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DIPLOMA EXAMINATION IN ELECTRICAL &ELECTRONICS ENGINEERING
SECOND SEMESTER
BASIC ELECTRICAL ENGINEERING

Scheme of Evaluation

PART A

1. Specific resistance is defined as the resistance offered by a unit length and unit cross-section of the substance to a current when a voltage is applied to it. Its SI unit is Ω–m.
2. The energy conversion that happens in a battery is chemical energy to electrical energy
3. The reciprocity theorem states that in any linear and bilateral network or circuit having only one independent source, the ratio of response to excitation is constant even though the source is interchanged from the input terminals to output terminals.
4. The maximum electric field that a dielectric medium can withstand without breakdown (of its insulating property) is called its dielectric strength
5. Self inductance is defined as the induction of a voltage in a current-carrying wire when the current in the wire itself is changing. In the case of self-inductance, the magnetic field created by a changing current in the circuit itself induces a voltage in the same circuit.

PART B

II

1. **Heating Effect** (2 marks)

When our clothes are crumpled, we use the iron box to make our clothes crisp and neat. On the principle of heating effect of current, iron boxes work. There are many such devices that employ the heating effect.When an electrical current flows through a conductor, heat is generated within the conductor.

The heating effect is given by the following equation

$H=I^2RT$

Magnetic Effect (2 marks)

When an electric current passes through a wire, it behaves like a magnet. This is the magnetic effect of the electric current. If the electric current does not passes through, it loses its magnetic effect. These coils of wire are called electromagnets.

Chemical Effect (2 marks)

When an electric current passes through a solution, the solution ionizes and breaks down into ions. This is because a reaction takes place when an electrical current passes through the answer. Depending on the nature of the solution and the electrodes used, the effects can be observed in the solution are Change in the color of the solution,Metallic deposits on the electrodes,a release of gas or production of bubbles in the solution

2. . (2 marks)

Total resistance = (10Ω +5Ω) | | 10Ω (2 marks)

=15Ω | | 10Ω

$$\frac{1}{R_{eq}} = \frac{1}{15} + \frac{1}{10}$$

$$R_{eq} = \frac{15 * 10}{15 + 10} = 6\Omega$$

(2 marks)

3. **Lightning** (6 marks)

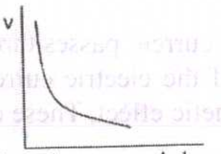
Lightning is a natural phenomenon in which the electric charges travel from one point to another in between the clouds or between clouds and the Earth. It appears to be a beautiful display, however, as the lightning carries a large amount of electric charge, it is deadly as it can destroy things and lifeforms within a few seconds of striking them.

During lightning, the electrons are in motion as they travel through a conducting path from one cloud to another in order to balance out the difference of charges. It can also take place between the cloud and the ground. When the clouds that are negatively charged gather a lot of electrons, they find a way to release the excess of the negative charge they possess.

When they come in contact with a neutral or a positively charged body, they release the excess electrons. Now, when this large amount of charge is released through a conducting path, the air that is present gets heated up very fast and therefore is expanded. This results in the thundering sounds during lightning.

4. The potential gradient represents the rate of change of potential along with displacement. In other words, it represents the slope along which potential is changing. It is also called dielectric stress or voltage stress.

$\partial V/\partial x = \nabla V$



From the graph, we can conclude that the potential gradient is high at points near the sourceof the voltage, and is low at the points farther from the source.

Now, this slope gives a field strength. And this is the electric field strength.

So we can write,

$$\partial V/\partial x = \nabla V = -\partial E$$

The terms in the expression are the electric field and the electric potential.

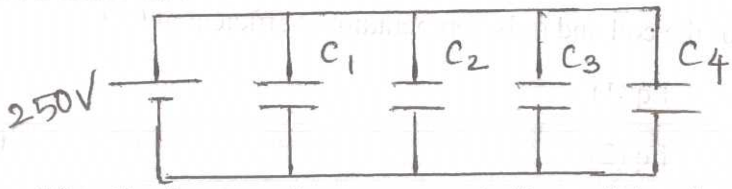
Electric field - The electric field is the field of force an electrically charged particle (Q1) would create, and enact force on an imaginary positively charged particle (Q2) if placed in the vicinity of the charged particle Q1.

Potential - The potential between 2 points can be defined as the difference between the electric potential energies between the 2 points. Potential tells the measure of the work required to move a charged particle in the electric field.

