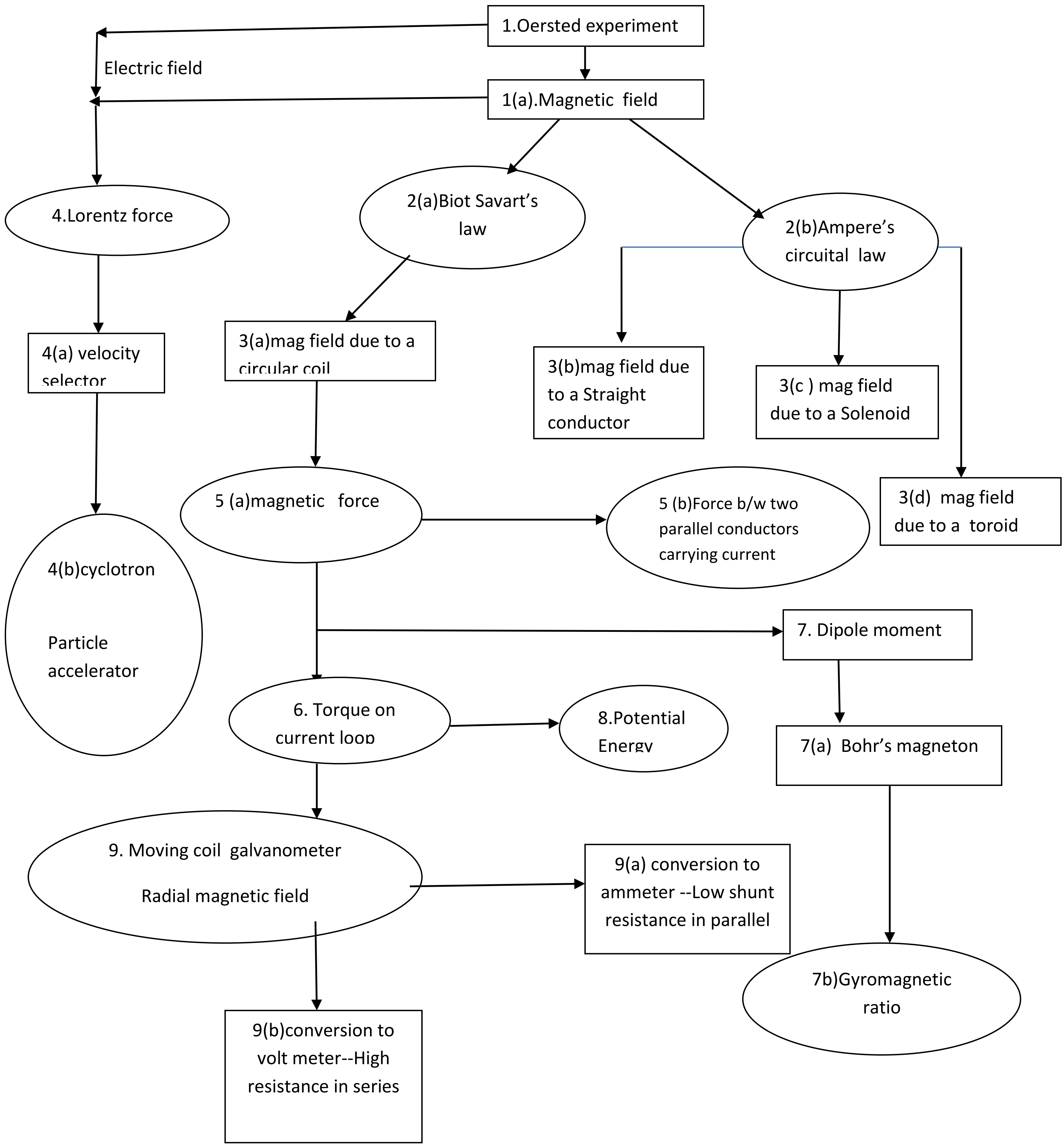
4-Magnetic effects of current



GIST OF MAGNETIC EFFECTS OF CURRENT

1.Oersted's Experiment:

When current was allowed to flow through a wire placed parallel to the axis of a magnetic needle kept directly below the wire, the needle was found to deflect from its normal position. magnetic field is produced by current carrying conductor.

