UNIT-III MAGNETOSTATICS

PART – A

1. State Biot – Savart law.

It states that the magnetic flux density at any point due to current element is proportional to the current element and sine of the angle between the element length and line joining and inversely proportional to the square of the distance between them.

$$dB = \frac{\mu_0 I\, dl}{4\pi r^2} \sin\theta$$

2. State Ampere's circuital law

Magnetic field intensity around a closed path is equal to the current enclosed by the path.

$$\oint H \cdot dl = I$$

3. Define the term "Magnetization".

Magnetisation is defined as the ratio of magnetic dipole moment to unit volume.

$$M = \frac{M}{\text{Volume}} = \frac{Q_m \bar{a}}{A} \left(\frac{A}{m}\right)$$

4. What do you mean by magnetic moment?

A small bar magnet of length *l* with pole strength Qm may be considered as magnetic dipole. The product of pole strength Qm and length *l* is called magnetic moment.

$m = Q_m l$

Magnetic dipole is considered as equivalent to current loop with area A and carrying a current I. The magnetic moment is,

$m = I A$

5. Give four similarities between Electrostatic field magnetic field.

Sl.No.	Electro Static field	Magnetic field
1	Energy stored is ½ CV^2	Energy stored is ½ LI^2
2	Charges are at rest	Charges are at motion
3	Electric flux density E V/m	Magnetic flux density H A/m
4	Electric flux density D = £ E C/m	Magnetic flux density B = « H Wb/m^2

6. What is H due to a long straight current carrying conductor.

The Magnetic field intensity at any point due to long straight conductor of carrying current of I with a distance of d is

$$H = \frac{I}{2\pi d}$$

7. Distinguish between magnetic scalar potential and magnetic vector potential.

Sl.No.	Magnetic scalar potential	Magnetic vector potential
1	It is defined as dead quantity whose negative gradient gives the magnetic intensity if there is no current source present.	It is defined as that quantity whose curl gives the magnetic flux density
2	$H = -\nabla V_m$	$B = \nabla \times A$

8. State Lorent's Law and application

If a charge particle is moving with velocity 'v' in the presence of both an electric field 'E' and a magnetic field 'B', then the total electromagnetic force acting on it is

$$F = Q (E + v \times B)$$

This is called Lorentz force.

Applications:

i. Used to determine electron or bits in magnetron.
ii. Used to determine proton path in cyclotron.
iii. Used to determining plasma characteristics in a magnetro hydrodynamic generator.
iv. Used to determine the motion of charged particle in a combined electric and magnetic field.

9. A long straight wire carries a current I=1 Amp. At what distance is the magnetic field H=1 A/m.

Given data:

I = 1 Amp
H=1 A/m.

Find :

d = ?

Formula:

$$H = \frac{I}{2 \pi d} \qquad d = \frac{I}{2 \pi H}$$

Solution:

$$d = \frac{1}{2 \times \pi \times 1} = 0.159$$

Result:

d = 0.159 m

10. **Determine the force per unit length between two long parallel wires separated by 5cm in air and carrying currents of 40A in the same direction.**

Given data:

$I_1 = I_2 = 40$ A d=1 A/m.

Find :

Force/length = ?

Formula:

$$\text{Force/length} = \frac{\mu_0 I_1 I_2}{2 \pi d}$$

Solution:

$$\text{Force/length} = \frac{4 \times \pi \times 10^{-7} \times 40 \times 40}{2 \times \pi \times 5 \times 10^{-2}} = 6.4 \times 10^{-3}$$

Result:

Force/length = 6.4×10^{-3} N/m.

