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 may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more 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 may give credit for any equivalent figure drawn.
5) Credits may 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.
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

1 a) Temperature coefficient of resistance: - The Temperature coefficient of resistance is defined as change in resistance of material per degree Celsius to its resistance at t^o C. 1 mark

Therefore RTC at $t^oC = \Delta$ R per ^oC / R t . 1 mark

1 b) Resistance: It is defined as the opposition to flow of current. Its unit is ohm(Ω). 1 mark

Factors affecting resistance: Temperature, Length of conductor, area of cross section & type and nature of material.

$R = \sigma\, l / a$. 1 mark

1	c)	Application of lead acid battery: 1) In the telephone system 2) In UPS 3) In substations 4) In battery operated vehicles 5) In automobiles for starting and lighting	Any two applications 1 mark each
1	d)	Passive network: The network which does not contain any energy source.	1 mark
		Bi-lateral circuit: It is the circuit whose characteristics or response does not depend on the direction of current through the various elements in it.	1 mark
1	e)	Resistance of lamp : $R = P/I^2 = 500/4^2 = 31.25\ \Omega$	1 mark
		Voltage Drop across lamp = $I \times R = 4 \times 31.25 = 125$ V	1 mark
1	f)	Application of air cored inductor: high frequency applications, such as oscillators, RF amplifiers, radio & TV receivers etc	Any two appl. 1 mark each
1	g)	For series connection of capacitors we have,	
		$1/C = 1/C_1 + 1/C_2 + 1/C_3$	1 mark
		Therefore, $C = 1.25\ \mu F$.	1 mark
1	h)	Faraday's laws of electromagnetic induction:	
		1st law: When a conductor cuts or is cut by the magnetic flux, an EMF is generated in the conductor.	½ mark
		2nd law: The magnitude of EMF induced in the coil depends on rate of change of flux linking with coil.	½ mark
		$|e| \propto$ (change in flux)/(time in which it occurs)	
		Therefore, $e = -N\, d\text{Ø}/dt$	1 mark

1 i) i) Leakage flux: The flux which completes its path through the air or the medium surrounding the magnetic circuit instead of completing it through the core and air gap is known as the leakage flux. — 1 mark

ii) Fringing: the tendency of magnetic flux to spread out at the edges of air gap is called as Magnetic Fringing. — 1 mark

1 j) Two indications of fully charged battery:.

1) Gassing.
2) Full Voltage
3) Specific gravity.
4) Colour of plates.

Any two indication 1 mark each

1 k) i) Breakdown voltage: Breakdown voltage of a dielectric material is defined as the maximum potential that can be applied across it without resulting in breakdown. — 1 mark

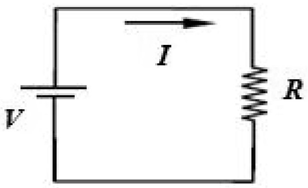
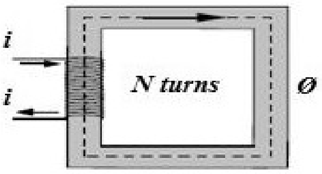
ii) Dielectric Strength: It is define the dielectric strength of an insulating material as the ability of the insulating medium to resist its breakdown when large voltage is applied across it. Its unit is volts per meter (V/m). — 1 mark

1 l) Three resitances in parallel we have,

$1/R = 1/R_1 + 1/R_2 + 1/R_3$ — 1 mark

Therefore $R = 3.846\ \Omega$ — 1 mark

2 a)