2(a): Biot-Savart's law: $$\mathbf{B} = \frac{\mu_0}{4\pi} \int_C \frac{I d\mathbf{l} \times \mathbf{r}}{|\mathbf{r}|^3}$$

Value of $\mu_0 = 4\pi \times 10^{-7}$ Tm A^{-1} or Wb m^{-1} A^{-1}

Direction of dB is same as that of direction of dl x r which can be determined by Right Hand Screw Rule.

Current element is a vector quantity whose magnitude is the vector product of current and length of small element having the direction of the flow of current. (I dl)

2(b) Ampere' Circuital law: $$\oint_C \mathbf{B} \cdot d\boldsymbol{\ell} = \mu_0 \iint_S \mathbf{J} \cdot d\mathbf{S} = \mu_0 I_{\text{enc}}$$

3 (a) Circular coil: $B= \mu_o n I a^2/ 2 \pi(a^2 + x^2)^{3/2}$

3(b)Straight Conductor: $B= \mu_o i/ 2 \pi r$

3(c) Solenoid: $B= \mu_o ni$

3(d) Toroid: $B= \mu_o ni/2\pi r$

(4) Lorentz's force$F=F_e+ F_m= q E + q(v X B)= qE+ qvB \sin\theta$

Special Cases:

i) If the charge is at rest, i.e. v = 0, then $F_m = 0$.

So, a stationary charge in a magnetic field does not experience any force.

ii) If θ = 0° or 180° i.e. if the charge moves parallel or anti-parallel to the direction of the magnetic field, then $F_m = 0$.

iii) If θ = 90° i.e. if the charge moves perpendicular to the magnetic field, then the force is maximum.

Fleming's left hand rule

If the central finger, fore finger and thumb of left hand are stretched mutually perpendicular to each other and the central finger points to current, fore finger points to magnetic field, then thumb points in the direction of motion (force) on the current carrying conductor.

(4a) Velocity Selector : qE=qvB i.e. v=E/B

(4b) Cyclotron: Cyclotron frequency is independent of speed of particle.

$r=mv/qB$ $\quad$ $f = qB/2\pi m$ $\quad$ $KE= q^2B^2R^2/2m$

6) Torque τ =M X B= MB sinθ

1) The coil will rotate in the anticlockwise direction (from the top view, according to the figure) about the axis of the coil shown by the dotted line.
2) The torque acts in the upward direction along the dotted line (according to Maxwell's Screw Rule).
3) If $\Phi = 0°$, then $\tau = 0$.
4) If $\Phi = 90°$, then τ is maximum. i.e. $\tau_{max} = N I A B$
5) Units: B in Tesla, I in Ampere, A in m^2 and τ in Nm.
6) The above formulae for torque can be used for any loop irrespective of its shape.

7) Dipole moment: M = N I A

7a) Magnetic moment of revolving electron $\mu_l = e L / 2 m_e$

Bohr's magneton: $e/2m_e$

7b) Gyromagnetic ratio: $\mu_l / L = e / 2 m_e$

8) Potential energy: P.E. = -M.B=-MBCosθ

9) Moving coil Galvanometer: N I A B = c θ

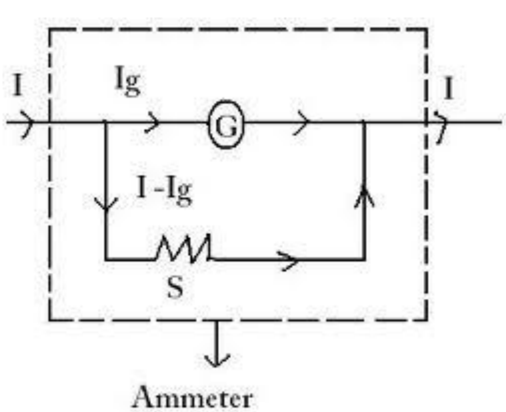
Current sensitivity: It is the defection of galvanometer per unit current.

