Summer – 2017 Examinations

Model Answer **Subject Code: 17214 (FEE)**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner should assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner should give credit for any equivalent figure/figures drawn.

5) Credits to be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer (as long as the assumptions are not incorrect).

6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept

I	Attempt **any ten** of the following:	**(10×2=20)**
I 1)	Define resistance. Also mention the factors upon which it depends. **Ans:** **Resistance**: It is the opposition offered by substance to the electric current passing through it.	1 Mark
	Factors on which resistance depends: i) Nature of material ii) Length of conductor iii) Cross sectional area of conductor iv) Temperature of conductor	1 Mark
I 2)	What is internal voltage drop and terminal voltage? **Ans:** **Internal voltage drop (I.r):** Voltage drop across internal resistance of the source is known as internal voltage drop. **OR** Potential difference between Emf induced across terminals of battery at no load (I=0 amp)and Terminal voltage when external load is connected is known as internal voltage drop $I \times r = E - V$ **OR** When source delivers current to load, the current flowing through the internal resistance causes voltage drop across it. This voltage drop is called 'Internal Voltage Drop'. **Terminal voltage (V):** Terminal voltage of a cell is the potential difference across its terminals when it is delivering a current to the external load.	1 Mark for each Definition = 2 Marks
I 3)	State any two features of carbon composition resistors. **Ans:** **Features of Carbon composition resistance:** i) Low cost ii) Wide resistance range (ohm to mega ohm) iii) Wide range of working voltage iv) Simple in construction	1 Mark for each of any two features = 2 Marks
I 4)	State Ohm's law. Also express it in the form of equation. **Ans:** **Ohm's Law**- As long as physical conditions (such as dimensions, pressure and temperature) are constant, the potential difference or voltage applied across the conductor is directly proportional to current flowing through it.	1 Mark
	i.e $V \propto I$ **or** $V = RI$ where R = constant of proportionality, called as the resistance of the conductor.	1 Mark
I 5)	What is dielectric strength of an insulating material? What is its unit? **Ans:** **Dielectric Strength**: The dielectric strength of an insulating material is the maximum voltage which the insulating medium can withstand without breakdown.	1 Mark

Unit is volts per millimeter (V/mm), or kV/mm or kV/cm — 1 Mark

I 6) State any two applications of electromagnet.

Ans:

Applications of Electromagnet:

Cranes, Motors, Generators, Transformers, Electromagnetic Relays, Circuit breakers, Traction, Measuring instruments, Electrical Bell etc.

Any two 1 Mark each = 2 Marks

I 7) Define magnetic lines of force. Also draw and show magnetic lines of force of a bar type magnet**.**

Ans:

Magnetic Lines of force- These are the imaginary lines (having no physical existence) introduced by Faraday for the pictorial representation of the distribution of a magnetic field.

Definition 1 Mark

OR

A line of force is defined as a line along which an isolated N-pole would travel if free to move in a magnetic field and it is such that the tangent at any point gives direction of the resultant force at that point.

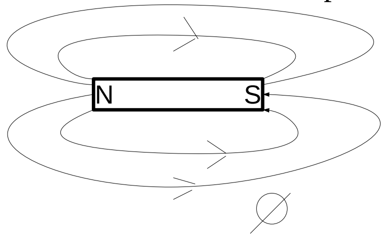


Diagram 1 Mark

I 8) State Lenz's law.

Ans:

Lenz's law: It states that the direction of statically induced emf is such that it always opposes the cause that produces it.

In fact, the induced emf produces current, which produces magnetic flux and this magnetic flux opposes the changing magnetic field that is responsible for emf induction.

2 Marks

I 9) Classify electrical materials.

Ans:

Classification of electrical materials:

i) Conducting Materials
ii) Insulating materials
iii) Magnetic materials
iv) Semiconducting materials

2 Marks

I 10) State Faradays laws of electromagnetic induction.

Ans:

Faraday's laws of electromagnetic induction:

First law: When a conductor cuts the magnetic flux or a changing magnetic field links with a conductor, an emf is induced in the conductor. — 1 Mark

Second law: The magnitude of emf induced in the conductor is directly proportional to the rate of change of flux linking with conductor. — 1Mark

i.e $e = -N\, d\emptyset\, /dt$.

I 11) What is Amorphous metal? Give one application of this metal.

Ans:

Amorphous Metals:

Amorphous Metals means materials that do not possess a particular structure. Metal alloys typically possess crystalline atomic structure. The atoms are arranged in particular order with repetitive pattern. The amorphous metal alloys differ in crystalline structure. The atoms are arranged in random configuration. — 1 Mark for definition

Applications-

a) Making nanocomposites for field electron emission devices.
b) Manufacturing cores of high efficiency distribution transformers
c) Manufacturing cores of special transformers
d) Manufacturing magnetic sensors
e) Magneto-motive sensors

1 Mark for any one application

I 12) State the factors affecting hysteresis loss.

Ans:

i) Flux density
ii) Frequency
iii) Volume of the magnetic material
iv) Nature of magnetic material

½ Mark for each of any four = 2 Marks

II Attempt **any four** of the following: **(4×4=16)**

II 1) Why is Source conversion needed? Also explain how voltage source can be converted into an equivalent current source. Explain with suitable figures.

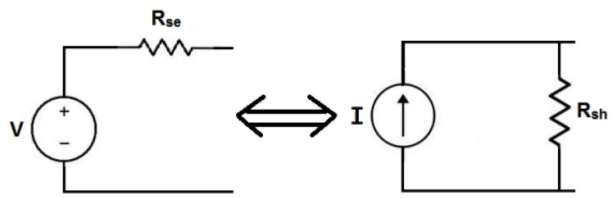
Ans:

Need of Source Conversion:

- To simplify complex electrical network.
- To find equivalent source (voltage or current) in network.
- To facilitate network analysis.