Electric circuit:	Magnetic circuit
	

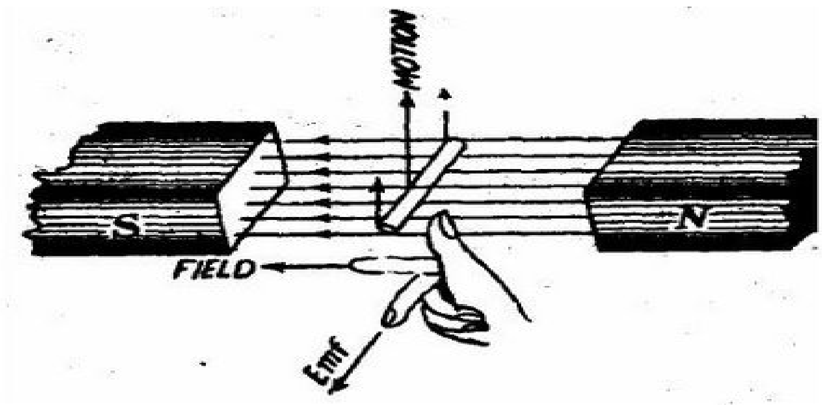
1 mark each pt. max 4 marks. Other pts as electric fields , magnetic

Voltage 'V' (volts)	MMF = Ø S (amperes)
Current 'I' (amperes)	Flux 'Ø' (webers)
Resistance R = ρl/a ohms.	Reluctance S = l/(μA) amperes/weber
V = I R (volts)	MMF = Ø S (amperes)
Conductance G = 1/R (Siemens)	Permeance P = 1/S (webers/ampere)

field if given must be considered

2 b) Fleming`s right hand rule:

Fleming`s right hand rule state that, outstretch the first three fingers of right hand perpendicular to each other such that first finger pointing the direction of magnetic field, thumb directing the motion of the conductor, then second finger will indicates the direction of induced e. m. f.(or current). 3 marks



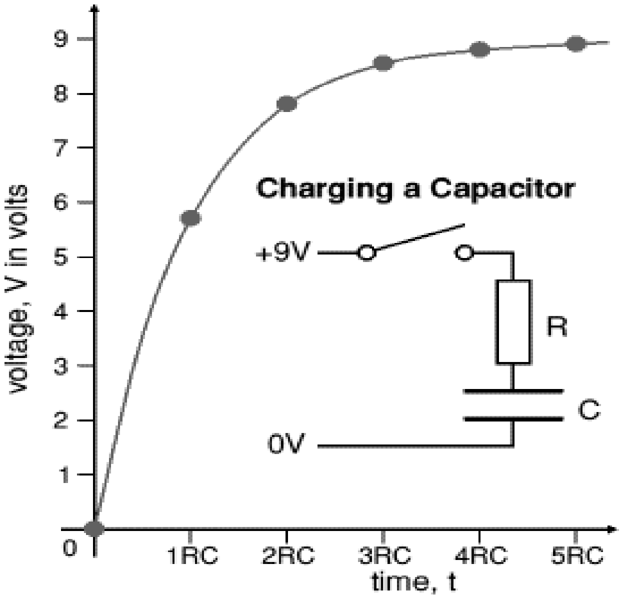
1 mark

2 c) Charging of capacitors:

Capacitors are charged through resistances where the time of charging depends on the value of resistance and capacitor as follows.

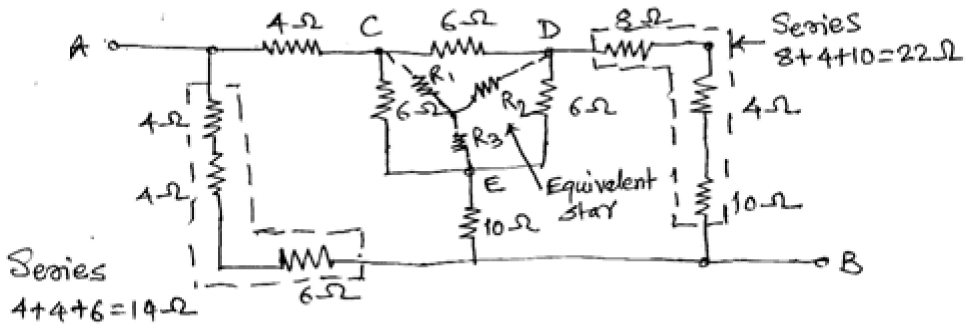
Instanteneous charging voltage v_c = V (1 – $e^{-t/RC}$) 1 mark

Instanteneous charging current $i_C = I_O(e^{-t/RC})$ 1 mark



Graph 2 marks

2 d)