5. Capacitance in parallel

The charges of four capacitors are 750,1000,1500,2000 μC and the voltage is 250 V

We know that C=Q/V (2 marks)



When the four capacitors are connected in parallel, so the equivalent capacitance will be the sum of all the capacitors

$$C_{eq} = \frac{1}{V}(Q_1 + Q_2 + Q_3 + Q_4)$$

$C_{eq} = \frac{1}{250}(750 + 1000 + 1500 + 2000) * 10^{-6}$ (2 marks)

$\boldsymbol{C_{eq} = 20.5\mu F}$ (2 marks)

6. Applications of electromagnet (6 marks)
   - Electromagnets are used in electrical appliances like electric bells, fans, motors, etc.
   - Electromagnets are used in electric generators where strong magnetic fields are required.
   - They are used in devices like picture tubes of televisions to produce deflection of electron beams.
   - They are used to separate magnetic ores like iron ore from other substances.
   - They are used in the preparation of strong permanent magnets.
   - Electromagnets are used in the field of medicine for the diagnosis and treatment of certain diseases
7. Absolute and Relative permeability of a medium

   Absolute permeability: (3 marks)

   In electrostatics, permeability is the measure of the ability of the material to allow the formation of magnetic lines of force or magnetic field within. Absolute permeability refers to the permeability of the free space.

   The absolute permeability is a constant and its value is given as:

   $\mu_0 = 4\pi * 10^{-7} H/m.$

   Relative permeability: (3 marks)

   Relative permeability is the ratio of permeability of the substance to absolute permeability.

   The ratio of permeability of a substance to the permeability of the vacuum is known as relative permeability:

$$\mu_r = \frac{\mu}{\mu_0}$$

Where

is the relative permeability,

is the permeability of the substance, and

is the permeability of the vacuum.

The relative permeability is a dimensionless quantity.

PART C

III a)

Let R_0 be the resistance of the coil and α_0 is temperature coefficient at $0\,^{o}C$

Then , $18 = R_0(1+\alpha_0 * 20)$ Eq (1)

and $20 = R_0(1+\alpha_0 * 50)$ Eq (2) (2 marks)

$$\frac{20}{18} = \frac{1+50\alpha_0}{1+20\alpha_0}$$

$$\alpha_0 = \frac{1}{250} / ℃$$

(2 marks)

If $t\,^{o}C$s the temperature of coil when its resistance is 24Ω, then

$$24 = R_0\left(1+\frac{t}{250}\right) \qquad \text{Eq (3)}$$

Dividing Eq(3) by Eq(1)

$$\frac{24}{18} = \frac{R_0\left(1+\frac{t}{250}\right)}{R_0(1+20\alpha_0)}$$

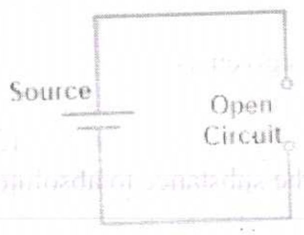
$$t = \mathbf{110}℃$$

Temperature rise $=110 - 18 = \mathbf{92^{o}C}$ (4 marks)

(3.5 marks)

III b) Open Circuit

An open circuit is defined as an electric circuit in which current does not flow. Current can only flow in a circuit if it finds a continuous path—known as a "closed circuit". If there's a break anywhere in the circuit, you have an open circuit, and current cannot flow.



Open Circuit

In an open circuit, the two terminals are disconnected. Hence the continuity of the circuit is broken. But while current cannot flow through the circuit, there is some voltage drop between two points of a circuit.

Hence in an open circuit, the current flowing through the circuit is zero, and voltage is present (non-zero).Power is equal to V/I and the current is equal to zero. Hence power is also equal to zero, and no power dissipates from an open circuit. According to ohm's law

$R=V/I$,as $I=0$; $R=V/0$

Total wattage of fan =80*3=240 watts

Wattage of Iron box=1000 watts

Wattage of Electric cooker =1000 watts

Energy consumed by the appliances per day

=(360*4)+(240*6)+(1000*2)+(1000*2)

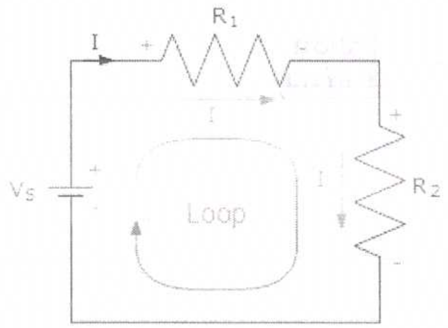
=6880 watt hour =6.88 KWh (4 marks)

Total energy consumed in 30 days

=6.88* 30 =206.4 KWh

Bill for 30 days = Rs.3 *133.8 = **Rs.620** (5 marks)

V a) **Kirchoff's voltage law** (3 marks)



In a closed loop series path, the algebraic sum of all the voltages around any closed loop in a circuit is equal to zero. This is because a circuit loop is a closed conducting path so no energy is lost.