θ/I= NAB/c ;

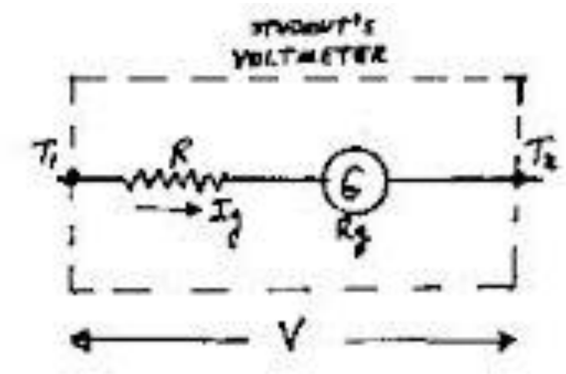
Voltage sensitivity: It is the defection of galvanometer per unit voltage.

θ/V= NAB/c R

9a) Galvanometer to Ammeter : $S= I_g G/(I – I_g)$ $\quad$ $R_A= G+S$

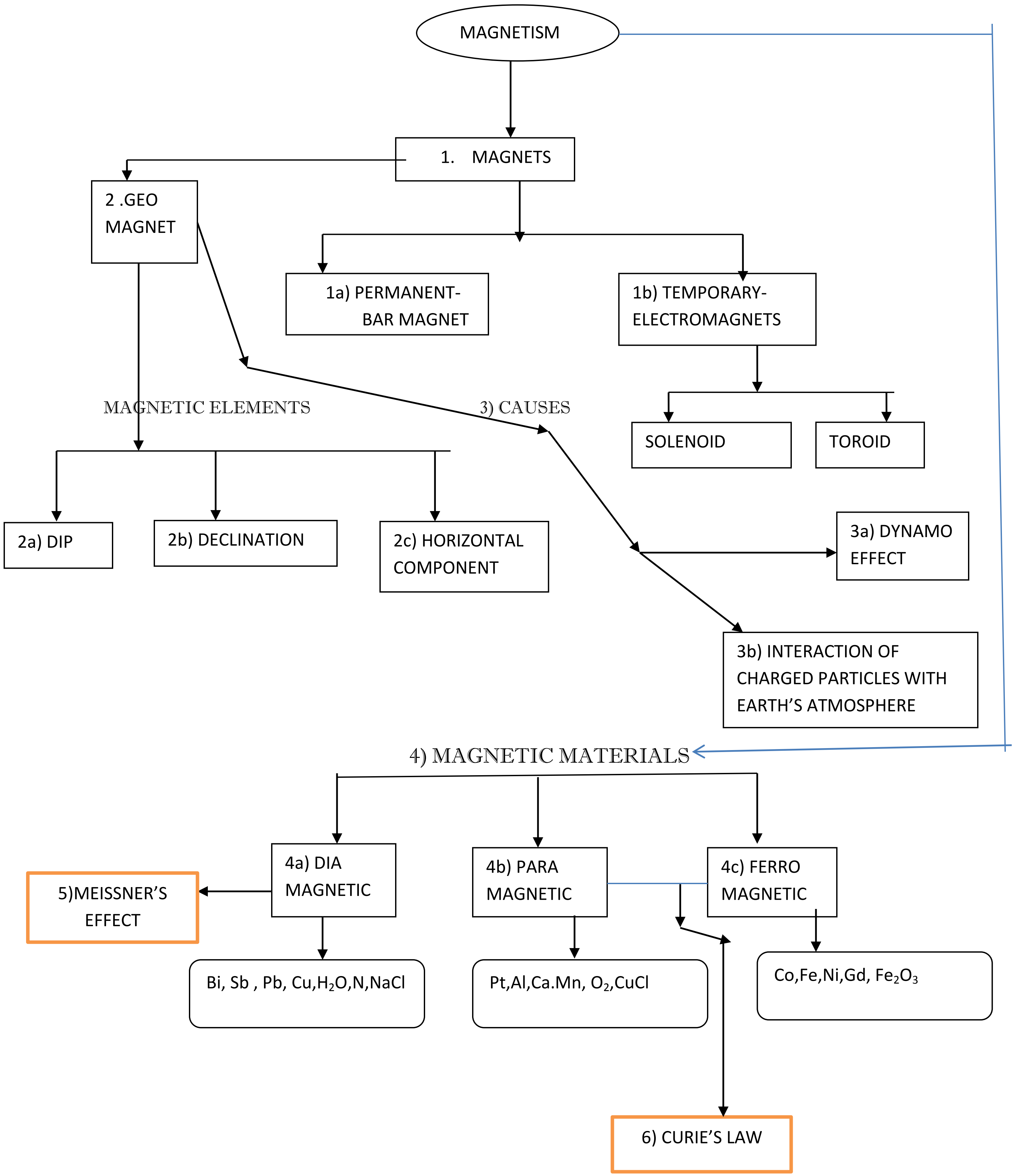


9(b)Galvanometer to voltmeter: $R = (V/I_g) - G$ $R_V = GR/(G+R)$

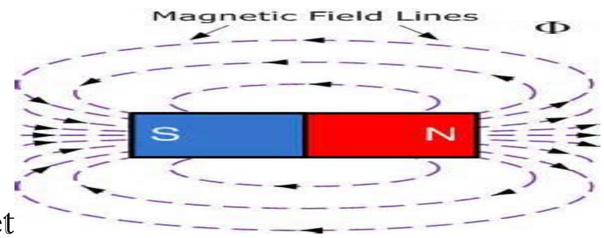


S.No.	Ammeter	Voltmeter
1	**It is a low resistance instrument.**	**It is a high resistance instrument.**
2	**Resistance is GS / (G + S)**	**Resistance is G + R**
3	**Shunt Resistance is** $(GI_g) / (I - I_g)$ **and is very small.**	**Series Resistance is** $(V / I_g) - G$ **and is very high.**
4	**It is always connected in series.**	**It is always connected in parallel.**