11. Define self inductance.

The self inductance of a coil is defined as the rate of total magnetic flux linkage to the circuit through the coil.

$$L = \frac{N\phi}{i}$$

Where, ϕ --- Magnetic flux N --- No. of turns of coil

I --- Current

12. Define mutual inductance.

The mutual inductance between two coils is defined as the rate of induced magnetic flux linkage in one coil to the through in other coil.

$$M = \frac{N_2 \Omega_{12}}{i_1}$$

Where, N_2 ---- No.of turns in coil 2 Ω_{12} ----- magnetic flux links coil 2

i_1 ---- current through coil 1

13. Compare the energy stored in inductor and capacitor.

For magnetic field, Energy stored in inductor $W = \frac{1}{2} LI^2$

For electric field, Energy stored in capacitor $W = \frac{1}{2} CV^2$

14. A region in free space has a magnetic field intensity of B web/m^2. What is the energy stored per m^3 of space ?

Energy density = energy per volume

$$= \frac{1}{2} \frac{B^2}{\mu} \text{ Joules/m}^3$$

Where, μ ---- is the permeability of the medium.

B ---- magnetic field intensity

15. Calculated the emf induced in a circuit in a circuit having an inductance of 700 μH if the current through it varies at a rate of 5000 A per second.

Given data:

$L = 700\ \mu H$

$\frac{di}{dt} = 5000\ A/s$

Find :

Induced emf (v) = ?

Formula:

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

Solution:

$v = 700 \times 10^{-6} \times 5000$

Result:

$v = 3.5$ volts.

16. What will be the magnetic field of a toroidal solenoid (with N turns, carrying a current I) within the volume of the ring and outside the ring?

magnetic field intensity of a toroidal solenoid is given by

$$H = \frac{N I}{2 \pi r} \quad \text{(inside ring)}$$

$H = 0$ (outside ring)

17. What is the significance of energy density? It depends on what factors?

It indicates the amount of energy stored/unit volume of a system (electric or magnetic). More is the energy density more will be the work done for the given volume.

It depends on the medium for the givenfield(Electric For Magnetic H)

18. What is solenoid?

An inductor coil consisting of multiple turns of wire wound in a helical geometry around a cylindrical core is called as solenoid.

19.Give the expression for inductance of a solenoid.

$$L = \frac{\mu_0 N^2 A}{l}$$

Where, N -- is number of turns. A -- is area of cross-section. l -- is length of solenoid. μ_0 --is free space permeability

20. Distinguish between solenoid and toroid.

Solenoid is a cylindrically shaped coil consisting of a large number of closely spaced turns of insulated wire wound usually on a non-magnetic frame.

If a long, slender solenoid is bent into the form of a ring and thereby closed on itself, it becomes toroid.

PART – B

1.

a) An Iron ring with a cross sectional area of $3cm^2$ and a mean circumference of 15cm is wound with 250 turns of wire carrying a current of 0.3A. The relative permeability of the ring is 1500. Calculate the flux established in the ring.

b) Region, $0 \le z \le 2$ m is occupied by an infinite slab of permeable material($\mu_r = 2.5$).If $B = 10ya_x - 5xa_y$ m wb/m2 within the slab, determine:

i. J ii. J_b iii. M iv. K_b on z=0

2. a) The xy-plane serves as the interface between two different media. Medium 1 ($z < 0$) is filled with a material whose $\mu_r = 6$, and medium 2 ($z > 0$) is filled with a material whose $\mu_r = 4$. If the interface carries current $\frac{1}{\mu_0} a_y$ m A/m, and $B_2 = 5a_x + 8a_z$ m wb/m^2, find H_1 and B_1

b) A small current loop L_1 with magnetic moment $5a_z$ A.m^2 is located at the origin while another small loop current L_2 with magnetic moment $3a_y$ A.m^2 is located at (4,-3,10). Determine the torque on L_2.

3.

a) Establish the relation of force between current carrying parallel conductors.
b) Obtain the magnetic flux density on the axis of a circular coil carrying current I.

4.

a) Derive an expression for inductance of a solenoid with N turns and *l* meter length carrying of I amperes.
b) Deduce the expression to find the magnetic field intensity H at any point P due to an infinite filamentatry current carrying conductor lies in Z-axis and carrying I ampere.

5.

a) State and Explain Ampere's circuital law , Biot – Savart law.
b) State and Explain Lorent's Law