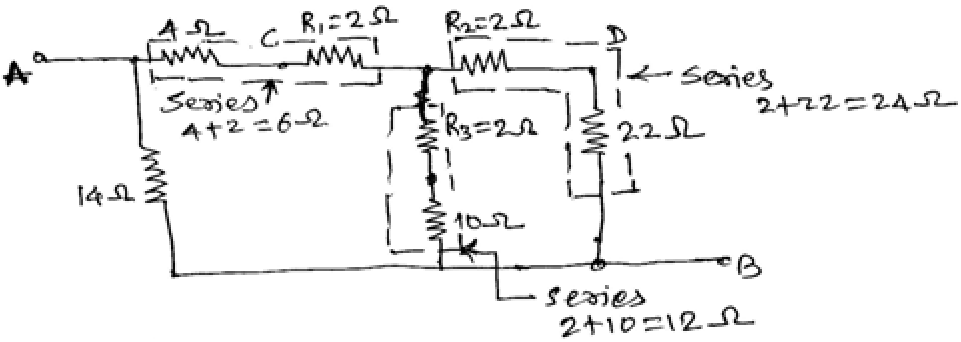


1 mark

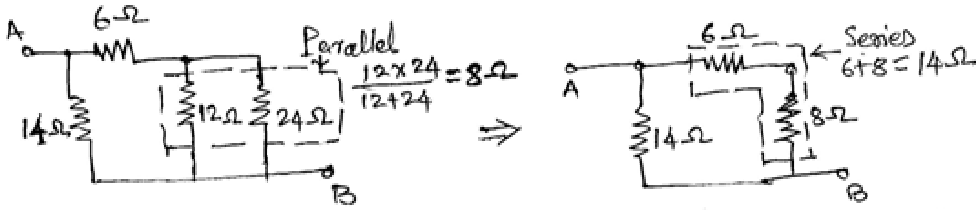
Convert delta CDE into star

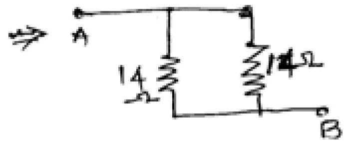
$$R_1 = \frac{6\times6}{6+6+6} = 2\,\Omega,\quad R_2 = \frac{6\times6}{18} = 2\,\Omega,\quad R_3 = \frac{6\times6}{18} = 2\,\Omega$$

1 mark



1 mark





$\therefore R_{AB} = \frac{14 \times 14}{28} = 7\,\Omega$ 1 mark

2 e) Permanent magnet: The permanent magnet have the properties of magnetism naturally permanently present. 1 mark

Electromagnet: Electromagnets are formed by passing an electric current arround a certain ferrous material & which acts as a magnet as long as the current is present. 1 mark

Applications of permanent magnet: in mall electric motors, in techogenrators, in pemanent magnet stepper motor, in two wheeler & car dynamo, for magnetic therapy.

Applications of electromanent magnet: In DC genrators, In DC motors, In solenoid valves, in AC machines.

Any two application of each ½ mark each = 2 marks

2 f) Statically induced emf: The emf induced due to flux linking with stationary coil or conductor is called as statically induced emf. 1 mark

Two types: i) self induced emf: The emf is induced in coil due its own flux change.

$e = - L\, dI / dt$ volts 1 mark

ii) Mutually induced emf: The emf induced in second coil due to change in of flux in first nearby coil. 1 mark

Statically induced emf finds application in transformers. 1 mark

3 a) i)Kirchhoff's current law : - It states that in any electrical network at any node the algebraic sum of current is equal to zero. 1 mark