1 Mark

Source Conversion:



1 Mark

Practical voltage source can be converted to equivalent current source & vice versa.

R_{se} and R_{sh} are internal resistance of sources. The equivalent current source is given by,

$$I = \frac{V}{R_{se}}$$ 1 Mark

And internal resistance of current source is given by,

$$R_{sh} = R_{se}$$ 1 Mark

II 2) A potential difference of 200 V is applied to copper field coil at a temperature of 15ºC and the current is 10 A. What will be the mean temperature of the coil when the current has fallen to 5A, the applied voltage being the same as before? $\boldsymbol{\alpha_{15} = \frac{1}{534.5} /°C}$

Ans:

Given:

At temperature t_1 = 15°C, V = 200V and I = 10A

∴ R_{15} = Resistance of the coil at 15°C = V/I = 200/10 = **20Ω**

At temperature t_2 = t°C, V = 200V and I = 5A

∴ R_t = Resistance of the coil at t°C = V/I = 200/5 = **40Ω**

Resistance-temperature coefficient at 15°C $\alpha_{15} = \frac{1}{534.5} /°C$

Considering the temperature rise from 15°C to t°C, the resistance of the coil changes from 20Ω to 40Ω. The resistance of coil at t°C can be expressed as, — Stepwise solution 4 Marks

$$R_t = R_{15}\{1 + \alpha_{15}(t - 15)\}$$

$$40 = 20\{1 + \frac{1}{534.5}(t - 15)\}$$

$$\frac{40}{20} = 2 = 1 + \frac{1}{534.5}(t - 15)$$

$$1 = \frac{1}{534.5}(t - 15)$$

$$(t - 15) = 534.5$$

∴ t = 519.5 °C

OR

The resistance-temperature coefficient at 15°C is given by,

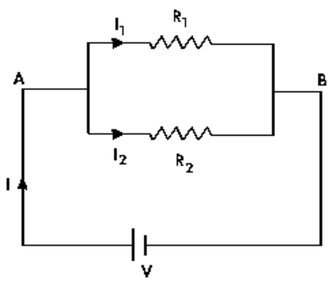
$$\alpha_{15} = \frac{R_t - R_{15}}{R_{15}(t - 15)} /°C$$

$$\frac{1}{534.5} = \frac{40 - 20}{20(t - 15)}$$

$$(t - 15) = 534.5$$

∴ t = 519.5 °C

II 3) Prove that $I_1 = \frac{IR_2}{R_1 + R_2}$ in the parallel combination of two resistors R_1 and R_2.



Ans:

$I_1 = \frac{V}{R_1}$ $I_2 = \frac{V}{R_2}$ $\frac{I_1}{I_2} = \frac{R_2}{R_1}$ — 1 Mark for eq. of I_1 and I_2

Hence, the division of currents in two branches of a parallel circuit is inversely proportional to their resistances. Current in branch can also be expressed in terms of total current drawn by the circuit.

$$V = IR = I_1 \times R_1 = I_2 \times R_2$$ — 1 Mark

Where, R is the equivalent resistance of parallel combination of R_1 and R_2.

$$I_1 = I \times \frac{R}{R_1}$$ — 1 Mark

But, Equivalent resistance = $R = \frac{R_1 R_2}{R_1 + R_2}$

$$I_1 = I \times \frac{R_2}{R_1 + R_2}$$ — 1 Mark

II 4) State and explain Kirchhoff's current law and voltage law.

Ans:

Kirchhoff's laws:

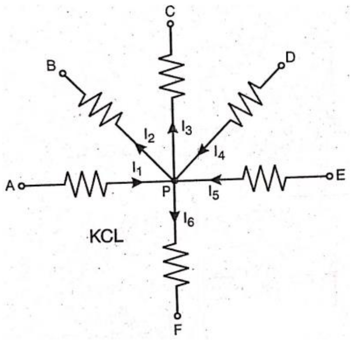
1) **Kirchhoff's Current Law (KCL):**

It states that in any electrical network, the algebraic sum of the currents meeting at a node (point or junction) is zero.

i.e $\Sigma I = 0$

At junction point P,

$I_1 - I_2 - I_3 + I_4 + I_5 - I_6 = 0$



2 Marks

Sign convention:

Incoming current at the node is considered to be positive and outgoing current to be negative.

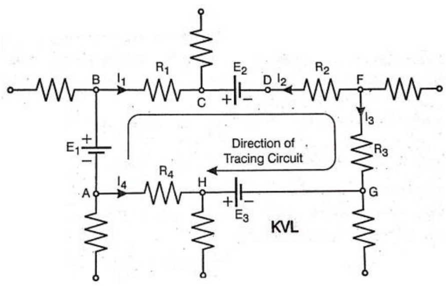
2) **Kirchhoff's Voltage Law (KVL):**

It states that, in any closed path in an electric circuit, the algebraic sum of the emfs and products of the currents and resistances is zero.

i.e $\Sigma E - \Sigma IR = 0$ or $\Sigma E = \Sigma IR$

OR

It states that, in any closed path in an electrical circuit, the total voltage rise is equal to the total voltage drops.



2 Marks

i.e Voltage rise = Voltage drop

Referring to the circuit, by KVL we can write,

$(E_1 - E_2 + E_3) = (I_1R_1 - I_2R_2 + I_3R_3 - I_4R_4)$

Sign convention:

While tracing the loop or mesh, the voltage rise is considered as positive and voltage drop is considered as negative.