In other words the algebraic sum of ALL the potential differences around the loop must be equal to zero as: ΣV = 0. Note here that the term "algebraic sum" means to take into account the polarities and signs of the sources and voltage drops around the loop.

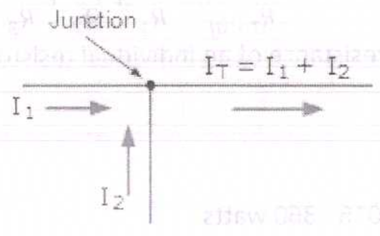
$$\sum V = 0$$

$$V_s = IR_1 + IR_2$$

This idea by Kirchhoff is commonly known as the **Conservation of Energy**,

Kirchoff's current law (3 marks)

The total current entering a circuits junction is exactly equal to the total current leaving the same junction. This is because it has no other place to go as no charge is lost.

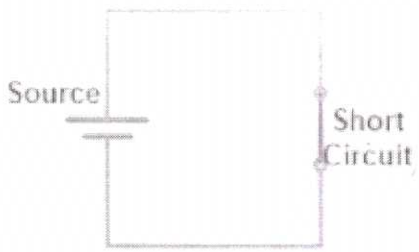


The resistance is infinite under open circuit conditions

Short Circuit (3.5 marks)

A direct connection of zero resistance across an element or combination of elements is called a short circuit.In short circuit conditions, a very high amount (infinite) of current passing through the circuit. The resistance between two terminals of shorts circuits is ideally zero. But practically there is very low resistance.

R=V/I ,as I=infinite; R=V/infinity which imlies that resistance is zero under short circuit condition



IV a)

1. **Resistors in series** (3 marks)

   Two or more resistors are said to be connected in series when the same amount of current flows through all the resistors. In such circuits, the voltage across each resistor is different

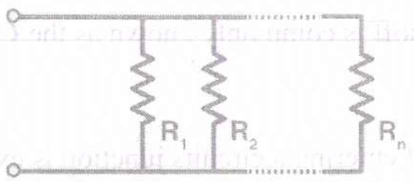
For the above circuit, the total resistance is given as:

$$R_{total} = R_1 + R_2 + R_3$$

The total resistance of the system is just the total sum of individual resistances

Resistors in parallel (3 marks)

Two or more resistors are said to be connected in parallel when the voltage is the same across all the resistors. In such circuits, the current is branched out and recombined when branches meet at a common point.



$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

The sum of reciprocals of resistance of an individual resistor is the total reciprocal resistance of the system.

IV b)

Total wattage of lamps =60*6 =360 watts

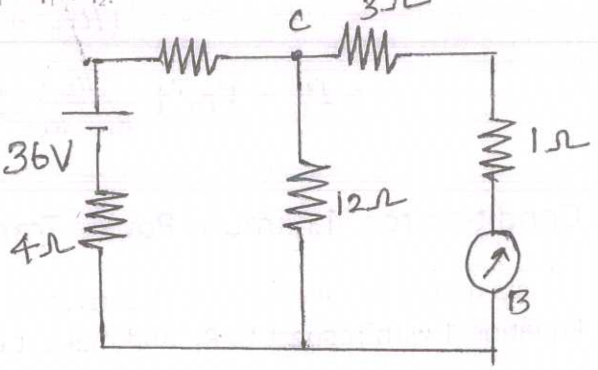
In other words the algebraic sum of ALL the currents entering and leaving a junction must be equal to zero as:

$$\Sigma I_{IN} = \Sigma I_{OUT}.$$

This idea by Kirchhoff is commonly known as the **Conservation of Charge**, as the current is conserved around the junction with no loss of current.