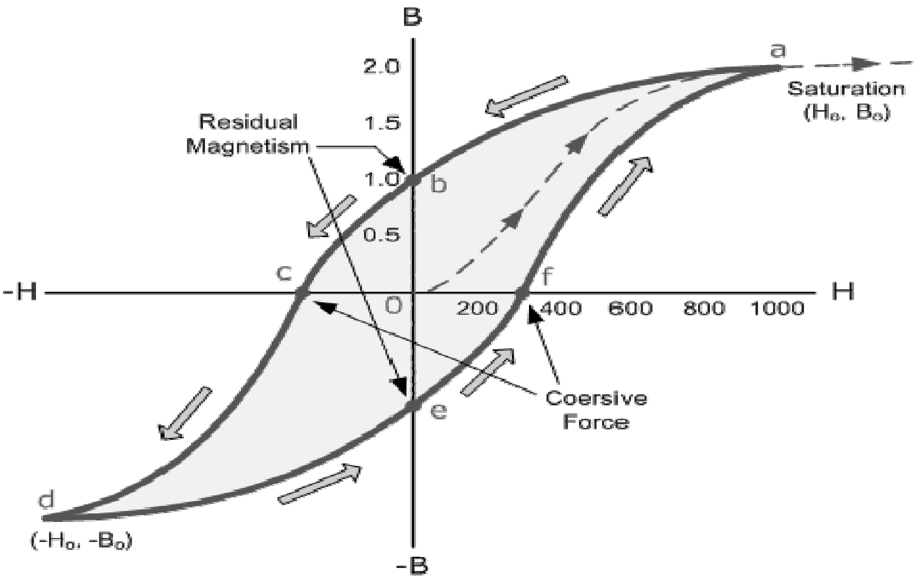
i. e. At a node $\sum I = 0$ 1 mark

ii) Kirchhoff's voltage law : - It states that in any electrical network around a closed path the algebraic sum of the e.m.f. and the voltage drop (I.R.) across each part of the path is zero. 1 mark

i.e. Around a closed loop $\sum$ e.m.f. + $\sum$ I.R. = 0 1 mark

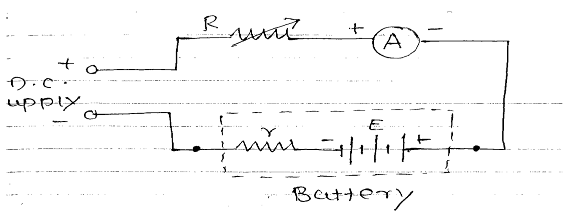
3 b) Magnetic hysteresis: The property of magnetic material due to which magnetic flux density (B) always lags behind magnetic field strength(H) is called as magnetic hysteresis. 1 mark

Hysteresis loss: Due to presence of magnetic hysteresis a fraction of power is lost in the form of heat, is called as hysteresis loss. 1 mark



2 marks for correct loop, other outline fig allowed

3 c) Constant current charging : -



1 mark

- In this method a number of batteries can be charged together by connecting them in series.

- Safe charge rate of battery is provided by the manufacturer.
- But if the charging current is not known it is decided by the number of +veplates in a cell by considering one amp for every positive plate in the cell. 1 mark
- The total voltage of battery should not exceed the main applied voltage otherwise the battery may damage.
- The temperature of battery should not exceed 430C

Advantages :

The system of charging the battery increases the life of battery. 1 mark

Disadvantages :

It takes longer time to charge a battery and needs constant observation to check the charging current. 1 mark

3 d) $R_{18} = 12.7\ \Omega$ & $R_{50} = 14.3\ \Omega$

$R_{50} = R_{18}\ [1 + \alpha_{18}\ (50 - 18)]$ 1 mark

$\alpha_{18} = [(R_{50}/ R_{18}) - 1]/ (50 - 18) = 3.9 \times 10^{-3}\ /\ ^{O}C$ 1 mark

Therefore $\alpha_{18} = 3.9 \times 10^{-3}\ /\ ^{O}C$

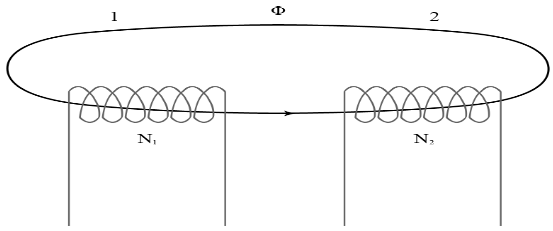
$R_0 = R_{18}\ [1 + \alpha_{18}(0 - 18)] = 12.7\ [1 + 3.9 \times 10^{-3}(-18)] = 11.8\ \Omega$ 1 mark