II 5) Two batteries A and B are connected in parallel and a load of 10 ohm is connected across their terminals. A has an e.m.f. of 12V and an internal resistance of 2 ohm, B has an emf of 8V and an internal resistance of 1 ohm. Use Kirchhoff's laws to determine the values and direction of the currents flowing in each of the batteries and in the external resistance. Refer fig. 1.

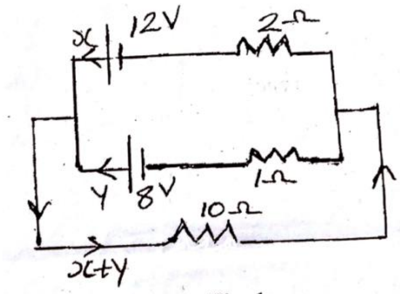
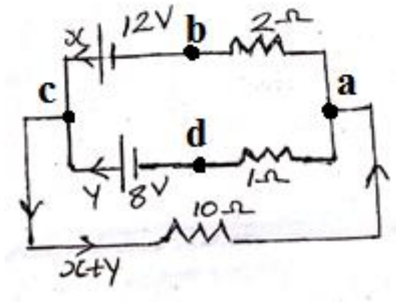


Fig. 1

Ans:



Apply KVL to
Loop abca

$$-2x + 12 - 10(x+y) = 0$$

$$12x + 10y = 12 \ldots\ldots\ldots\ldots\text{(i)}$$

1 Mark

Loop adca

$$-1y + 8 - 10(x+y) = 0$$

$$10x + 11y = 8 \ldots\ldots\ldots\ldots\text{(ii)}$$

1 Mark

By solving equation (i) and (ii).

$$y = \frac{-12}{16}$$

$$\boldsymbol{y = -0.75\ amp}$$

½ Mark

Direction of actual current y is opposite to that shown in figure.
By substituting $y = -0.75\ amp$ in equation (i)

$$12x + 10 \times (-0.75) = 12$$

$$\boldsymbol{x = 1.62\ amp}$$

½ Mark

Current through resistance 10 ohm = **(x+y)** = 1.62 - 0.75 = **0.875 amp** 1 Mark

II 6) Define the following terms of a magnetic circuit:
a) MME b) Ampere turns c) Reluctance d) Permeance
Ans:

- **i)** ~~**MME**~~ **(MMF):** It is the force that drives magnetic flux through magnetic circuit. It is measured in amp-turns. 1 Mark
- **ii)** **Ampere Turns**: It is the product of current I through a coil having number of turns N. It is the magneto-motive force (MMF) which sets up the magnetic flux in the magnetic circuit. 1 Mark

  Amp–turns = I × N
- **iii)** **Reluctance:** The opposition offered by magnetic circuit to establish magnetic flux in it, is called as "Reluctance". Its unit is AT/weber. 1 Mark
- **iv)** **Permeance:** It is the reciprocal of reluctance and implies the readiness with which magnetic flux is developed. It is measured in weber/AT. 1 Mark

III Attempt **any four** of the following: **(4×4=16)**

III1) Derive the equation to find capacitance of a capacitor having medium partly air.
Ans:
As shown in figure, the medium consists partly air parallel sided dielectric slab of thickness 't' and relative permittivity ϵ_r.
The electric flux density D = Q/A is the same in both media.
But electric intensities are different.

$E_1 = \frac{D}{\epsilon o \epsilon r}$ ……………………….. in the dielectric medium

$E_2 = \frac{D}{\epsilon o}$ ……………………….. in the air

1 Mark for E_1 and E_2

P.D. between plates,

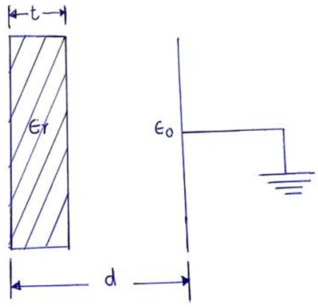
$V = E_1.t + E_2(d - t)$

$= \frac{D}{\epsilon o \epsilon r} \times t + \frac{D}{\epsilon o} \times (d - t)$

$= \frac{D}{\epsilon o} (\frac{t}{\epsilon r} + d - t)$

$= \frac{Q}{\epsilon o A} [d - (t - \frac{t}{\epsilon r})]$

1 Mark for V



1 Mark for diagram

$\therefore \frac{Q}{V} = \frac{\epsilon o.A}{[d - (t - \frac{t}{\epsilon r})]}$

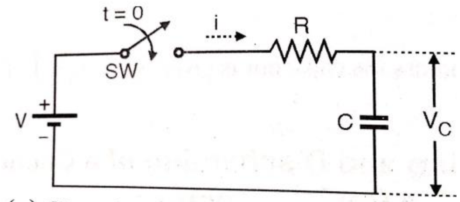
$\therefore$ Capacitance $C = \frac{Q}{V} = \frac{\epsilon o.A}{[d - (t - \frac{t}{\epsilon r})]}$

1 Mark for C

III2) Draw the arrangement by which a capacitor C may be charged through a resistance R and explain it in brief.

Ans:

Charging of a capacitor:



(a) **Charging circuit of a capacitor**

1 Mark for circuit diagram

Fig(a) shows the circuit arrangement for charging of capacitor through a resistor. Here R and C are in series, V is the DC voltage source and SW is the switch. When switch SW is closed, say at time instant t=0, the DC voltage is supplied to RC combination. At t=0, the capacitor acts as short circuit. So the voltage across capacitor is zero. The full supply voltage appears across resistance R. Therefore, the current is given by,

$$i_c(0) = I_0 = \frac{V}{R}$$

The voltage across capacitor slowly builds up exponentially and finally reaches to Supply voltage V at instant t→∞. The initial charging current falls exponentially to zero as t→∞.