$I_T = I_1 + I_2.$

V b)



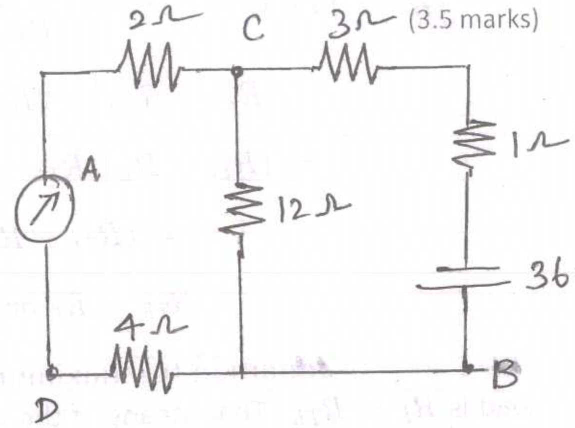
Equivalent resistance between points C and B is

$$= 12 * \frac{4}{16} = 3\Omega$$

Total circuit resistance = 2+3+4= 9Ω

Battery current =36/9 =4A

Ammeter current =4 $* \frac{12}{16} = 3A$



(3.5 marks)

Equivalent resistance between points C and D is

$$= 12 * \frac{6}{18} = 4\Omega$$

Total circuit resistance = 4+3+1= 8Ω

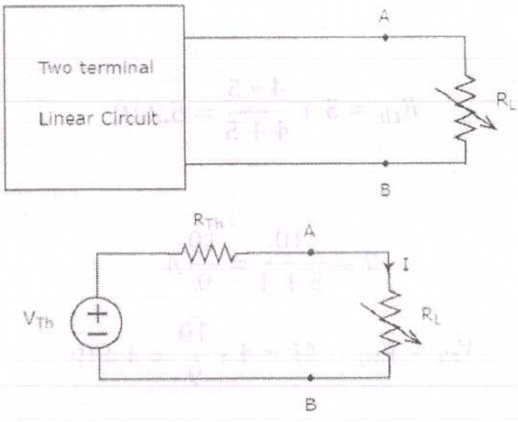
Battery current =36/8 =4.5A

Ammeter current =4.5 $* \frac{12}{16} = 3A$

Hence ammeter current in both the cases are same.

(3.5 marks)

VI a)



(3 marks)

The amount of power dissipated across the load resistor is

$$P_L = I^2 R_L$$

Substitute $I = \frac{V_{Th}}{R_{Th}+R_L}$ in the above equation.

$$P_L = \left(\frac{V_{Th}}{(R_{Th}+R_L)}\right)^2 R_L$$

$$\Rightarrow P_L = {V_{Th}}^2 \left\{\frac{R_L}{(R_{Th}+R_L)^2}\right\}$$ **Equation 1**

Condition for Maximum Power Transfer

For maximum or minimum, first derivative will be zero. So, differentiate Equation 1 with respect to R_L and make it equal to zero.

$$\frac{dP_L}{dR_L} = {V_{Th}}^2 \left\{\frac{(R_{Th}+R_L)^2 \times 1 - R_L \times 2(R_{Th}+R_L)}{(R_{Th}+R_L)^4}\right\} = 0$$

$$\Rightarrow (R_{Th}+R_L)^2 - 2R_L(R_{Th}+R_L) = 0$$

$$\Rightarrow (R_{Th}+R_L)(R_{Th}+R_L-2R_L) = 0$$

$$\Rightarrow (R_{Th}-R_L) = 0$$

$$\Rightarrow R_{Th} = R_L \; or \; R_L = R_{Th}$$

(3 marks)

Therefore, the **condition for maximum power** dissipation across the load is $R_L = R_{Th}$. That means, if the value of load resistance is equal to the value of source resistance i.e., Thevenin's resistance, then the power dissipated across the load will be of maximum value.

VI b) Thevenin's resistance (2 marks)

Rth =3+(4|| 5)

$$R_{th} = 3 + \frac{4*5}{4+5} = 5.22\Omega$$

Finding Voc (2 marks)