$\alpha_0 = [\ (R_{18} - R_0) / (18 - 0)\ ] / R_0 = 4.23 \times 10^{-3} / ^{O}C.$ 1 mark

3 e) **Coefficient of mutual inductance:**

Change of the current in a coil produces an EMF in another (neighboring) coil by mutual induction. The EMF so induced is mutually induced EMF. 1 mark

Figure:



Example: In given figure current I_A changes in coil A to produce change in flux due to it. The part of changing flux linking coil B produces EMF in it by mutual induction called as mutually induced EMF.

Thus Mutually Induced EMF in coil B due to change in current in coil A is

$$E_{BA} = - M_{AB} (dI_A/dt) \text{ (V)}$$

(where M_{AB} = coefficient of mutual inductance between coils A and B in Henry, I_A is in amperes, and time t in secs). 1 mark

Coefficient of coupling:

It is the fraction of the flux created by a coil circuit linking another circuit/coil(When they have some common magnetic path for the fluxes created by the currents in them). 1 mark

It gives an idea of how much the two circuits/coils are magnetically close (linked) with respect to the flux they have in common.

If LA and LB are coefficients self inductances of two coils having mutual inductance 'M'

between them then the coefficient of coupling between these coils is given by

$K = M/ \sqrt{(LA.LB)}$

When K = 1 it means that all the flux created by one of the coils links the other, rigid coupling between the coils. 1 mark

d when K < 1 it means that not all flux created by either coil links the other and it is a loose coupling between the coils.

3 f) Types of capacitors:

Air capacitors used in radio receivers, Any 4

Paper capacitors used as filter capacitors, types

Mica capacitors used for high frequency radio applications, with one

Ceramic capacitors also used for high frequency radio applications, app.

Polycarbonate capacitors used for high voltage & high frequency applications, 1 mark

Electrolytic capacitors used as filters. each

4 a) i) Magnetic flux density (B): The magnetic flux per unit area (A), measured in a plane perpendicular to the flux is called as magnetic flux density. Its unit is wb/m^2 OR tesla (T).

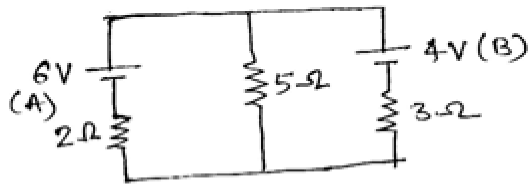
ii) Magnet-motive force: MMF produces or tends to produce the flux in the magnetic circuit. It depends on number of magnetizing coil turns (N) and the current flowing in the coil (I) in ampere i.e. MMF = NI amperes.

iii) Permeance(P): It is the property of magnetic circuit due to which it permits the passage of magnetic flux through it and it is reciprocal of reluctance.
Permeance = 1/ Reluctance. Unit: Weber / ampere.

iv) Magnetic field strength(H): it is the magneto motive force acting per unit length of the magnetic flux path also called as the magnetic field strength(H). Its SI unit ampere per meter.

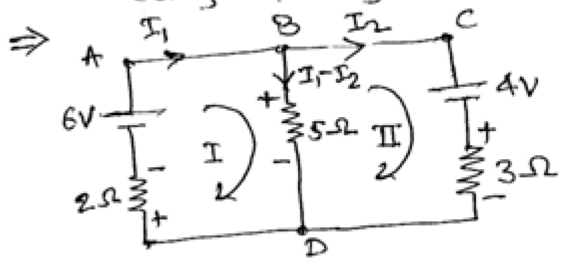
½ mark For each definition & ½ mark For unit

4 b)



Using loop analysis

1 mark



loop equations: loop I: ABDA

$6 = 5(I_1 - I_2) + 2I_1$

$\therefore\ 7I_1 - 5I_2 = 6$ ——— (I)

1 mark

loop II: BCDB, $3I_2 + 4 = 5(I_1 - I_2)$

$\therefore\ 5I_1 - 5I_2 - 3I_2 = 4$

$\therefore\ 5I_1 - 8I_2 = 4$ ——— (II)

1 mark

From above equations

$I_1 = 0.9$ A, $I_2 = 0.065$ A.

