circuit current flowing in the short circuit. It is called Norton current IN. 5
- Determine the resistance between the two open terminals with all ideal voltage sources shorted and all ideal current sources opened (a non-ideal source is replaced by its internal resistance). It is called Norton's resistance RN. It is easy to see that RN = R0.
- Connect IN and RN in parallel to produce Norton equivalent circuit between the two terminals under consideration.
- Place the load resistor removed in step (i) across the terminals of the Norton equivalent circuit. The load current can now be calculated by using current-divider rule. This load current will be the same as the load current in the original circuit.

b)



(ii)

15

Solution. We shall find Thevenin's equivalent circuit at terminals *BD* in Fig. 3.90 (*i*).

(*i*) **Finding V_{Th}.** To find V_{Th} at terminals *BD*, remove the load (*i.e.* 40 Ω galvanometer) as shown in Fig. 3.90 (*ii*). The voltage between terminals *B* and *D* is equal to V_{Th}.

$$\text{Current in branch } ABC = \frac{2}{10+30} = 0{\cdot}05 \text{ A}$$

8

$$\text{P.D. between } A \text{ and } B,\quad V_{AB} = 10 \times 0{\cdot}05 = 0{\cdot}5 \text{ V}$$

$$\text{Current in branch } ADC = \frac{2}{20+15} = 0{\cdot}0571 \text{ A}$$

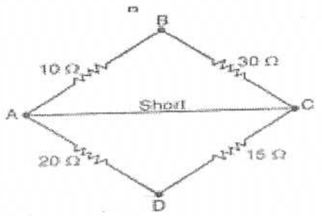
$$\text{P.D. between } A \text{ and } D,\quad V_{AD} = 0{\cdot}0571 \times 20 = 1{\cdot}142 \text{ V}$$

$$\therefore \text{ P.D. between } B \text{ and } D,\ V_{Th} = V_{AD} - V_{AB} = 1{\cdot}142 - 0{\cdot}5 = 0{\cdot}642 \text{ V}$$

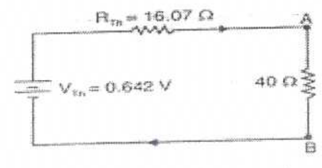
2

Obviously, point B^* is positive w.r.t. point *D* *i.e.* current in the galvanometer, when connected between *B* and *D*, will flow from *B* to *D*.

(*ii*) **Finding R_{Th}.** In order to find R_{Th}, remove the load (*i.e.* 40 Ω galvanometer) and replace the battery by a short (as its internal resistance is assumed zero) as shown in Fig. 3.91 (*i*). Then resistance measured between termianls *B* and *D* is equal to R_{Th}.



(*i*)



(*ii*)

2

$$R_{Th} = \text{Resistance at terminals } BD \text{ in Fig. 3.91 } (i).$$

$$= \frac{10 \times 30}{10+30} + \frac{20 \times 15}{20+15} = 7{\cdot}5 + 8{\cdot}57 = 16{\cdot}07\ \Omega$$

2

Thevenin's equivalent circuit at terminals *BD* is V_{Th} (= 0·642 *V*) in series with R_{Th} (= 16·07 Ω). When galvanometer is connected between *B* and *D*, the circuit becomes as shown in Fig. 3.91 (*ii*).

$$\therefore \text{ Galvanometer current} = \frac{V_{Th}}{R_{Th}+40} = \frac{0{\cdot}642}{16{\cdot}07+40}$$

$$= 11{\cdot}5 \times 10^{-3} \text{ A}$$

$$= 11{\cdot}5 \text{ mA } \textit{from B to D}$$

2

VII a)

(i) Uniform Dielectric-Medium

A parallel-plate capacitor consisting of two plates M and N each of area A m^2 separated by a thickness d metres of a medium of relative permittivity ε_r is shown in Fig. If a charge of $+Q$ coulomb is given to plate M, then flux passing through the medium is $\psi = Q$ coulomb. Flux density in the medium is

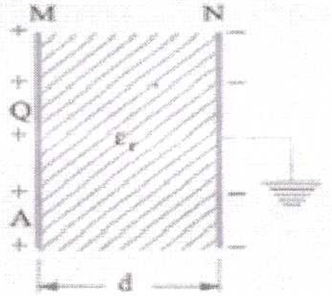


Fig 2 | 7

$$D = \frac{\Psi}{A} = \frac{Q}{A}$$

Electric intensity $E = V/d$ and $D = \varepsilon E$

or $\quad \frac{Q}{A} = \varepsilon \frac{V}{d} \quad \therefore \quad \frac{Q}{V} = \frac{\varepsilon A}{d}$

Derivation 5

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d} \text{ farad} \qquad \text{– in a medium} \qquad ...(i)$$

$$= \frac{\varepsilon_0 A}{d} \text{ farad} \qquad \text{– with air as medium}$$

b) Energy stored in a capacitor

Charging a capacitor means transferring electrons from one plate of the capacitor to the other. This involves expenditure of energy because electrons have to be moved against the opposing forces. This energy is stored in the electrostatic field set up in the dielectric medium. On discharging the capacitor, the field collapses and the stored energy is released.