5	**Resistance of an ideal ammeter is zero.**	**Resistance of an ideal voltmeter is infinity.**
6	**Its resistance is less than that of the galvanometer.**	**Its resistance is greater than that of the voltmeter.**
7	**It is not possible to decrease the range of the given ammeter.**	**It is possible to decrease the range of the given voltmeter.**

5. Magnetism and Matter- CONCEPT MAP

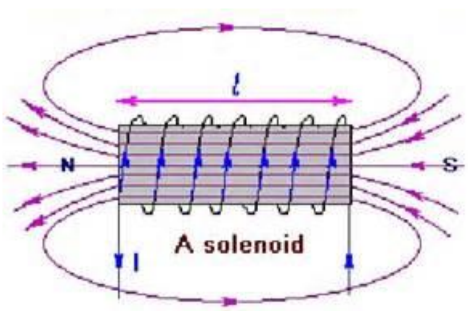


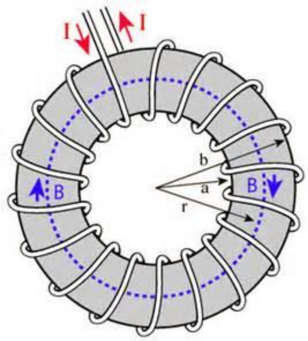
GIST OF MAGNETISM AND MATTER



1a) Bar magnet: Permanent magnet

1b) Electromagnets: Toroid





2a) Dip: Angle between resultant magnetic field with horizontal

2b) Declination: Angle between geographic and magnetic meridian planes

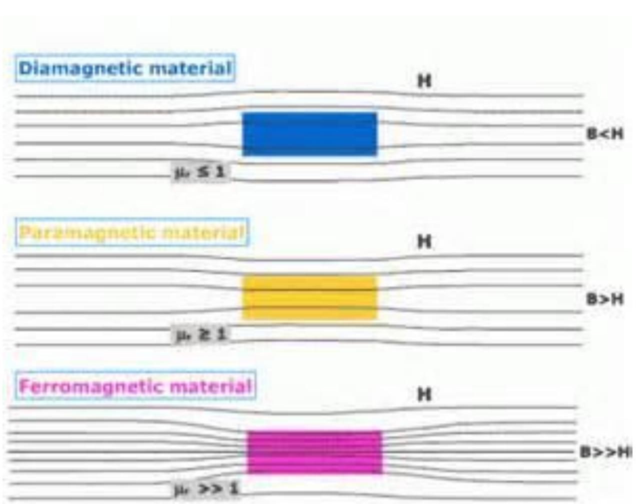
2c) Horizontal component of earth's magnetic field: H=B Cosθ