Current in 5 ohms = $I_1 – I_2 = 0.9 – 0.065 = 0.835$ A 1 mark

4 c) Effects of electric current:

i) Heating effect : -

When an electric current flows through a conductor, the flow of e- is opposed by the resistance of conductor and heat is produced.

Joules law of heating. *$H \alpha I^2Rt$. (Joules)*

Used in electric irons, water heaters, Hot plates, electric lamps etc. Any two effects 2 marks each

ii)The chemical effect of electric current:

Whenever a DC is passed through a chemical solution, the solution is decomposed into its constituent substances. it is utilized in the electrolytic processes, in production of different chemicals, for refining of metals.

iii) Magnetic effects:

Whenever an electric current passes through a conductor or coil a magnetic field gets developed across it, and coil starts acting as electromagnet. The electromagnet looses its magnetic properties as soon as current passing through the coil reduce to zero.

- When a magnetic compass is placed around / under a current carrying conductor it is deflected.
- This shows there is some relation between current and magnetism.
- Thus, the current carrying conductor doesn't become a magnet but produces a magnetic field.

It is used in electric bells, motors, funs, electrical measuring instruments etc.

4 d)
1) The capacity of battery is expressed in ampere hour (AH). 1 mark
2) It is defined as product of a constant discharge current and the time duration beyond which the battery voltage falls below a voltage level 1 mark

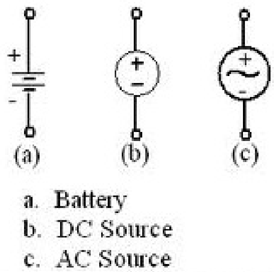
called the "final discharge voltage".

3) During process of discharge the battery voltage should not be allowed to fall below the "final discharge voltage" otherwise battery life is shortened. 1 mark

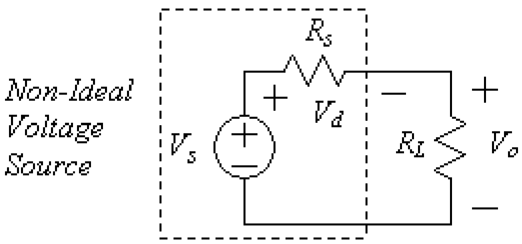
4) If battery capacity of say 10 AH, it means that this battery is capable of supplying 10 A current for an hour. If we want the time to be 2 hours , then the current has to be reduced to 5 A keeping AH=10 1 mark (other eg. Acceptable)

5) Hence, "Amp-Hour capacity of lead acid battery is idealized approximation of its life".

4 e)

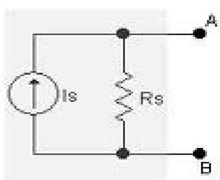


Voltage Sources and their Symbols



1 mark for each correct sysmbol

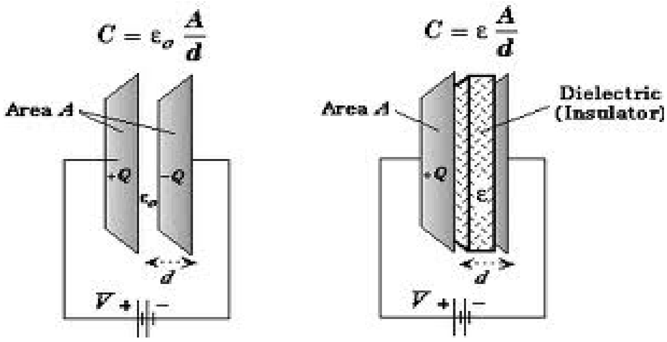
Figure: Ideal Current Source



Practical current source

4 f) Operation of parallel plate capacitor:

