Model Answer

Winter – 2018 Examinations

Subject & Code: Fundamentals of Electrical Engineering (17214)

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

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1 Attempt any TEN of the following: 20

1 a) Define electric potential and state its unit.

Ans:

Electric Potential: Electric potential at a point is defined as work done in bringing unit positive charge from infinity to that point.

OR

The capacity of the any charged body to do the work per unit charge is called as "Electric potential"

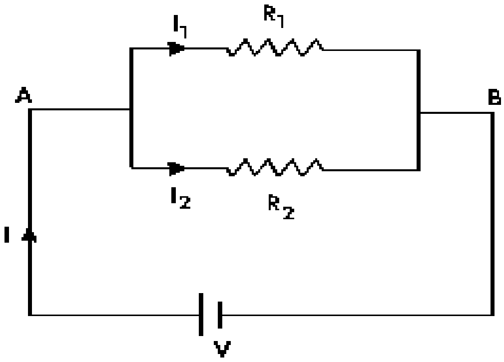
Unit of Potential: volts

1 mark for definition + 1 mark for unit

1 b) With neat circuit, state the current division rule in two parallel resistances R_1 and R_2 in terms of total current.

Ans:

Current Division Rule in Two Parallel Resistances R_1 and R_2 in Terms of Total Current:



1 mark

Current flowing through R_1 is (I_1) which is given by equation

$$I_1 = I \times \frac{R_2}{R_1+R_2} \text{ ampere.}$$

½ mark

Current flowing through R_2 is (I_2) which is given by equation

$$I_2 = I \times \frac{R_1}{R_1+R_2} \text{ ampere.}$$

½ mark

where I = Value of total current.

1 c) Define the term active network and passive network.

Ans:

Active network: Active network is one which contains at least one source of e.m.f. or energy in it.

Passive network: Passive network is one which does not contain any source of e.m.f. or energy in it.

1 mark for each definition = 2 marks

1 d) Give one example of each, series and parallel circuit in actual practice.

Ans:

Example of series circuit:

Decorative lighting in house, Voltage regulation in a DC rectifying circuit, Power line filters (e.g. inductor in series with a capacitor), Voltage divider, Resonant circuits, Analog filters, etc.

Example of parallel circuit:

Lighting load in house, Fans, Electric home appliances, Commercial electric load, Electronic home appliances, Industrial electric load etc.

1 mark for each example

1 e) Define capacitor.Give its unit.

Ans:

Definition of Capacitor:

A capacitor is a passive two-terminal component that stores electrical energy in it in electrostatic field. — 1 mark

Unit of ~~Capacitor~~ Capacitance: farad — 1 mark

1 f) Define magnetic flux and flux density. State their units.

Ans:

Magnetic flux (ϕ): The total number of lines of magnetic force in any particular magnetic field is called as magnetic flux. (Its unit is weber) — 1 mark

Magnetic flux density (B): It is the magnetic flux per unit area measured at right angles to the flux path. (Its unit is weber/m^2 or tesla). — 1 mark

1 g) Give any two applications of electromagnet.

Ans:

Applications of Electromagnet: — 2 marks for any two applications

Cranes, Motors, Generators, Transformers, Electromagnetic Relays, Circuit breakers, Traction, Measuring instruments, Electrical Bell, Various electrical appliances, Electrical coils etc. **OR Any Valid Applications**

1 h) State formula for energy stored in magnetic field.

Ans:

Energy Stored in Magnetic Field:

$$E = \frac{1}{2} L I^2 \text{ joule}$$ — 1 mark

where,
E = Energy stored in inductor in joule.
L = Inductance in henry — 1 mark
I = Current in ampere.

1 i) State Fleming's right hand rule.

Ans:

Fleming's Right Hand Rule:

Arrange three fingers of right hand mutually perpendicular to each other, if the first figure indicates the direction of magnetic flux, thumb indicates the direction of motion of the conductor, then the middle finger will give the direction of induced current / emf. — 2 marks

1 j) Define frequency and state its unit.

Ans:

Frequency: Number of cycles completed by an alternating quantity in one second is called its frequency. — 1 mark

Unit of Frequency: hertz (Hz) **OR** cycles / second — 1 mark

1 k) Name any four insulating materials.

Ans:

1.Wood
2.Rubber
3.Plastic
4.PVC
5.Glass

6.Porcelain
7. Mica
8. Polypropylene Film
9. Transformer Oil
10.Condenser Oil
11.Synthetic Insulating Oil
12.Hydrogen
13.SF6 gas
14.Nitrogen
15.Air

½ Mark for each of any four = 2 marks

OR Any Valid Insulating Material

1 l) State the necessity of series and parallel connection of batteries.

Ans:

Necessity of series and parallel connection of batteries:

- **i)** Batteries are connected in series to produce higher voltage which is in multiples of single battery voltage. i.e. To produce 220V DC supply, 110 batteries each having voltage of 2V are connected in series. The AH rating of combination remains same as that of single battery.
- **ii)** Batteries are connected in parallel to deliver higher current to the load. i.e. to deliver 100AH current at 12V, total 4 batteries each having 12V, 25AH rating are connected in parallel.

1 mark for each point = 2 marks

2 Attempt any FOUR of the following: **16**

2 a) What is amorphous metal? State any two properties and one application of this metal.

Ans:

Amorphous metal:

An amorphous metal (also known as metallic glass or glassy metal) is a solid metallic material, usually an alloy, with disordered atomic-scale structure, i.e. non-crystalline, and have a glass-like structure. Amorphous metals are made from alloys whose constituents may include Fe, Ni, and Co and a metalloid or glass former such as silicon, boron, or carbon.

1 mark

Properties of amorphous metal:

1) Thermal conductivity of amorphous metal is lower than that of crystalline metal.
2) High magnetic susceptibility with low coercivity and high electrical resistance which contribute to low losses.
3) High resistance which leads to low eddy current losses.
4) The tensile strength is almost that of high grade titanium.
5) They are true glasses, which mean that they soften and flow upon heating, which allows easy processing.
6) The alloy does not undergo shrinkage on solidification, which helps in bones attachments.