Tangent law: Tanθ= B_v/B_H

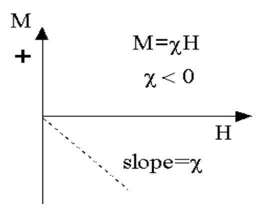
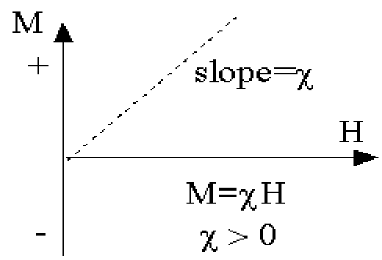
3a) Dynamo effect: Circulating ions in the highly conducting liquid region of earth's core

3b) Interaction of charged particles of earth's atmosphere and rotation of earth about its axis

4) Magnetic field lines of dia,para,ferro



4) Classification of magnetic materials:

S.NO.	Diamagnetism	Paramagnetism	. Ferromagnetism
1	**Diamagnetic substances are composed of atoms which have no net magnetic moments (ie., all the orbital shells are filled and there are no unpaired electrons)**	**This class of materials, some of the atoms or ions in the material have a net magnetic moment due to unpaired electrons in partially filled orbitals.**	**the atomic moments in these materials exhibit very strong interactions.**
2			$\chi=1$
3	**If diamagnetic liquid taken in a watch glass is placed in uniform magnetic field, it collects away from the centre when the magnetic poles are closer and collects at the centre when the magnetic poles are farther.**	**If paramagnetic liquid taken in a watch glass is placed in uniform magnetic field, it collects at the centre when the magnetic poles are closer and collects away from the centre when the magnetic poles are farther**	**If ferromagnetic liquid taken in a watch glass is placed in uniform magnetic field, it collects at the centre when the magnetic poles are closer and collects away from the centre when the magnetic poles are farther**
4	**6. Induced Dipole Moment (M) is a small – ve value.** **Magnetic permeability μ is large i.e. much more**	**Induced Dipole Moment (M) is a small + ve value.** **Magnetic permeability μ is more than uInduced Dipole Moment** **(M) is a small + ve value.** **Intensity of Magnetisation (I) has a small + ve value.** **Magnetic permeability μ is more than unity**	**Induced Dipole Moment (M) is a large + ve value.** **Induced Dipole Moment (M) is a small + ve value.** **Intensity of Magnetization** **(I) has a large + ve value.** **Magnetic permeability μ is large i.e. much morethan unity.**
5	**They do not obey Curie's Law. i.e. their properties do not change with temperature**	**They obey Curie's Law. They lose their magnetic properties with rise in temperature**	**They obey Curie's Law. At a certain temperature called Curie Point, they lose ferromagnetic properties and behave like paramagnetic substances.**

5. **Definition of Meissner's Effect:** The expulsion of magnetic lines of force from a superconducting specimen when it is cooled below the critical temperature is called Meissner effect.

6. According to the curies law of magnetism, the intensity of magnetisation (M) of a magnetic material is

- directly proportional to the magnetic induction (B),
- inversely proportional to the temperature (T) of the material.

that is $M \propto B/T$ —(1) as $B \propto H$ (magnetic intensity)

$M \propto H/T$ or $M/H \propto 1/T$

or $\chi \propto 1/T$ (because magnetic susceptibility $\chi = M/H$)

$\chi = C/T$ where C is a constant of proportionality and is called Curie constant

Thus, according to the Curie's law, magnetic susceptibility is inversely proportional to the temperature of the material.