Diagram or eqv. circuit 1 mark



1 mark for each point

1) When a voltage source is applied across a capacitor, charging current start flowing in the circuit.
2) Let the charge acquired by the capacitor in time dt be dq. This will increase the potential different across the capacitor plates by dV.
3) The current is defined as rate of change of charge with time,

Therefore, I= dq/dt

But dq = C.dV

Therefore, I= C. dV/dt

This is the expression for capacitor current

5 a) Given $N = 100$, $\phi = 20$ mwb, $dt = 2$ ms

emf e,

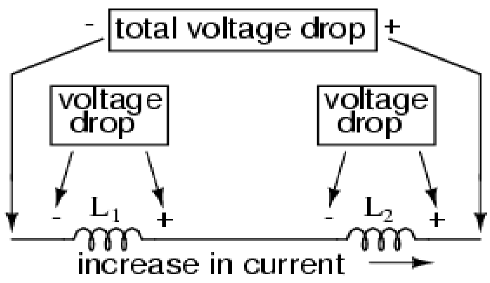
$$e = N \frac{d\phi}{dt}$$ 1 mark

$d\phi = 20 \times 2 = 40$ mwb .. as flux is reversed.

$dt = 2$ ms $= 2 \times 10^{-3}$ sec 1 mark

$\therefore e = 100 \times \frac{40 \times 10^{-3}}{2 \times 10^{-3}} = 2000$ volts. 2 marks

5 b)



1 mark (voltage drops not expected)

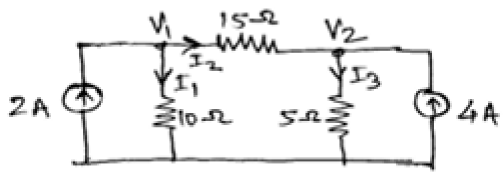
$$L_T = L_1 + L_2 + 2M$$
$$L_T = L_1 + L_2 - 2M$$

1 mark each equation

where: L_T = The total inductance
L_1, L_2 = The inductances of L_1, L_2
M = The mutual inductance between the two inductors

1 mark

5 c)



1 mark

Mark currents I_1, I_2 & I_3

Node 1:

$2 = I_1 + I_2$

$2 = (V_1/10) + (V_1 - V_2)/15$

$60 = 5\ V_1 - 2\ V_2$ --- I

1 mark

Node 2:

$I_2 = I_3 - 4$

$(V_1 - V_2)/15 = (V_2/5) - 4$

$-60 = V_1 - 3V_2$ --II

1 mark

Solving I and II

$V_1 = 23$ V and $V_2 = 27.69$ V.

1 mark

5 d) Ohm's law of magnetic circuit:

In magnetic circuit the closed path traversed by magnetic flux is directly proportional to magneto motive force and inversely proportional to reluctance. 3 mark

Hence, Flux = M.M.F. / Reluctance 1 mark

5 e) Given data : -

$d = 0.15$ mm $= 0.15 \times 10^{-3}$ m

$a = 500$ cm^2 $= 500 \times 10^{-4}$ m^2 1mark

$\in r = 1$ for air, $\in o = 8.854 \times 10^{-12}$ F/m. 1mark

We have $C = \in o \in r\, A/d$ (F) 1 mark

$= 8.854 \times 10^{-12} \times 1 \times 500 \times 10^{-4} / (0.15 \times 10^{-3})$

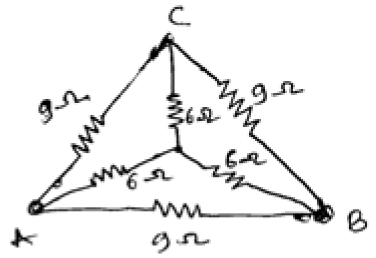
$\therefore C = 29513.3 \times 10^{-13}$ F $= 2951.3$ PF 1 mark