1 mark for each of any two properties = 2 marks

Applications of amorphous metal:

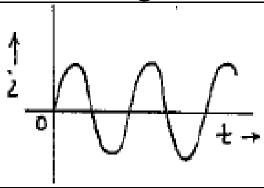
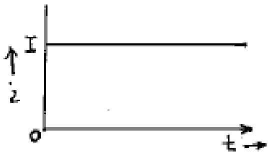
1) Making nanocomposites for field electron emission devices.
2) Manufacturing cores of high efficiency distribution transformers
3) Manufacturing cores of special transformers

1 mark for any one application

4) Manufacturing magnetic sensors
5) Magnetomotive sensors

2 b) Compare A.C and D.C. supply. (Any four points).

Ans:

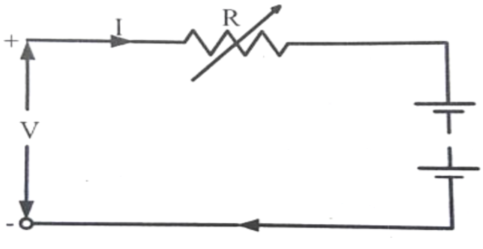
Particulars	**Alternating current**	**Direct current**
Waveform		
Definition	It is the current whose magnitude and direction continuously changes with respect to time.	It is the current whose magnitude and direction do not change with respect to time.
Use of transformer	Possible	Not Possible
Distribution efficiency	High	Low
Design of machines	Simple	Complicated
Generation	Mostly by electromechanical energy conversion	Mostly by electrochemical energy conversion and also by conversion of AC to DC using converters
Applications	AC machines, Domestic and industrial	DC machines, electroplating, HVDC system, battery charging

1 mark for each of any four points = 4 marks

2 c) Describe constant voltage charging of a battery.

Ans:

Constant voltage charging method of charging batteries:



2 marks for diagram

- In this method the charging voltage is held constant throughout the charging process.
- The charging current is high in the beginning when the battery is in discharged condition, but drops off as the battery picks up charge resulting in increased back e.m.f.
- This is the common method of charging used in battery shops and in automotive equipment.
- In this method time of charging is almost reduced to half.

2 marks for explanation

2 d) If a coil of 200 turns is linked with a flux of 0.02 wb when carrying current of 20A, calculate the inductance of the coil. If this current is uniformly reversed in 0.2 sec,

calculate the self-induced emf in the coil.

Ans:

Given Data:

N= 200   di = -20-(20) = - 40 amp

ϕ = 0.02 wb   dt = 0.2 sec

I = 20 A

1. **Inductance of coil (L):**

$$L = \frac{N\emptyset}{I}$$

$$L = \frac{200 \text{ x } 0.02}{20}$$

L = 0.2 henry

2 marks for stepwise solution of L

2. **Self-induced EMF:**

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

$$e = -0.2\frac{(-40)}{0.2}$$

e = 40 volts

2 marks for stepwise solution of e

2 e) Show the duality between series and parallel dc circuits.

Ans:

Duality between Series and Parallel DC Circuits:

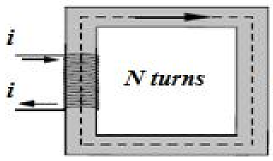
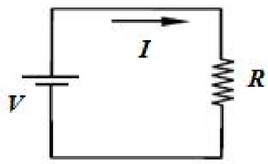
Series circuit	Parallel circuit
1) $I_T = I_1 = I_2 = I_3 =$…….. Current is same through all the branches of the circuit	$V_T = V_1 = V_2 = V_3 =$……… Voltage is same across all the parallel branches of the circuit
2) $V_T = V_1 + V_2 + V_3 +$….. Total voltage is addition of all voltage drops	$I_T = I_1 + I_2 + I_3 +$…….. Total current is addition of all branch currents
3) $R_T = R_1 + R_2 + R_3 +$…. Total resistance is addition of all individual resistances	$G_T = G_1 + G_2 + G_3 +$….. Total conductance is addition of all individual conductances
4) $I_T = V_1 / R_1 = V_2 / R_2 = V_3 / R_3$.. Total current can be obtained by applying ohm’s law at any individual resistance.	$V_T = I_1/G_1 = I_2 /G_2 = I_3/G_3$ Total voltage can be obtained by applying ohm’s law at individual branch.

1 mark for each of any four points = 4 marks

2 f) Compare magnetic and electric circuits on any four points.

Ans:

Sr. No.	Magnetic circuit	Electric circuit
1	The path in which magnetic flux is set up, is magnetic circuit	The path through which an electric current flows is an electric circuit

2	MMF is the driving force in the magnetic circuit. The unit is ampere turns.	EMF is the driving force in the electric circuit. The unit is volts.
3	There is magnetic flux ϕ in the magnetic circuit which is measured in the weber.	There is a current I in the electric circuit which is measured in amperes.
4	The number of magnetic lines of force decides the flux.	The flow of electrons decides the current in conductor.
5	Reluctance (S) is the opposition by magnetic path to the flux. The unit is ampere turn/weber.	Resistance (R) is the opposition to the flow of the current. The unit is ohm
6	$S = l / (\mu_0\mu_r a)$. Directly proportional to length of magnetic circuit (1). Inversely proportional to area of cross-section of magnetic path (a) Depends upon the nature of magnetic material.	$R = \rho.\ l/a$. Directly proportional to length of conductor (1). Inversely proportional to area of cross section of conductor (a). Depends on nature of material.
7	The Flux = MMF/ Reluctance	The current I = EMF/ Resistance
8	The flux density	The current density
9	Kirchhoff's mmf law and flux law is applicable to the magnetic flux.	Kirchhoff's current law and voltage law is applicable to the electric circuit.
10		

1 mark for each of any four points = 4 marks

3 **Attempt any <u>FOUR</u> of the following:** **16**

3 a) The resistance of a coil of wire increases from 80Ω at 10°C to 96.6Ω at 60°C. Find the temperature co-efficient of the material at zero degree centigrade.