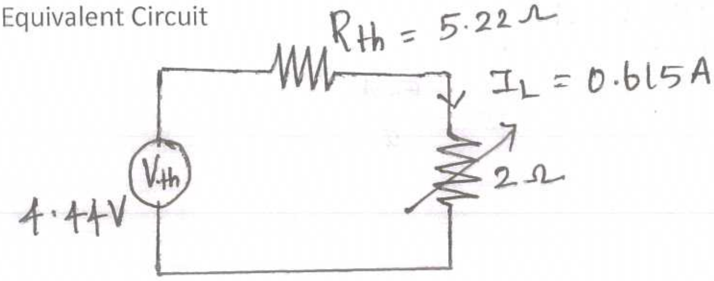
$$I = \frac{10}{5+4} = \frac{10}{9}A$$

$$V_{th} = V_{4\Omega} = 4I = 4*\frac{10}{9} = 4.44V$$

Current through 2Ω, (2 marks)

$$I_L = \frac{V_{th}}{R_L + R_{th}} = \frac{4.44}{2 + 5.22} = 0.615A$$

Thevenin's Equivalent Circuit (3 marks)



VII a) Elecric flux density= charge density =10^{-9} C/cm^2

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

Now (2 marks)

$$E = \frac{D}{\epsilon_0 \epsilon_{rt}} = \frac{V}{d}$$

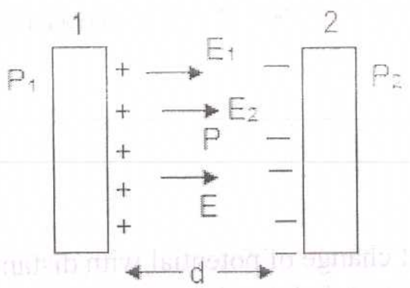
$$V = \frac{d}{\epsilon_0 \epsilon_r}$$

$$V = 0.015 * 10^{-2} * \frac{10^{-5}}{8.854 * 10^{-12} * 6} = 28.2V$$

(4 marks)

VII b)
Consider a parallel plate capacitor consisting of two large conducing plates held parallel to each other and separated by a small distance (d), (A>> d2),
A → area of each plate
if plate 1 carries a charge + Q and plate 2 carries - Q then, due to attraction the charges exist only on inner surfaces facing each other.

Let surface density of charge on 1 and 2 be σ_1=QA and σ_2=QA respectively.



(3 marks)

The electric field due to a plane charged sheet, at a point close to it in vacuum is $\sigma 2\epsilon_0$ directed normal to the surface.

The field at a point P between the plates then is:
E= $E_1 + E_2 = \sigma 2\epsilon 0 + \sigma 2\epsilon 0 = \sigma\epsilon 0 \rightarrow (1)$ (2marks)
along the direction from (1) to (2), due to both plates.

The work done in moving a unit positive charge from the negative to positive plate against field is Ed. Which is by definition `V' or the potential difference between the plates.

Hence, we have V = Ed = Q dϵ_0A→(2) (2 marks)

∴ Capacitance of the parallel plate capacitor is

$$C = QV = \frac{\epsilon_0 A}{d}$$

(2 marks)

VIII a)

The energy stored in a capacitor is nothing but the electric potential energy and is related to the voltage and charge on the capacitor. If the capacitance of a conductor is C, then it is initially uncharged and it acquires a potential difference V when connected to a battery. If q is the charge on the plate at that time, then

$q = CV$

The work done is equal to the product of the potential and charge. Hence, $W = Vq$

If the battery delivers a small amount of charge dQ at a constant potential V, then the work done is

$dW = Vdq = \frac{q}{C}dq$

Now, the total work done in delivering a charge of an amount q to the capacitor is given by

$W = \int_0^q \frac{q}{C}dq = \frac{1}{C}\frac{q^2}{2} = \frac{1}{2}\frac{q^2}{C}$

Therefore the energy stored in a capacitor is given by

$U = \frac{1}{2}\frac{q^2}{C}$

Substituting

$q = CV$

in the equation above, we get

$U = \frac{1}{2}CV^2$

The energy stored in a capacitor is given by the equation

$U = \frac{1}{2}CV^2$

VIII b)

a) Potential gradient (2 marks)

It is defined as the rate of change of potential with distance in the direction of electric force E=-dv/dx. The electric intensity at any point is equal to the negative potential gradient at that point

b) Electric flux density (2 marks)

The number of electric field lines or electric lines of force flowing perpendicular through a unit surface area is called electric flux density. Electric flux density is represented as D, and its formula is D=ϵE

c)Breakdown voltage (2 marks)

X b)