5 f) Duality between series and parallel DC circuit. :-

Series circuit.	Parallel circuit.	
1) $I_T = I_1 = I_2 = I_3 = \ldots\ldots$	$V_T = V_1 = V_2 = V_3 =$	1 mark
2) $V_T = V_1 + V_2 + V_3 + \ldots$	$I_T = I_1 + I_2 + I_3 + \ldots\ldots$	1 mark
3) $R_T = R_1 + R_2 + R_3 + \ldots$	$G_T = G_1 + G_2 + G_3 + \ldots$	1 mark
4) $I_T = V_1 / R_1 = V_2 / R_2 = V_3 / R_3$..	$V_T = I_1/G_1 = I_2/G_2 = I_3/G_3 =$	1 mark

(some students may state in words the dual quantities which must be awarded marks)

6 a)

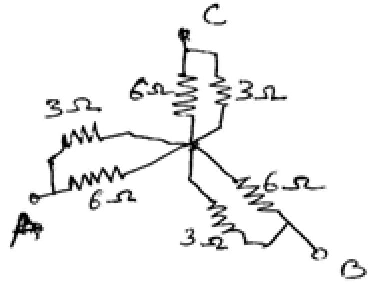


Converting outer Δ to Y

$R_A = \frac{9\times 9}{9+9+9} = 3\Omega$

$R_B = 3\Omega, \quad R_C = 3\Omega$ 2 marks

After converting to star as the star point of both networks are equipotential (as they are balanced) we connect them to get the below network.



6Ω || 3Ω is equivalent resistance

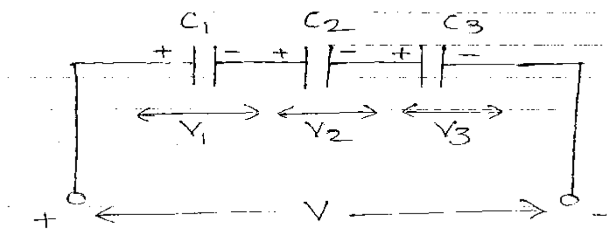
$\frac{6\times 3}{6+3} = \frac{18}{9} = 2\Omega$ 2 marks

$\therefore R_{AB} = 2+2$
$= 4\Omega$

6 b) Capacitors connection in series : -

- As shown in fig. three capacitors are connection in series across C voltage. V.
- In series combination, the charge on each capacitor remains same and is equal to total charge 'Q'

$\therefore Q = Q_1 = Q_2 = Q_3$ 1 mark



1 mark

- The P.D. across each unit is different

Total voltage $V = V_1 + V_2 + V_3$

But we known that $V = Q/C$, 1 mark

Hence $Q/C = (Q/C_1) + (Q/C_2) + (Q/C_3)$

as the charge is same.

$Q/C = Q[(1/C_1) + (1/C_2) + (1/C_3)]$ 1 mark

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

For equivalent capacitance in series connection.

6 c) Lenz's Law : -

This law states that the direction of induced e.m.f. will be in such a direction so as to produce a current whose effect will oppose the cause which produces it. 3 mark

i.e. according to lenz's law the e.m.f. effect tries to nullify it's causes. 1 mark

$e = -N(d\Phi/dt)$ volts.

6 d) Relation between Magnetism and electricity : -

When an electric current flows through a conductor a magnetic field is immediately produced around the conductor. 1 mark

That is we can say that when electrons are in motion they produces a magnetic field. 1 mark

Also when a changing magnetic field is linking with conductor, it causes a flow of electron in a conductor. 1 mark

Thus, electric current produces a magnetic field and magnetism can be used to produce to electricity. 1 mark

6 e) i) Active networks: If a network consists of energy source, then it is called as active network. 1 mark for each definition

ii) Node: A point in electrical circuit at which different branches meet.

iii) Electric N/w :- The combination of various electric elements or parameters connected in a manner to achieve a desired outcome is known as an "Electric

iv) Network"

Linear networks: - A circuit whose parameters are always constant irrespective of changes in voltage. Or current is known as "Linear network."

6 f) Given: Reluctance, $S = 10^6$ AT/wb.

$N = 1000$, $I = 5$ A.

Inductance $L = N^2 / S = 1000^2 / (10^6) = 1$ H. 2 marks

Energy stored, $E = \frac{1}{2} L I^2$ 1 mark

$= 12.5$ Joules. 1 mark