Ans:

The resistance at t°C is given by standard equation $R_t = R_0(1+\alpha_0 t)$

$\therefore R_{10} = 80 = R_0(1+10\,\alpha_0)$ …...…………………..(i)

$\therefore R_{60} = 96.6 = R_0(1+60\,\alpha_0)$ ……………………(ii)

Take ratio, $\frac{80}{96.6} = \frac{(1+10\,\alpha_0)}{(1+60\,\alpha_0)}$, solving it we get,

$80\,(1+60\,\alpha_0) = 96.6(1+10\,\alpha_0)$

$\therefore (4800-966)\alpha_0 = 96.6-80$

The temperature coefficient of resistance at 0°C is,

$\boldsymbol{\therefore \alpha_0 = 0.00433\ /°C}$

4 marks for Stepwise solution

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3b) Represent ideal and practical voltage source, also convert voltage source of figure 1 into an equivalent current source.

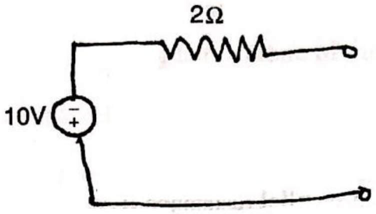
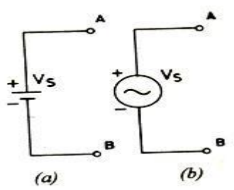


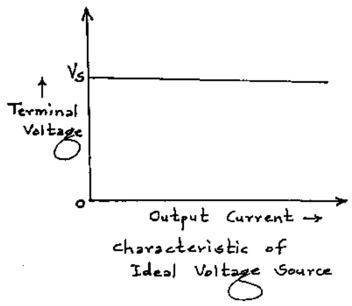
Figure 1

Ans:

i) Ideal voltage source: A voltage source whose terminal voltage always remains constant for all values of output current, is known as an ideal voltage source. It has zero internal resistance.

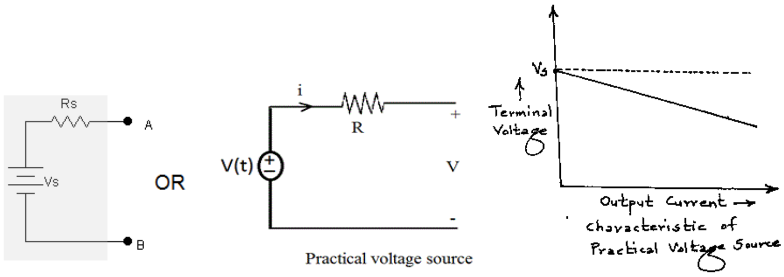
1 mark



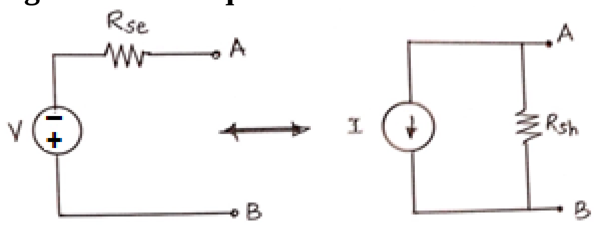


ii) Practical voltage source: A voltage source whose terminal voltage falls with the increase in the output current due to the voltage drop in the internal resistance.

1 mark



Conersion of Voltage sorce into equivalent Current source:



Practical voltage source can be converted to equivalent current source & vice versa. 2 marks

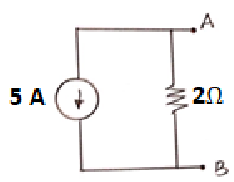
R_{se} and R_{sh} are internal resistance of sources.

The equivalent current source is given by,

$$I = V/R_{se} = 10/2 = 5\Omega$$

And internal resistance of current source is given by,

$$R_{sh} = R_{se} = 2\ \Omega$$



3c) Calculate currents I_1, I_2 and I_3 of the circuit shown in figure 2 using loop analysis.

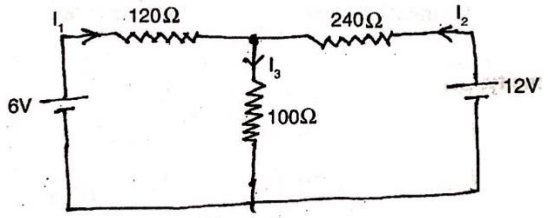
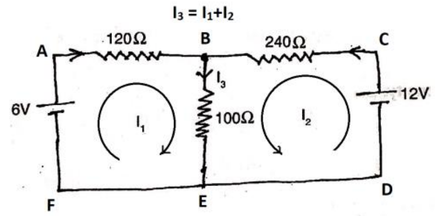


Figure 2

Ans:



Apply KVL for loop ABEFA :

$– 120I_1 –100(I_1+ I_2)+6 = 0$ OR

$220\ I_1+100I_2 = 6$………………………………. (i) ½ mark

Apply KVL for loop BCDEB :

$–240I_2 –100(I_1+ I_2) + 12 = 0$ OR

$100I_1+340I_2 =12$……………………… ………...(ii) ½ mark

Multiplying eq. (i) by 100 and multiplying eq. (ii) by 220, we get

$22000I_1+10000I_2 = 600$………………………………..(iii)

$22000I_1+74800\ I_2 = 2640$…………….…………………… ..(iv)

Subtracting eq. (iv) from eq. (iii),

$– 64800\ I_2 = – 2040$ $\therefore$ **I_2 = 0.03148 A** 1 mark

Substituting I_1 in eq. (ii),

$100\ I_1+ 340×0.03148 = 12$ $\therefore$ **I_1= 0.012968 A** 1 mark

$I_3 = (I_1+ I_2) = 0.03148 + 0.012968$ $\therefore$ **I_3= 0.044448 A** 1 mark

3d) Calculate resistance between terminals A and B using delta star conversion in figure 3.