2 Marks for explanation

The voltage across the capacitor at any instant t is given by,

$v_c = V(1 - e^{-\frac{t}{\tau}})$

Where, V is the maximum voltage to which capacitor can charge (supply voltage)

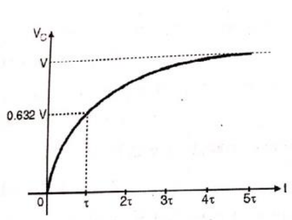
τ = RC = charging time-constant of the circuit.

The instantaneous charging current is given by,

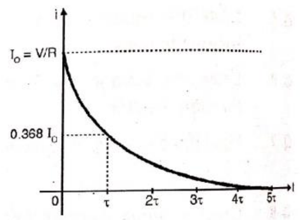
$$i_c = I_0 e^{-\frac{t}{\tau}}$$

where, I_0 is the maximum current at instant t = 0

The charging curves for voltage and current are shown in the fig (b) and (c) respectively.



(b) Variation in capacitor voltage while charging



(c) Variation in capacitor current while charging

1 Mark for curves

III3) Three capacitors A, B, C have capacitances 10, 50 and 25 μF respectively. Calculate (a) charge on each when connected in parallel to a 250 V supply (b) Total capacitance.

Ans:

Given C_1 = 10μF, C_2 = 50μF, C_3 = 25μF in parallel with 250Vsupply

$Q_1 = C_1 V$ = 10 x 250 = **2500 μC**

$Q_2 = C_2 V$ = 50 x 250 = **12500 μC**

$Q_3 = C_3 V$ = 25 x 250 = **6250 μC**

1 Mark each charge = 3 Marks

Total capacitance (C_T) = $C_1 + C_2 + C_3$ as capacitors are in parallel

= 10 + 50 + 25 = **85μF** 1 Mark

III4) A 50 μF capacitor is charged from a 200V supply. After being disconnected, it is immediately connected in parallel with 30 μF capacitor. Find (a) p.d across the combination (b) the electrostatic energies before and after the capacitors are connected in parallel.

Ans:

Given: C = 50 μF is charged by 200 V

The charge on 50 μF capacitor is, Q = CV = 50 x 200 = 10000 μC 1 Mark for Q

When the two capacitor are connected in parallel, the equivalent or total capacitance is, C_t = 50 + 30 = 80 μF

Since second capacitance of 30 μF is uncharged before connection, the net charge after parallel connection remains same as that was on 50μF, however it gets distributed on 50 μF and 30 μF.

a) P.d. across the combination:

V_T = Charge / total capacitance = Q / C_t

= 10000/80 = 125V

1 Mark for V_T

b) Electrostatic energy before the connection:

$= ½ C V^2 = ½ \times 50 \times 10^{-6} \times 200^2$ = 1 joule 1 Mark

c) Electrostatic energy after the connection:

$= ½ C_t V_T^2 = ½ \times 80 \times 10^{-6} \times 125^2$ = 0.625 joule 1 Mark

III5) What is magnetic hysteresis? What is the cause of hysteresis?

Ans:

Magnetic hysteresis: When a magnetic material is subjected to cycle of magnetization, it is found that flux density (B) in the material lags behind applied magnetizing force (H). This phenomenon is known as magnetic hysteresis. 2 Marks

Cause: This is due to non-linear relationship between magnetic field intensity and magnetic flux density. When we attempt to produce magnetic field through magnetic material, the domains orient along the direction of field. The magnetic material has tendency to oppose the movement of orientation, due to which the flux density lags behind the magnetic field 2 Marks intensity.

III6) Define the following terms as referred to battery.

a) E.M.F
b) Internal resistance
c) Ah efficiency
d) WAh efficiency

Ans:

a) **E.M.F :**

The electromotive force of a battery is defined as the energy spent or the work done in taking a unit positive charge around the complete circuit of the battery i.e., in the circuit outside the cell as well as in the electrolyte inside the cell. 1 Mark

When no current is drawn from a battery i.e. when the battery is in open-circuit condition, then potential difference between the terminals of the battery is its E.M.F.

b) **Internal resistance:**

The resistance within the source that causes a drop in the source voltage when load current flows, is called internal resistance. 1 Mark

c) **AH efficiency:**

Ampere-hour efficiency of a battery is defined as the ratio of the output of battery in amp-hr during discharging to the input amp-hr of battery during charging. 1 Mark

$$\eta_{Ah} = \frac{amp - hours\ during\ discharge}{amp - hours\ during\ charge}$$

$$= \frac{I_d T_d}{I_c T_c}$$

where, Id be the discharge current,
Td be the time of discharge,
Ic be the charging current,
T_c be the time of charging

d) **~~WAh~~ Watt – Hr efficiency:**

The ratio of the output of a battery, measured in watt-hours, to the input required to restore the initial state of charge, under specified conditions, is called Watt-hr efficiency. 1 Mark

$$\eta_{Wh} = \frac{watt\ hours\ during\ discharge}{watt\ hours\ during\ charge}$$

$$= \frac{I_d T_d V_d}{I_c T_c V_c} = \eta_{Ah} \frac{V_d}{V_c}$$

where, Vd be the average potential difference (voltage) of battery during discharge,
Vc be the average potential difference (voltage) of battery during charging.