$\mu_r = 980$

$l = 120\,cm = 120 \times 10^{-2}\text{m}$

$A = 10\,cm^2 = 10 \times 10^{-4}\,m^2$

$I = 0.3\,A$

$\Phi = 40\mu\text{Wb} = 40 \times 10^{-6}\text{Wb}$

$$S = \frac{l}{\mu_0 \mu_r A}$$

$$= \frac{120 \times 10^{-2}}{4\pi \times 10^{-7} \times 980 \times 10 \times 10^{-4}}$$

$= 97{,}491.23\text{AT/Wb}$ (3 Marks)

$$\Phi = \frac{\mathcal{E}}{S}$$

$$N = \frac{\Phi S}{I}$$

$$= \frac{40 \times 10^{-6} \times 97{,}491.23}{0.3}$$

$= 12.998$

$= 13$ (3 Marks)

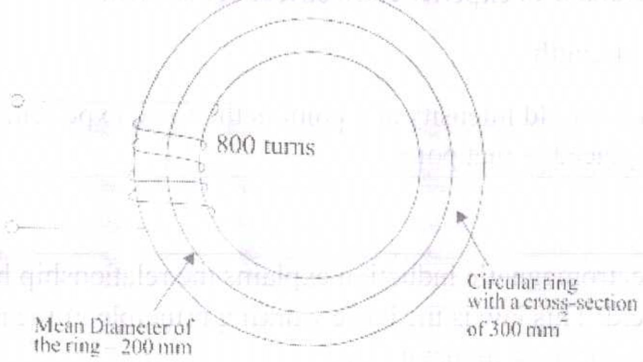
$$\text{Energy} = \frac{1}{2} L I^2$$

$$= \frac{1}{2} \times 1.733 \times 10^{-3} \times (0.3)^2$$

$= 7.8 \times 10^{-5}\text{J}$

$= 78\mu\text{J}$ (3 Marks)

IX b)



With a current of 2 amp

Coil m.m.f. = 800 × 2 = 1600 AT

Mean length of path = π × 0.2

= 0.628 m

(i) H = 1600/0.628 = 2548 amp-turns/meter (3 Marks)

(ii) $B = \mu_0 \mu_r H = 4\pi \times 10^{-7} \times 1 \times 2548$ (3 Marks)

$= 3.20 \times 10^{-3}$ Wb/m²

This Flux density is produced by a coil current of 2-amp

(iii) For producing a flux of 0.02 Wb/m², the coil current required is (3 Marks)

2 x 0.02/0.0032 = 12.5 amp

X a)

Dynamically induced emf	Statically induced emf
Emf induced in the coil is due to physical movement of magnetic field or coil	Emf induced in the coil is due toflux link with the coil changes
There is physical motion of conductors	There is no physical motion of conductors
E=BIv sinΘ	E=-N dφ/dt
Current through electromagnet remain constant	Current through electromagnet must vary with respect to time
Examples : Alternator, Dc generator	Examples: Induction motor, transformer

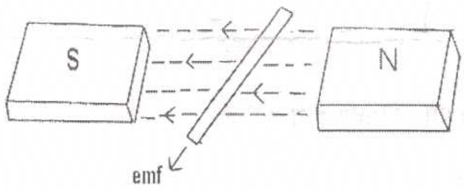
The breakdown voltage of an insulator is the minimum voltage that causes a portion of an insulator to experience electrical breakdown

d)Electric field strength (2 marks)

The electric field intensity at a point is the force experienced by a unit of positive charge placed at that point.

IX a)

Faraday's laws of of electromagnetic induction explains the relationship between electric circuit and magnetic field. This law is the basic working principle of the most of the electrical motors, generators, transformers, inductors etc.



Faraday's First Law: (3 marks)
Whenever a conductor is placed in a varying magnetic field an EMF gets induced across the conductor (called as induced emf), and if the conductor is a closed circuit then induced current flows through it.
Magnetic field can be varied by various methods -
1. By moving magnet
2. By moving the coil
3. By rotating the coil relative to magnetic field

Faraday's Second Law:

Faraday's second law of electromagnetic induction states that, the magnitude of induced emf is equal to the rate of change of flux linkages with the coil. The flux linkages is the product of *number of turns* and *the flux associated with the coil.*

The EMF induced in the conductor is equal to the rate of change of flux linkage.

$$\therefore e = \frac{N(\phi_2 - \phi_1)}{t} \quad ..1$$

In differential form,

$$e = N\frac{d\phi}{dt} \quad ..2$$

(3 marks)

Where, $\phi = \phi_2 - \phi_1$, the total change in magnetic flux.