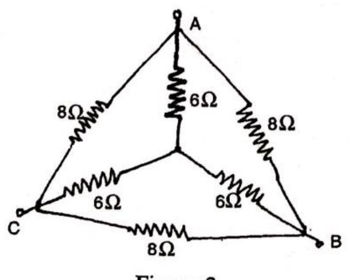
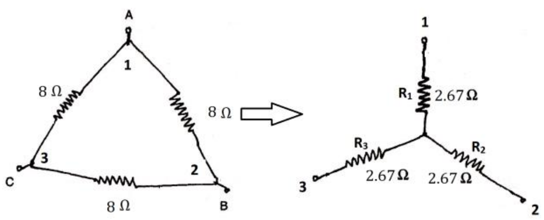


Figure 3

Ans:

Converting the external delta network into star:



1 mark

$R_1 = R_2 = R_3 = (R_{12}\ R_{31}) / (R_{12} + R_{23} + R_{31})= (8×8) / (8+8+8) = 2.67\ \Omega$

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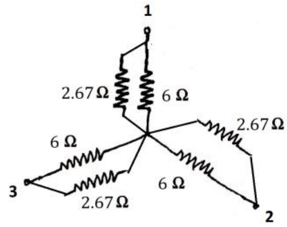
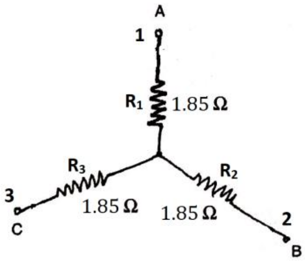


1 mark

When the external delta is converted into star, it appears in parallel with inner star as shown above. The resultant star is as shown below.

$R_1 = R_2 = R_3 = (6)(2.67)/(6+2.67) = 1.85\Omega$ — 1 mark



The resistance between terminals a and B is given by, — 1 mark

$R_{AB} = 1.85+1.85 = \mathbf{3.7\ \Omega}$

3 e) Calculate the capacitance and energy stored in parallel plate capacitor which consist of two metal plates, each 60 cm^2 separated by a dielectric of 2.0 mm thickness of $\in_r = 3.6$ if P. D. of 150V is applied across it..

Ans:

Data Given: Area of plates: $A = 60\ cm^2 = 60\times10^{-4}\ m^2$

Distance of separation: $d = 2\ mm = 2\times10^{-3}$ m

Relative permittivity of dielectric $\in_r = 3.6$

Permittivity of free space $\in_0 = 8.854\times10^{-12}$ F/m

Voltage across capacitor: V = 150V

i) Capacitance of Capacitor:

$$C = \frac{\epsilon_0\epsilon_r A}{d} = \frac{8.854\times10^{-12}\times3.6\times60\times10^{-4}}{2\times10^{-3}} = \mathbf{95.62\times10^{-12}\ F}$$ 2 marks

ii) Energy stored in capacitor:

$$E = \frac{1}{2}CV^2 = \frac{1}{2}(95.62\times10^{-12})(150^2) = \mathbf{1.076\times10^{-6} J}$$ 2 marks

3 f) Three capacitors have capacitances of 2 μF, 6 μF and 8 μF respectively. What is the effective capacitance when they are connected in

(I) Series

(II) Parallel

If 120V is applied across the series combination, what is the charge on each capacitor?

Ans:

Value of equivalent capacitance:

i) For parallel combination: $C_p = C_1 + C_2 + C_3$

$= 2+ 6+8$ — 1 mark

$C_p = 16\ \mu F$

ii) For Series combination:

$1/C_s = (1/C_1)+(1/C_2) +(1/C_3)$

$= (1/2)+(1/6)+(1/8)$ 1 mark

$1/C_s = 0.7916$

$C_s = 1.263\ \mu F$

iii) Charge on each capacitor in series combination:

Charge on effective capacitor = C × V

$= 1.263 \times 10^{-6} \times 120$ 2 marks

$= 1.156\times 10^{-4}$ coloumb

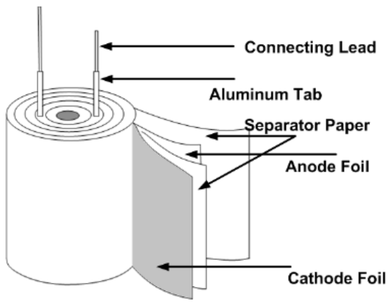
Charge on each capacitor is same as charge on effective capacitor.

4 Attempt any FOUR of the following: 16

4 a) Explain the electrolytic capacitor with neat diagram.

Ans:

Electrolytic capacitors:



1 mark for diagram

The electrolytic capacitor uses an electrolyte (an ionic conducting liquid) as one of its plates to achieve a larger capacitance per unit volume than other types. The capacitors are able to increase the capacitance in a number of ways: increasing the dielectric constant; increasing the electrode surface area; and by decreasing the distance between the electrodes. Electrolytic capacitors use the high dielectric constant of the aluminium oxide layer on the plate of the capacitor which averages between 7 and 8. This is greater than other dielectrics such as mylar which has a dielectric constant of 3 and mica of around 6 - 8. In addition to this, the effective surface area within the capacitors is increased by a factor of up to 120 by roughening the surface of the high-purity aluminium foil. This is one of the keys to producing very high levels of capacitance. The plates of an electrolytic capacitor are constructed from conducting aluminium foil. As a result they can be made very thin and they are also flexible so that they can be packaged easily at the end of the production process. The two plates, or foils are slightly different. One is coated with an insulating oxide layer, and a paper spacer soaked in electrolyte is placed between them. The foil insulated by the oxide layer is the anode. The second foil acts as the cathode and although this does have a naturally occurring oxide layer, this is very much thinner. The thickness of the anode oxide thin film in an aluminium electrolytic capacitor is selected by the required working withstand voltage. 3 marks for explanation

In order to package them the two aluminium foils with the electrolyte soaked paper are rolled together to form a cylinder, and they are placed into an aluminium can. In this way the electrolytic capacitor is compact while being robust as a result of the protection afforded by the can.