IV Attempt **any four** of the following: **16**

IV 1) State any two harmful effects of hysteresis loss. Also draw hysteresis loop for (a) non-magnetic material (b) hard steel

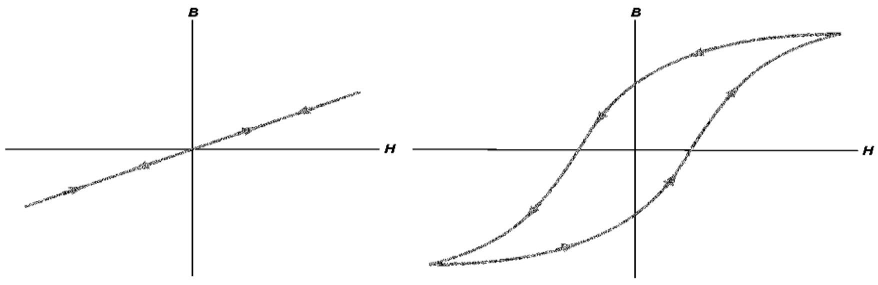
Ans:

Harmful effects of hysteresis loss:

1) Hysteresis loss results in a dissipation of energy which appears as a heating of the magnetic material.
2) It creates buzzing sound.
3) Develops vibrations in core

1 Mark for each of any two = 2 Marks

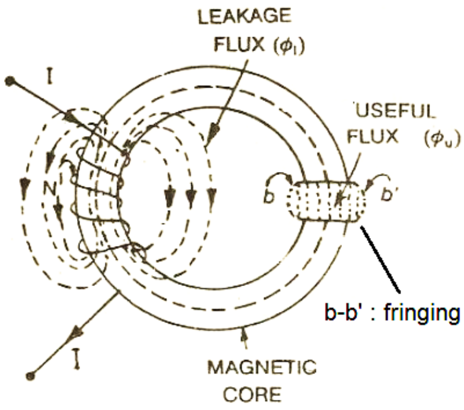
Hysteresis loop:



1 Mark for each = 2 Marks

IV 2) With the help of diagram, explain the concept of leakage flux, useful flux and fringing.

Ans:



1 Mark

Leakage flux: Some flux while passing through the magnetic circuit, leaks through the air surrounding the core. This flux is called as leakage flux. 1 Mark

Useful flux: The flux in the air gap which is actually utilized for various purposes depending upon the application is called as useful flux 1 Mark

Fringing : When the magnetic flux passing or crossing an air gap tends to bulge outwards the iron ring, this effect is called as fringing 1 Mark

IV 3) A mild steel ring having a cross-sectional area of 5 cm^2 and mean circumference of 40 cm has a coil of 200 turns wound uniformly around it.

Calculate:
a) Reluctance of the ring
b) Current required to produce a flux of 800 μWb in the ring.
Assume relative permeability of mild steel as 380.

Ans:
Data Given:
Cross-sectional area of ring a = 5 cm^2 = 5×10^{-4} m^2
Length of magnetic path l = Mean circumference = 40 cm = 0.4 m
No. of turns N = 200
Relative permeability of mild steel μ_r = 380
Permeability of free space $\mu_0 = 4\pi\times10^{-7}$ H/m
Flux ϕ = 800 μWb = 800×10^{-6} Wb

a) Reluctance (S) = $\frac{l}{\mu_0 \mu_r a} = \frac{0.4}{4\pi \times 10^{-7} \times 380 \times 5 \times 10^{-4}}$ 1 Mark

$= \mathbf{1675315.19\ AT/Wb}$ 1 Mark

MMF = S x ϕ = 1675315.19 × 800 × 10^{-6} = 1340.25 AT 1 Mark

b) Current I = MMF/N = 1340.25/200 = **6.7 amp** 1 Mark

IV 4) In the network of resistance shown in fig.2 calculate the network resistance measured between B and C.

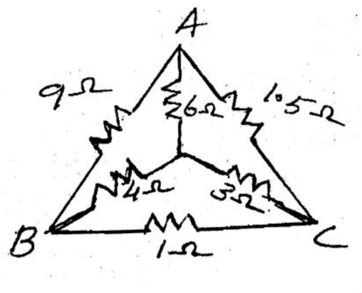
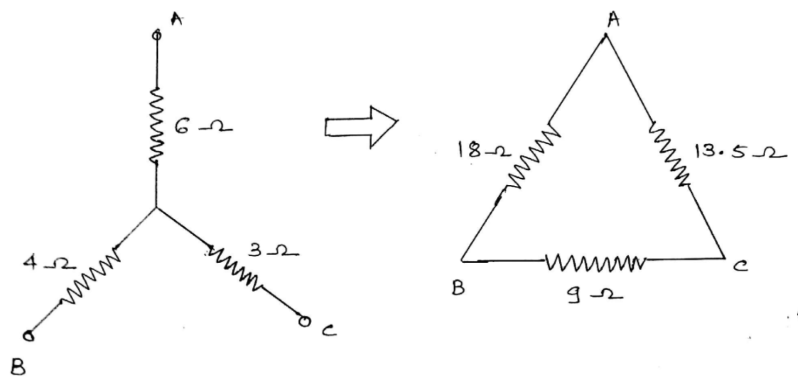


Fig. 2

Ans:
Step 1: Converting Inner Star into equivalent Delta



$$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$$

$$= 6 + 4 + \frac{6 \times 4}{3} = 18\,\Omega$$

$$R_{BC} = R_B + R_C + \frac{R_B R_C}{R_A}$$

$$= 4 + 3 + \frac{4 \times 3}{6} = 9\,\Omega$$

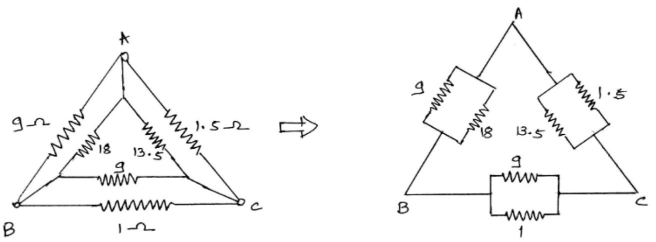
$$R_{CA} = R_C + R_A + \frac{R_C R_A}{R_B}$$

1 Mark

$$= 6 + 3 + \frac{6 \times 3}{4} = 13.5\,\Omega$$

Step 2: Modified Network

Inner equivalent delta appears in parallel with outer delta.