Consider a capacitor of C farad being charged from a d.c source of V volts as shown in figure. Suppose at any stage of charging, the charge on the capacitor is q coulomb and p.d. across the plates is v volts.

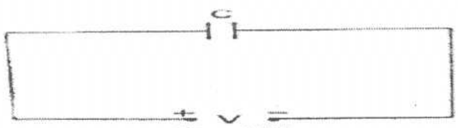


Fig. 4·26

fig 1 | 8

Then $\quad C = \frac{q}{v}$

At this instant, v Joules of work will be done in transferring 1C of charge from one plate to the other. If further small charge dq is transferred, then work done is

$$dW = v\,dq$$
$$= C\,v\,dv \qquad \therefore q = C\,v \quad ; \quad dq = C\,dv$$

$\therefore$ Total work done in raising the potential of uncharged capacitor to V volt is

Derivation 5 | 15

$$W = \int_0^V Cv\,dv$$
$$= C\left[\frac{v^2}{2}\right]$$

Or $\quad W = \frac{1}{2} C\,V^2$ Joules

This work done is stored in the electrostatic field set up in the dielectric.

$\therefore$ Energy stored in the capacitor $\quad E = \frac{1}{2} C\,V^2$ Joules

2

VIII a)	**First law.** Like charges repel each other while unlike charges attract each other.	2		
	Second law Coulomb's second law states that, the force of attraction or repulsion between the two electrically charged particles is directly proportional to the product of magnitudes of two charges and inversely proportional to the square of the distance between two charges. This force of attraction or repulsion between two charges is also depends on the medium in which charges are placed.	2		
	$F \propto \frac{Q_1 Q_2}{d^2}$ (OR) $F = k\frac{Q_1 Q_2}{d^2}$ Where, F = Force of attraction or repulsion between the charges Q1, Q2= Magnitude of charge 1 and charge 2 d = Distance between two charges. k = Constant whose value depends on the medium in which charges are placed. $k = \frac{1}{4\pi\varepsilon}$; $k = \frac{1}{4\pi\varepsilon_0\varepsilon_r}$ Where $\varepsilon = \varepsilon_0\varepsilon_r$ Where, ε_0 = absolute permittivity of air or vacuum = 8.854×10^{-12} F/m ε_r= relative permittivity of medium with respect to free space. For vacuum, the relative permittivity $\varepsilon_r = 1$, Hence $\varepsilon = \varepsilon_0$	2	7	
	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 d^2}$ in vacuum $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0\varepsilon_r d^2}$ in medium (Or) $F = 9\times10^{9}\,\frac{Q_1Q_2}{\varepsilon_r d^2}$ in medium	1		
b)	Circuit diagram	1		
	$C = C_1 + C_2 + C_3$ $= 800\mu F + 60\mu F + 1200\mu F = 2060\mu F$	2		15
	Charge on capacitor $C_1 = Q_1 = C_1V = 800\times10^{-6} \times 48 = 0.0384$ C	1	8	
	Charge on capacitor $C_2 = Q_2 = C_2V = 60 \times10^{-6} \times 48 = 0.00288$ C	1		
	Charge on capacitor $C_3 = Q_3 = C_3V = 1200 \times10^{-6} \times 48 = 0.0576$ C	1		
	The total charge $Q = Q_1 + Q_2 + Q_3$ $= 0.0384\text{ C} + 0.00288\text{ C} + 0.0576\text{ C} = 0.09888$ C	2		
IXa)	**Fleming's Left Hand Rule** Whenever a current carrying conductor is placed in a magnetic field, the conductor experiences a force which is perpendicular to both the magnetic field and the direction of current. According to **Fleming's left hand rule**, if the thumb, fore-finger and middle finger of the left hand are stretched to be perpendicular to each other as shown in the illustration at left, and if the fore finger represents the direction of magnetic field, the middle finger represents the direction of current, then the thumb represents the direction of force.	2½		
	Fleming's left hand rule is applicable for motors.	1		

Fleming's Right Hand Rule

As per Faraday's law of electromagnetic induction, whenever a conductor is forcefully moved in an electromagnetic field, an emf gets induced across the conductor. If the conductor is provided a closed path, then the induced emf causes a current to flow. 7 | 2½

According to the Fleming's right hand rule, the thumb, fore finger and middle finger of the right hand are stretched to be perpendicular to each other as shown in the illustration at right, and if the thumb represents the direction of the movement of conductor, fore-finger represents direction of the magnetic field, then the middle finger represents direction of the induced current.