There are two geometries that are used for the connection leads or tags. One is to use axial leads, one coming from each circular face of the cylinder. The other alternative is to use two radial leads or tags, both of which come from the same face of the cylinder. The lead styles give rise to the descriptions used for the

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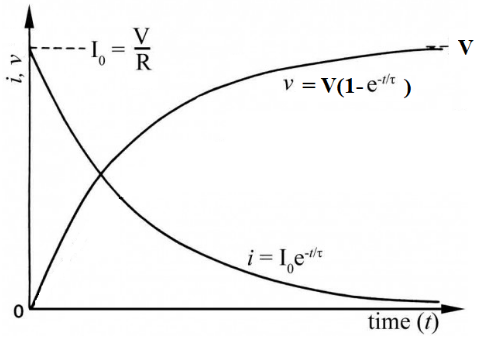
overall capacitors. To increase the surface area of both anode and cathode to increase the capacitance, the surface is roughened by etching.

4 b) Draw voltage and current curves during charging of capacitor through resistor. Write expressions for the same.

Ans:

Voltage and Current curves during charging of capacitor through resistor:



Charging curves of capacitor voltage and current

2 marks

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

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

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,

$$i_c = I_0 e^{\frac{-t}{\tau}}$$ 1 mark

where, $I_0 = \frac{V}{R}$ is the maximum current at instant t = 0.

4 c) State Kirchhoff's voltage law. Write the sign convention used while writing loop equation.

Ans:

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. 2 marks

i.e ΣE - ΣIR=0 or ΣE = ΣIR

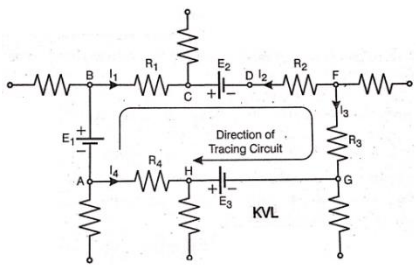
OR

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

i.e Voltage rise = Voltage drop

e.g. 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. 2 marks

4 d) Find the resistance between terminals A and B of the network shown in Figure 4.

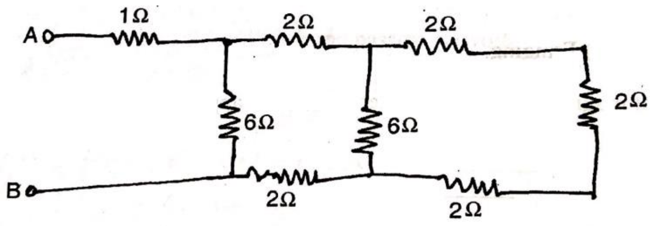


Figure 4

Ans:

The resistance between terminals A and B of the network is given by,

R_{AB} = 1 + 6 || (2 + {6 || (2+2+2)}+2)

= 1 + 6 || (2 + {6 || 6} + 2)

= 1 + 6 || (2 + 3 + 2)

= 1 + 6 || 7

= 1 + (42/13)

= 4.23Ω

4 marks for stepwise solution

4 e) State the effects of electric current and give applications of each (any four effects).

Ans:

Effects of electric current:

i) Magnetic Effect of Electric Current:

Whenever a conductor carries electric current, the magnetic field is produced. If the conductor is a straight conductor, the magnetic field is produced round the conductor itslef. If the conductor is in the form of coil or winding (solenoid) wound over the core, the magnetic field is produced in the core.

½ mark for each of any four effects = 2 marks

Applications: Electric motors, Electric generators, Electric bell, Analog electrical measuring instruments, Relays, Contactors etc.

ii) Heating effect :

When an electric current flows through a conductor, the flow of electron is opposed by the resistance of conductor and heat is produced. The heat (H) produced is directy proportional to:

- Square of the current,
- Resistance of the conductor
- Time of flow of current

$$H \, \alpha \, I^2Rt$$

Applications: Electric iron, Electric water heaters, Hot plates, Electric lamps, Electric ovens etc.

½ mark for each of any one application of each of 4 effects = 2 marks

iii) Chemical effect:

Whenever a DC current is passed through a chemical solution, the solution is decomposed into its constituent substances.

Applications: It is utilized in the electrolytic processes such as electro-plating, electro-refining, production of different chemicals etc.

iv) Mechanical effect:

Whenever a current carrying conductor is placed in a magnetic field, mechanical force is exerted on the conductor.

Applications: AC & DC motors, Electric measuring instruments etc.

v) Biological effect:

When electric current flows through human body, depending upon the magnitude of current, the effects may range from that of no sensation to shock, to death. Injury or death may be caused by:

- Respiratory arrest resulting from involuntary contraction of the chest muscles or from temporary paralysis of the nerve center
- Interference with the normal rhythm of the heart, which causes ventricular fibrillation, or the suspension of heart action by involuntary muscular contractions
- Burns caused by current flowing through tissue or by high temperatures

Applications: The effects are observed in case of electrocuted person, Electric shock treatment is used to initiate normal rhythm of heart.

4f) State the different types of resistors. Explain any one of them with sketch.

Ans:

Types of Resistors:

Linear Resistor		Non-linear Resistor
Fixed Resistor	Variable Resistor	i) Thermistor ii) Light Dependent Resistor (LDR) iii) Varistor
i) Carbon Composition ii) Wire wound iii) Metal film	i) Potentiometer ii) Trimmers iii) Rheostat	

1 mark for classification

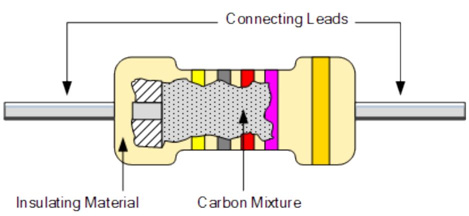
1 mark for sketch of any one type

2 marks for explanation of any one type

OR

1) Carbon Composition
2) Deposited Carbon
3) High-voltage Ink film
4) Metal film
5) Metal glaze
6) Wire-wound
7) Cermet

1) Carbon Composition Resistor:



Carbon composition resistors are a cheap general purpose resistor used in electrical and electronic circuits. Their resistive element is manufactured from a mixture of finely ground carbon dust or graphite and a non-conducting ceramic (clay) powder to bind it all together. The ratio of carbon dust to ceramic (conductor to insulator) determines the overall resistive value of the mixture and the higher the ratio of carbon, the lower the overall resistance. The mixture is moulded into a cylindrical shape with metal wires or leads are attached to each end to provide the electrical connection as shown, before being coated with an outer insulating material and colour coded markings to denote its resistive value.