Step 3: Solving Parallel Combinations

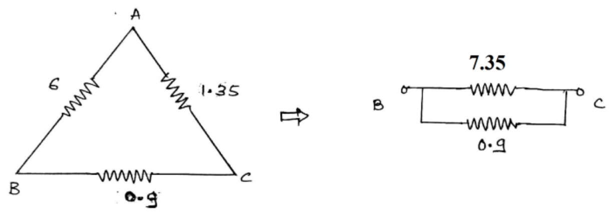
Resistance between AB $= \frac{9\times18}{9+18} = 6\,\Omega$

Resistance between BC $= \frac{9\times1}{9+1} = 0.9\,\Omega$

Resistance between CA $= \frac{1.5\times13.5}{1.5+13.5} = 1.35\,\Omega$

1 Mark

Step 4:



Between B and C, we have two parallel branches:

1 Mark

One has 6Ω in series with 1.35Ω and other branch has only one resistor of 0.9Ω.

Thus R_{BC} = (6+1.35) || 0.9 = 7.35 || 0.9 = **0.802Ω**

1 Mark

IV 5) Write down any three similarities between electric and magnetic circuits. Also give one important dissimilarity

Ans

Similarities between Electric and Magnetic Circuits:

Sr. No.	Electric circuit	Magnetic circuit
1	Current: flow of electrons through conductor is current, It is measured in amp.	Flux: lines of force through medium from N pole to S pole form flux. It is measured in weber.
2	EMF: It is driving force for current, measured in volts.	MMF: It is driving force for flux, measured in amp-turn.
3	Resistance: It is opposition of conductor to current, measured in ohms	Reluctance: It is opposition offered by magnetic path to flux, measured in AT/wb.
4	Resistance is directly proportional to length of conductor.	Reluctance is directly proportional to length of magnetic path.
5	For electric circuit we define the conductivity.	For magnetic circuit we define permeability.
6	Electric circuit is closed path for current.	Magnetic circuit is closed path for magnetic flux.
7	For electric circuit I = EMF/resistance	For magnetic circuit Φ = MMF/reluctance
8	Voltage = IR	M M F = Φ S
9	Resistivity	Reluctivity

1 Mark for each of Any three similarities = 3 Marks

Dissimilarities between Electric and Magnetic Circuits:

Sr. No.	Electric circuit	Magnetic circuit
1	Electric current flows	Flux does not actually flow (it only gets established or set up)
2	Energy is needed continuously for the flow of current.	Energy is only needed for establishment of field (flux).
3	Current cannot pass through the insulators.	Flux can pass through almost all things including air.
4	Electrical Insulator is available	Magnetic Insulator does not exist.

1 Mark for Any one dis-Similarity = 1 Mark

IV6) Classify insulating materials on the basis of state of material. Give two example of each.

1 Mark for classification

Ans:

Classification of insulating materials:

½ Mark for each of any two examples of each = 3 Mark

1) Solid insulating materials: wood, rubber, plastic, PVC, glass, porcelain, mica, Polypropylene film etc.
2) Liquid insulating materials: transformer oil, condenser oil, (both are mineral oils), synthetic insulating oil etc.
3) Gaseous insulating materials: Hydrogen, SF6, Nitrogen, Air.

V Attempt **any four** of the following: **16**

V 1) Define self-inductance and mutual inductance. Also write one equation for each.

Ans:

Self-inductance: It is the property by virtue of which a coil opposes change in current flowing through it by inducing an emf in it such that its effect is to circulate current (induced current) that produces a magnetic field which opposes the change in the field. 1 Mark for definition

Equation for self-inductance:

$L = N\frac{d\emptyset}{di}$ OR $L = \frac{N\emptyset}{I}$ OR $L = \frac{N^2}{S}$ 1 Mark for equation

where, L is the coefficient of self-inductance,
N is the no. of turns of coil,
$d\emptyset$ is the change in the flux,
di is the change in current,
S is the reluctance of magnetic path.

Mutual inductance: The ability of the coil 1 having changing current to induce an emf in a neighbouring coil 2 is called as mutual inductance. 1 Mark for definition

Equation for mutual inductance:

$M = N_2\frac{d\emptyset_{12}}{di_1}$ OR $M = \frac{N_2\emptyset_{12}}{I_1}$ OR $M = \frac{N_1N_2}{S}$ 1 Mark for equation

where, M is the coefficient of mutual inductance,
N_1 is the no. of turns of coil 1,
N_2 is the no. of turns of coil 2,
$d\emptyset_{12}$ is the change in the flux produced by coil 1 and linking with coil 2,
di_1 is the change in current in coil 1,
S is the reluctance of magnetic path.

V 2) Compare statically induced emf with dynamically induced emf on any four points.

Ans:

Comparision between statically induced emf and dynamically induced emf:

Sr.No.	Particulars	Statically induced emf	Dynamically induced emf
1	Movement of coil or magnet	Neither coil nor magnet moves	Either coil moves or magnet moves.
2	Current through coil of electromagnet	Must vary with respect to time	Can remain constant.
3	Expression for induced voltage	e = - L(di/dt) or -N(dΦ/dt)	e = Blv sinΘ
4	Applications	Transformer	DC generators, Back emf in DC motors, Induction motors.