Fleming's right hand rule is applicable for electrical generators. 1

b) Current through the coil, $I = \frac{V}{R} = \frac{240}{474} = 0.506$ A 1

Mean Length of the magnetic circuit , $l = \pi \times$ diameter 1

$= \pi \times (25\times 10^{-2}) = 0.7854$ m

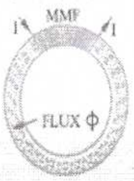
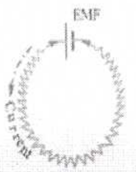
$\therefore$ *Magnetising force*, $H = \frac{NI}{l} = \frac{500\times 0.506}{0.7854} = 322.13$ AT/m 2

Flux density , $B = \mu_0\ \mu_r\ H = 4\pi \times 10^{-7} \times 250 \times 322.13$ 2 | 8

$= 0.1012$ Wb/m2

Flux in the ring , $\phi = B\times A = 0.1012\times 400\times 10^{-6} = 40.48\times 10^{-6}$ Wb 2 | 15

X(a)

Magnetic Circuit	Electric Circuit
 Fig. 6.27	 Fig. 6.28
1. Flux = $\frac{\text{m.m.f}}{\text{reluctance}}$	Current = $\frac{\text{e.m.f}}{\text{resistance}}$
2. M.M.F. (ampere-turns)	E.M.F. (volts)
3. Flux Φ (webers)	Current I (amperes)
4. Flux density B (Wb/m^2)	Current density (A/m^2)
5. Reluctance $S = \frac{l}{\mu A}\left(= \frac{l}{\mu_0 \mu_r A}\right)$	resistance $R = \rho \frac{l}{A} = \frac{l}{\rho A}$
6. Permeance (= 1/reluctance)	Conductance (= 1/resistance)
7. Reluctivity	Resistivity
8. Permeability (= 1/reluctivity)	Conductivity (= 1/resistivity)
9. Total m.m.f = $\Phi S_1 + \Phi S_2 + \Phi S_3 + \ldots$	9. Total e.m.f = $IR_1 + IR_2 + IR_3 + \ldots$

Any 7 | 7×1 | 7

b) Consider an inductor is connected to a Dc source as shown in Fig.

The energy supplied to the circuit is spent in two ways :

(*i*) A part of supplied energy is spent to meet I^2R losses and cannot be recovered.

(*ii*) The remaining part is spent to create flux around the coil (or inductor) and is stored in the magnetic field. When the field collapses, the stored energy is returned to the circuit.

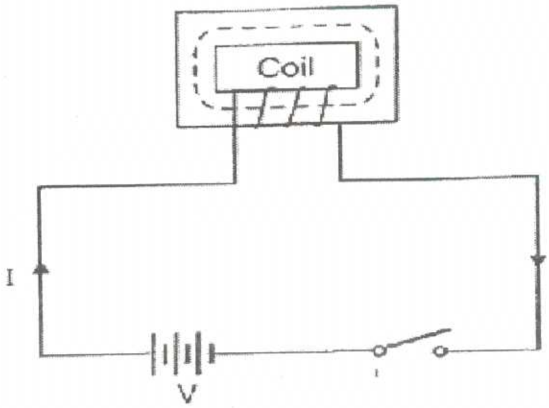


Fig 2

Mathematical Expression. Suppose at any instant the current in the coil is i and is increasing at the rate of di/dt. The e.m.f. e across L is given by :

$$e = L\frac{di}{dt}$$

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$\therefore$ Instantaneous power, $p = ei = Li\frac{di}{dt}$

During a short interval of time dt, the energy dw put into the magnetic field is equal to power multiplied by time *i.e.*

Deriv. 4

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$$dw = p.dt = \left(Li\frac{di}{dt}\right)dt = Li\,di$$

The total energy put into the magnetic field from the time current is zero until it has attained the final steady value I is :

$$W = \int_0^I Li\,di = \frac{1}{2}LI^2$$

$\therefore$ Energy stored in magnetic field, $E = \frac{1}{2}LI^2$ joules

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Note that energy stored will be in joules if inductance (L) and current (I) are in henry and amperes respectively