It is a low to medium type power resistor which has a low inductance making them ideal for high frequency applications but they can also suffer from noise and stability when hot. Carbon composite resistors are generally prefixed with

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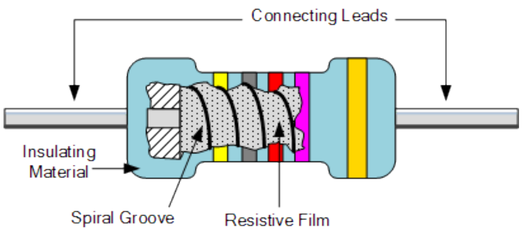
a "CR" notation (eg, CR10kΩ) and are available in E6 (± 20% tolerance (accuracy)), E12 (± 10% tolerance) and E24 (± 5% tolerance) packages with power ratings from 0.250 or 1/4 of a watt up to 5 watts. Carbon composite resistor types are very cheap to make and are therefore commonly used in electrical circuits.

2) Film type Resistors:

The generic term "**Film type Resistor**" consist of *Metal Film*, *Carbon Film* and *Metal Oxide Film* resistor types, which are generally made by depositing pure metals, such as nickel, or an oxide film, such as tin-oxide, onto an insulating ceramic rod or substrate.

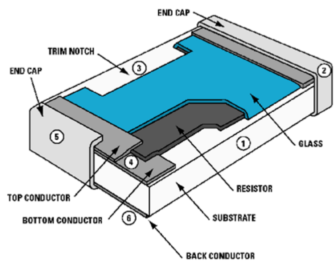


The resistive value of the resistor is controlled by increasing the desired thickness of the deposited film giving them the names of either "thick-film resistors" or "thin-film resistors".

Once deposited, a laser is used to cut a high precision spiral helix groove type pattern into this film. The cutting of the film has the effect of increasing the conductive or resistive path, a bit like taking a long length of straight wire and forming it into a coil. This method of manufacture allows for much closer tolerance resistors (1% or less) as compared to the simpler carbon composition types. Metal Film Resistors have much better temperature stability than their carbon equivalents, lower noise and are generally better for high frequency or radio frequency applications. Metal Oxide Resistors have better high surge current capability with a much higher temperature rating than the equivalent metal film resistors.

3) Cermet:

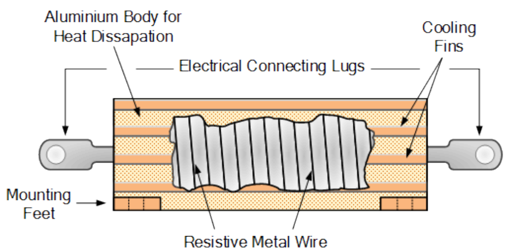
A Thick Film Resistor is manufactured by depositing a much thicker conductive paste of **CER**amic and **MET**al, called **Cermet**, onto an alumina ceramic substrate. Cermet resistors have similar properties to metal film resistors and are generally used for making small surface mount chip type resistors, multi-resistor networks in one package for pcb's and high frequency resistors. They have good temperature stability, low noise, and good voltage ratings but low surge current properties.



CERMET

4) Wire Wound Resistors:

A Wirewound Resistor is made by winding a thin metal alloy wire (Nichrome) or similar wire onto an insulating ceramic former in the form of a spiral helix. These types of resistor are generally only available in very low ohmic high precision values (from 0.01Ω to 100kΩ) due to the gauge of the wire and number of turns possible on the former making them ideal for use in



measuring circuits and Wheatstone bridge type applications. They are also able to handle much higher electrical currents than other resistors of the same ohmic value with power ratings in excess of 300 Watts. These high power resistors are moulded or pressed into an aluminium heat sink body with fins attached to increase their overall surface area to promote heat loss and cooling. These special types of resistor are called "Chassis Mounted Resistors" because they are designed to be physically mounted onto heatsinks or metal plates to further dissipate the generated heat. The mounting of the resistor onto a heatsink increases their current carrying capabilities even further.

5 Attempt any FOUR of the following **16**

5 a) Define the following:
I) Node II) Branch III) Bilateral circuit IV) Unilateral circuit

Ans:

I) Node: A point or junction in an electric circuit at which two or more branches meet.

II) Branch: A part of an electric network which lies between two junctions or nodes is known as branch.

III) Bilateral circuit: A bilateral circuit is one whose characteritic response or behavior is independent of the direction of current flowing through its elements.The usual transmission line is bilateral because it can perform its function in both directions.

IV) Unilateral circuit: If the characteristics response or behavior of circuit is dependent on the direction of current through its elements in it, then the circuit is called as a unilateral circuit. e. g. networks containing elements likes diodes, transistors etc.

1 mark for each definition = 4 marks

5 b) Explain B-H curve for magnetic and non-magnetic materials.