1 Mark for each of any 4 points = 4 Marks

5	Types	i) Self-induced emf ii) Mutual-induced emf	No sub-types

V 3) Derive an expression for energy stored in a magnetic field .

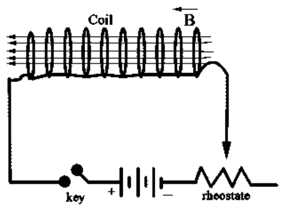
Ans:

Expression for energy stored in a magnetic field:

The energy is stored in magnetic field when current increases and return back when the current decreases.

At instant 't' seconds after closer of switch (Refer Fig.), let the current be 'I' amperes. If current increases by di amperes in dt seconds, then e.m.f. induced in the coil is given by,

e = - L (di/ dt) volts



The e.m.f. opposes the current and energy drawn from the source.

Component of applied voltage to neutralize the induced e.m.f. = - e volts.

Therefore Energy absorbed by the magnetic field during dt seconds

= Power x Time = (-e) idt = L (di/dt) × i × dt = L i di joules

Hence total energy absorbed by the magnetic field when current increases from 0 to I amperes

Stepwise derivation = 4 Marks

$$E = L\int_0^I i\,di = L[\frac{1}{2}i^2]_0^I = \frac{1}{2}LI^2$$

$\therefore$ E = ½ L I^2 joules

OR any other equivalent method

V 4) Calculate the inductance of a solenoid of 2000 turns wound uniformly over length of 50 cm on a cylindrical paper tube 4 cm in diameter. The medium is air.

Ans:

Given: N = 2000, l = 50 cm = 0.5m, r = 2cm = 0.02m

Step 1: Calculate reluctance S

Cross sectional area of the tube is , a = π r^2= π× $(0.02)^2$ 1 Mark

= $\mathbf{1.256\times 10^{-3}\ m^2}$

Reluctance S = $\frac{l}{\mu o\ \mu r\ a} = \frac{0.5}{4\pi\times10^{-7}\ \times1\times1.256\times10^{-3}}$ = **316.78**$\times \mathbf{10^6}$ **AT/Wb** 1 Mark

Step 2: Calculate Inductance:

L= $\frac{N^2}{S} = \frac{(2000)^2}{316.78\times10^6}$ 1 Mark

= **0.01262 H = 12.62 mH**

1 Mark

V 5) State any four advantages of A. C. over D. C .

Ans:

Advantages of AC over DC:

i) It is possible to use a transformer.
ii) Distribution efficiency is high.
iii) Generation is easy and economical.
iv) Construction of ac equipment/ machines is robust and simple.
v) Installation is less costly.
vi) AC switchgears are simple in construction and operation.
vii) AC system is economical than DC system.
viii) AC system is safer than DC system.

Any four advantages 1 mark each = 4 Marks

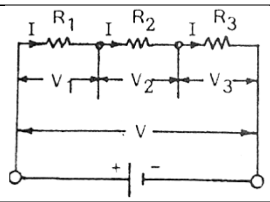
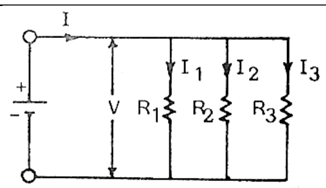
OR

Any equivalent answer.

V 6) Compare series resistive circuit with parallel circuit on any four points.

Ans:

Comparison between Series and Parallel Circuits:

Sr. No.	Series Circuit	Parallel Circuit
1		
2	A series circuit is that circuit in which the current flowing through each circuit element is same.	A parallel circuit is that circuit in which the voltage across each circuit element is same.
3	The sum of the voltage drops in series resistances is equal to the applied voltage V. $\therefore V = V_1+V_2+V_3$	The sum of the currents in parallel resistances is equal to the total circuit current I. $\therefore I = I_1+I_2+I_3$
4	The effective resistance R of the series circuit is the sum of the resistance connected in series. $R = R_1 + R_2 + R_3 + \cdots$	The reciprocal of effective resistance R of the parallel circuit is the sum of the reciprocals of the resistances connected in parallel. $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$
5	$I = (V_1/R_1) = (V_2/R_2) = (V_3/R_3)$	$V = (I_1/G_1) = (I_2/G_2) = (I_3/G_3)$

Any four points 1 mark each= 4 Marks

VI Attempt **any four** of the following: **16**

VI1) Describe current charging method of batteries in brief.

Ans:

Constant current method:

i) In this method, the charging current is kept constant by varying the supply voltage to overcome the increased back emf.
ii) If a charging booster is used, the current supplied by it can be kept constant by adjusting its excitation. 4 Marks
iii) If charged on dc supply, the current is controlled by varying the rheostat connected in the circuit.
iv) The value of charging current should be so chosen that there is no excessive gassing during final stages of charging, the cell temperature should not exceed 45° C.
v) This method takes a comparatively longer time.

VI2) Compare dry cell with liquid cell on any four points.

Ans:

Comparison between Dry cell and Liquid Cell:

Particulars	Dry Cell	Liquid Cell
Principle of operation	Irreversible chemical action	Reversible chemical action
Cost	Lower	Higher
Life	Lower	Higher
Maintenance	Very low maintenance	Maintenance required at regular intervals

Any four points 1 mark each = 4 Marks

VI3) Define the following terms in connection with A.C. generator:
a) Cycle
b) Frequency
c) Time
d) Amplitude

Ans:

i) **Cycle:** A complete set of variation of an alternating quantity which is repeated at regular interval of time is called a "cycle".