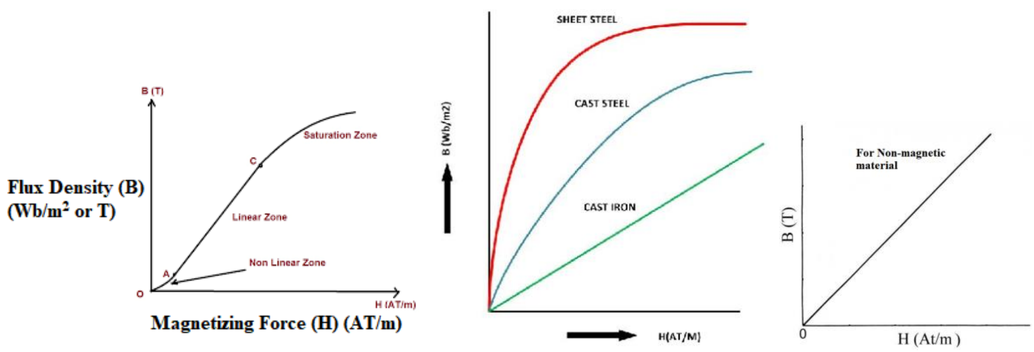
Ans:-

B-H Curve of Magnetic material:

The B-H curve is the graphical representation of magnetization of material with magnetizing force (H) plotted on X-axis and magnetic flux density (B) plotted on Y-axis.

2 marks for curve

Typical B-H curve is as shown in fig. below:



B-H curve for Magnetic material:

The B-H curve can be described by dividing it into 3 regions:

Region OA: For zero current, H = 0 and B is also zero. The flux density B then increases gradually as the value of H is increased. However B changes slowly in this region. The curve is non-linear in this region OA. — 2 marks for explanation

Region AC: In this region, for small change in H, there is large change in B. The B-H curve is almost linear in this region.

Region beyond C: After point C, the change in B is small even for a large change in H. Finally, the B-H curve will tend to be parallel to X axis. This region is called as saturation region.

B-H curve for Non Magnetic material:

The flux density (B) is proportional to magnetizing force (H), hence it is always a straight line graph. There is no magnetic saturation.

5 c) An iron ring of cross sectional area 7 cm^2 is wound with a wire of 110 turns and a saw cut of 2 mm, calculate the magnetizing current required to produce a flux 0.2 mWb. Its mean length of magnetic path is 30cm and relative permeability of iron is 500.

Ans:

a= 7 $cm^2 = 7 \times 10^{-4} m^2$, N=110,

Saw cut = (length of air gap) = lg = 2mm = $2 \times 10^{-3} m$,

Flux = 0.2mWb = 0.2×10^{-3}Wb,

Length of magnetic path = li = 30 cm = 30 X 10^{-2}m , μr = 500

Total MMF = MMF for iron(AT_i) + MMF for air gap(AT_g)

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

MMF for iron(AT_i) = $\frac{B}{\mu 0 \mu r} \times li$

$B = \frac{\emptyset}{a} = \frac{0.2\times10^{-3}}{7\times10^{-4}} = 0.2857\ Wb/m^2$ — 1 mark

$AT_i = \frac{B}{\mu 0 \mu r} \times li = \frac{0.2857}{4\pi\times10^{-7}\times500} \times 30 \times 10^{-2}$ = **136.41AT** — ½ mark

MMF for air gap (AT_g) = $\frac{B}{\mu 0} \times lg = \frac{0.2857}{4\pi\times10^{-7}} \times 2 \times 10^{-3}$= **454.70AT** — ½ mark

Total MMF = I N = $AT_i + AT_g$ = 136.41 + 454.70
= **591.11AT** — 1 mark

Therefore

591.11 = I × 500

$I = \frac{\mathbf{591.11}}{\mathbf{500}} = \mathbf{1.18}A$ — 1 mark

5 d) State and explain faradays laws of electromagnetic induction.

Ans:

Faraday's laws of electromagnetic induction:

First law: Whenever the flux linking with a circuit changes, an e.m.f. is induced in it.

OR

Whenever a conductor cuts magnetic flux, an e.m.f. is induced in the conductor.

Second law: It states that the magnitude of induced emf is equal to the rate of change of flux linkages. Expressed as $e = -N\frac{d\emptyset}{dt}$ volts.

1 mark for each law statement = 2 marks

Explanation:

A stationary coil is placed near a movable permanent magnet and galvanometer is connected across the coil to measure current flowing through it.

As magnet is moved closer to or away from the coil, the galvanometer starts showing deflection.

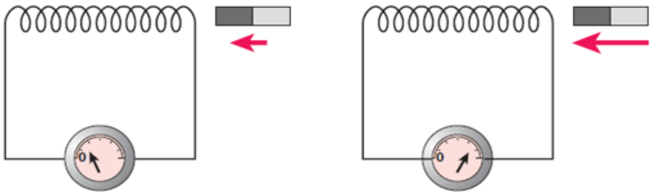
The magnitude of the current through the coil is zero when both coil & magnet are stationary and direction of coil current depends on the direction of movement of the magnet (i.e towards coil or away from coil).

The expression of induced emf is as follows:

$e = -N\frac{d\phi}{dt}$ volts

(The minus sign indicates that the direction of induced e.m.f. is such that it opposes the change of flux which produces it.)

2 marks for explanation



slow movement produces a small e.m.f.   faster movement produces a bigger e.m.f.

5 e) Compare air core inductor with ferrites core inductor. Give one application of each.

Ans:-

Sr. No.	Air core inductor	Ferrite core inductor
1	This type of inductor consists of former made of plastic or cardboard on which wire is wound.	Here former is made of ferrite material like (iron oxide + metal) on which conductive wire is wound.
2	**Application:** Air core inductor is useful for low frequency application i.e. from AF to 1 MHz	**Application:** Ferrite core inductor is used for high frequency range covering AF and RF up to 100 MHz.
3	High value of inductance is not possible.	High value of inductance can be achieved.
4	Size is large.	Size is small.
5	Q is low.	Q is high
6	Cost is low.	Cost is High.

1 mark each of any four points = 4 marks

5 f) Give eight steps to be followed while doing battery maintenance.

Ans:-

Steps to carry out the maintenance of lead acid batteries:

1) Keep the container surface dry by using dry cloths.
2) Tighten the terminal connections.
3) Battery should not be discharged below a minimum voltage.
4) Never keep battery in discharged condition.
5) Check the specific gravity of the electrolyte and maintain it by adding distilled water.
6) Electrolyte level should be maintained above the electrodes.
7) Battery should not be overcharged.

½ marks for each of any 8 steps = 4 marks

8) Charge battery at specific rate.
9) During initial charging use fresh electrolyte.
10) Avoid overcharging and short circuit of plates.

6 Attempt any FOUR of the following: **16**

6 a) Distinguish between paramagnetic and ferromagnetic materials with any four points.

Ans:-

Point	Paramagnetic materials	Ferromagnetic materials
Relative permeability (μr)	Very low positive value, slightly greater than one.	Very large values ranging from 400 to 1200 etc.
Reluctance	High	Very low.
Magnetization	Require large MMF or cannot be magnetized.	Require low MMF, can be easily magnetized.
Atomic dipoles orientation	Very random even with high field strength.	Easy parallel alignment with very low magnetizing current.
Examples	Copper, Aluminium, Titanium, Platinum Oxygen	Iron, Nickel, Cobalt.

1 mark for each of any four point = 4 marks

6b) Classify insulating materials on the basis of temperature withstanding capacity. Specify limiting temperature of each class with one example each.

Ans:

Sr. No.	Class of Insulating material	Temperature withstanding capacity °C	Examples
1	Class 'Y'	90°C	Cotton, Silk paper and similar organic materials neither impregnated nor immersed in oil, rubber, PVC
2	Class 'A'	105°C	Impregnated paper, Silk, cotton and polyamides resins
3	Class 'E'	120°C	Cotton fabric, synthetic resin enamels. Paper laminates and Powder plastics
4	Class 'B'	130°C	Inorganic materials (mica, fibres, glass, asbestos) impregnated with varnish and other compounds
5	Class 'F'	155°C	Mica, polyester, epoxide varnishes
6	Class 'H'	180°C	Composite material on mica, fibres, glass and asbestos impregnated with silicon rubber
7	Class 'C'	Above 180°C	Mica, Ceramics, Glass, Teflon,

1 mark for each of any four classes = 4 marks

6c) Compare dynamically induced EMF with statically induced EMF.

Ans:

Sr.no.	Particulars	Statically induced EMF	Dynamically induce EMF
1.	Moment of coil or magnet	Neither coil nor magnet	Either coil moves or magnet
2.	Current through coil	Must vary with respect	Can remain

1 mark for each point = 4 marks

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	of electromagnet	to time	constant.
3.	Expression for induced voltage	e = $-L\left(\frac{di}{dt}\right) or -N(\frac{d\phi}{dt})$	e = Blv $\sin\theta$
4.	Application	Transformers	DC Generator, Back EMF in DC motor, induction motors

6 d) What is coefficient of coupling? Explain in brief.

Ans:

Coefficient of coupling (k): It is defined as the ratio of actual mutual inductance present between two coils to the maximum possible value.

If L_1 and L_2 are coefficients of self-inductances of two coils having mutual inductance 'M' between them then the coefficient of coupling between these coils is given by: 2 marks for coeff. of coupling

$$k = M/ \sqrt{(L_1L_2)}$$

OR

The fraction of magnetic flux produced by the current in one coil that links with the other coil is called **coefficient of coupling** between the two coils.

$$k = \phi_{12}/\phi_1$$

where, ϕ_1 is the total flux produced by coil 1,
ϕ_{12} is the flux (out of ϕ_1) linking with coil 2 — 2 marks for explanation

Explanation of coefficient of coupling:

Mathematical expression for coefficient of coupling is

$$k = M / M_{max}$$
$$\text{But, } M_{max} = \sqrt{(L_1L_2)}$$
$$k = M / (\sqrt{L_1L_2})$$

The maximum value of k is 1 which represents the coupling of all flux produced by one coil with the other coil.

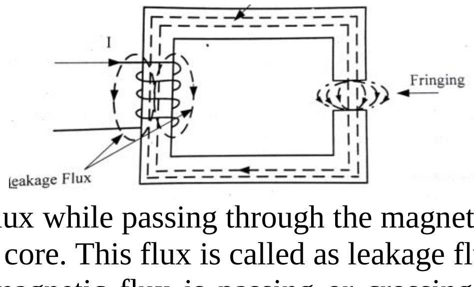
Corresponding to k = 1 the value of mutual inductance will be maximum and it is given by, $M_{max} = \sqrt{(L_1L_2)}$ corresponding to k = 1.

The coupling between the two coils is said to be a tight coupling if K = 1 and the coupling is called as loose coupling if K is less than one.

The coefficient of coupling is also called as Magnetic Coupling Coefficient.

6 e) Explain the terms with neat diagram.
I) Leakage flux II) Fringing.

Ans:



2 marks for valid diagram

Leakage flux: Some flux while passing through the magnetic circuit, leaks through the air surrounding the core. This flux is called as leakage flux. 2 marks for explanation

Fringing: When the magnetic flux is passing or crossing an air gap, it tends to bulge outwards the iron ring, this effect is called as "Fringing". Longer the air gap more the fringing.

6 f) What is permanent magnet and electromagnet? State two applications of each type.

Ans:

Permanent magnet:

A permanent magnet is an object made from a material that is magnetized and creates its own persistent magnetic field. As the name suggests, a permanent magnet is 'permanent'. This means that it always has a magnetic field and will display a magnetic behaviour at all times. 1 mark

Applications of Permanent magnet:

1) Field of DC motors
2) Tacho-generators
3) In stepper motors.
4) Field of two wheeler and car dynamo 1 mark for two applications
5) In magnetic therapy
6) In magnetic compass.
7) Speedometers
8) Telephones
9) Microphones
10) Earphones

Electromagnet:

An electromagnet is an object having a coil of wire wrapped around a core of ferromagnetic material like steel, which acts as a magnet when an electric current passes through the coil. If the current is interrupted, the magnetism is lost. 1 mark

Applications of electromagnet:

1) As Field and armature in DC Machine. 1 mark for two applications
2) In cores of solenoid valves.
3) In cores of electromechanical relays.
4) In electromagnetic circuits of all AC Machines
5) Electrical measuring instruments
6) In transformers.