OR

In an ac waveform, each repetition consisting of one positive and one identical negative part is called as one cycle.

ii) **Frequency (f):** It is defined as the number of cycles completed by an alternating quantity in one second.

iii) **Time (Time period)(T):**It is defined as the time taken in seconds by an alternating quantity to complete one cycle.

iv) **Amplitude:** The maximum value or peak value of an ac quantity is called as its amplitude. It is denoted by I_m, V_m etc.

1 Mark for each Definition = 4 Marks

VI4) Write down any two electrical and any two mechanical properties of high conductivity materials.

Ans:

Electrical Properties of high conductivity materials:

i) Low resistivity.
ii) Low temperature coefficient of resistance.

1 Mark for each of any

iii) High conductivity.
iv) Low heat dissipation.

two
= 2 Marks

Mechanical Properties of high conductivity materials:

i) High mechanical strength to withstand stress and strain.
ii) Malleable to fabricate easily.
iii) Ductile for wire drawing.
iv) Elastic in nature.

1 Mark for each of any two = 2 Marks

VI5) Classify magnetic material. Explain each type in brief.

Ans:

Classification of magnetic materials:

1)Paramagnetic materials
2)Diamagnetic materials
3)Ferromagnetic materials

1mark for Classification

1) **Paramagnetic materials**: The relative permeability of such materials is very less but positive (slightly greater than 1) so these materials cannot be magnetized and not suitable to carry the flux from one place to the other. In their case, the individual atomic di-poles are oriented in a random fashion. Following are the paramagnetic materials: magnesium, molybdenum, lithium, Aluminium, Titanium, Platinum.
2) **Diamagnetic materials:** These materials have relative permeability slightly less than one. Such materials are magnetized opposite to the direction of the external field and due to this they are pushed out of regions of the highest field intensity. So diamagnetic materials are not useful in magnetic applications. Most elements in periodic table, including Copper, Silver and Gold fall in this category.
3) **Ferromagnetic materials:** Relative permeability of ferromagnetic material is very large. These materials are very easily magnetized and used as conductors of magnetic flux from one place to other. These materials are characterized by the presence of parallel alignment of permanent magnetic dipole moments in a single direction. In the ferromagnetic materials the magnetization arises spontaneously i.e. in the absence of external magnetic field. Following are the ferromagnetic materials: Iron, Cobalt, Nickel

1 Mark each for explanation = 3 Marks

VI6) Find the resistance between the points P and Q in the series parallel network shown in fig.3

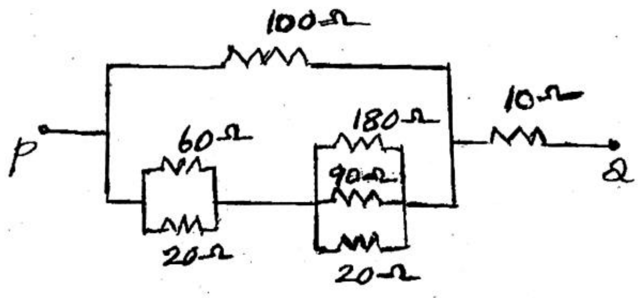


Fig. 3

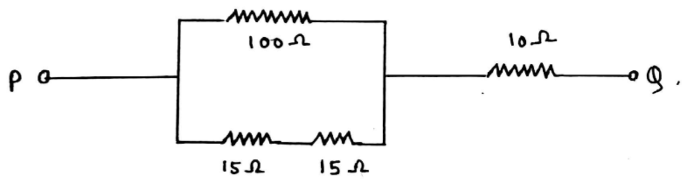
Ans:

Resistances 180Ω, 90Ω and 20 Ω are parallel with each other, their equivalent resistance will be $\frac{1}{R_P} = \frac{1}{180} + \frac{1}{90} + \frac{1}{20} = \frac{1}{15}$ 1 Mark

$R_P = 15\ \Omega$.

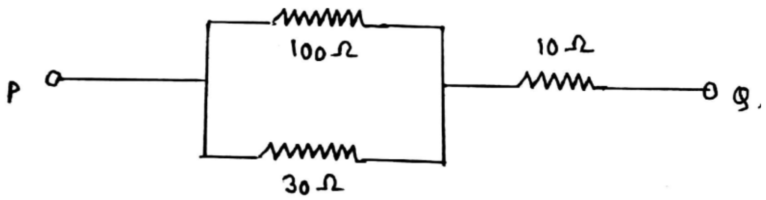
And Resistances 60 Ω and 20 Ω are parallel with each other, their equivalent resistance will be $R_{P1} = \frac{60\times20}{60+20} = 15\Omega$. 1 Mark

Now the equivalent circuit becomes as shown in figure below.



Resistances 15 Ω and 15 Ω are in series , their equivalent resistance is,

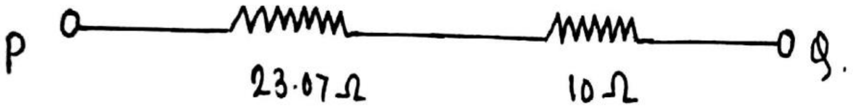
$R_S = 15 + 15 = 30\ \Omega$



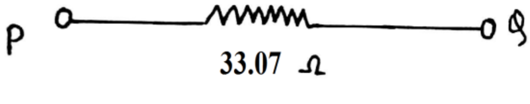
Resistance 100 Ω and 30 Ω are in parallel, their equivalent resistance will be,

$\frac{100\times30}{100+30} = 23.07\Omega$, 1 Mark

Now circuit will be as shown in figure.



Resistance 23.07 Ω and 10 Ω are in series , their equivalent resistance will be 23.07+ 10 = 33.07 Ω.



1 Mark

The resistance between points P and Q are 33.07 Ω.