Ferromagnetic Material *are strongly magnetized in a same direction to that of applied magnetic field. Magnetic properties of such materials are decreases with increase in temperature. E.g. Iron, Cobalt.*
Curie law: Magnetic susceptibility of paramagnetic substance inversely proportional to the temperature. i.e. $\chi \propto \frac{1}{T_c}$
Curie temperature or curie point: *The temperature above which ferromagnetic substance lose their property and becomes paramagnetic is called curie temperature. Curie point for Iron is* 760^0C.
Magnetic Hysteresis:

- ***Hysteresis curve****: Area of hysteresis curve give energy loss per cycle.* ***Retentivity:*** *The property of the magnetic material to retain magnetism even in the absence of magnetizing field.*
- ***Coercivity:*** *The reverse magnetizing field to completely demagnetized the material.*

Soft iron: *Low Coercivity, high Retentivity, narrow hysteresis loop (less energy loss), quickly magnetized and demagnetized, used to make electromagnet, and used in transformer, galvanometer*
Steel: *High Coercivity, low Retentivity, wide hysteresis loop, take long time to magnetized and demagnetized, used to make permanent magnet.*

1. a) Define the term magnetic permeability and susceptibility of a substance. Obtain the relation between relative permeability and magnetic susceptibility.
b) Explain the domain theory of ferromagnetism.
c) Discuss the magnetic hysteresis of ferromagnetic material. Can a hysteresis curve be drawn in the case of diamagnetic material?
d) Why is soft iron preferred for making the core of a transformer?
e) Steel is used in making permanent magnets whereas soft iron is preferred for making electromagnet. Why?
f) What is the significance of the area of a hysteresis loop?
g) What is Retentivity and Coercivity of a ferromagnetic material?
h) A ferromagnetic substance becomes paramagnetic above a curie temperature. Explain?
i) Why should the permeability of paramagnetic material be expected to decrease with increasing-temperature?
j) Why does a magnet loss its magnetism when heated to high temperature?

Electromagnetic Induction

Magnetic Flux*:* $\emptyset = BA\cos\theta$, *unit: Weber or* T/m^2 $\Rightarrow$*Flux Linkage=* $N\emptyset$
Induced Emf: $E = -N\frac{d\emptyset}{dt}$, *where N is number of turns*
Motional Emf: $E = Bvl\sin\theta$
Emf induced in rotating coil (or in AC generator) $E = NBA\omega\sin\omega t$ & $E_{max} = NBA\omega$
Self-Inductance: $L = \frac{\phi}{I} = \frac{E}{(\frac{dI}{dt})}$ *unit: Henry* (H) or $\frac{Wb}{A}$
Energy Stored in an Inductor (coil): $U = \frac{1}{2}LI_0^2$

Lenz's law states that, "the direction of induced current is such that it always opposes the cause which produced it."
Lenz's law obeys law of conservation of energy. The Mechanical work done on changing the magnetic flux is converted into electrical energy

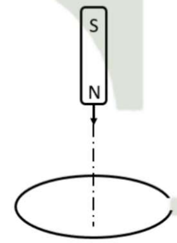


Fig: (b) magnet falling through open ring
Current is not induced as the circuit is not closed acceleration of magnet is equal to g above and below the ring ($a = g$)

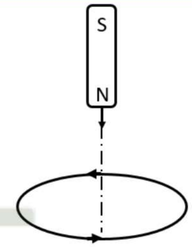


Fig: (a) magnet falling through close ring
The direction of induced current is ACW and acceleration of magnet is less than g above and below the ring ($a < g$)

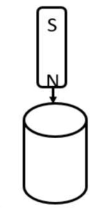
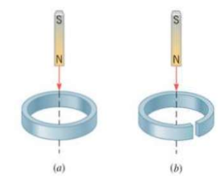
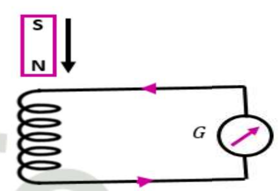


Fig: (c) magnet falling through metal pipe
Eddy current induced in pipe which opposes the motion of magnet and at a particular instant magnetic force due to eddy current balances the weight of magnet and magnet attains constant terminal velocity and acceleration of magnet is zero ($a = 0$)

1. Electromagnetic induction is the reverse phenomena of Orested's discovery.
   a) What are Faraday's laws of electromagnetic Induction?
   b) The magnetic flux passing perpendicular to the plane of coil is given by $\phi = 4t^2 + 5t + 2$ where ϕ is in weber and t is in second. Calculate the magnitude of instantaneous emf induced in the coil when $t = 2\ sec$.
2. Lenz law in electromagnetism gives the direction of induced current.
   a) State Lenz's law. Lenz law follows the principle of conservation of energy. Explain.
   b) An induced current has no direction of its own. Explain?
   c) Explain why the motion of the magnet in part (a) is retarded when the magnet is above the ring and below the ring as well. Draw any induced currents that appear in the ring. Also, explain why the motion of the magnet is unaffected by the ring in part (b)



   d) A student asserted that if a permanent magnet is dropped down a vertical copper pipe, it eventually reaches a terminal velocity even if there is no air resistance. Why should this be?
3. In fig. a magnet is moving towards one end of a solenoid connected to a sensitive galvanometer. During this movement a current is induced in the solenoid (coil).



   a. Suggest three possible changes to the system in the figure that would increase induced current.
   b. Does the direction of induced current change if the magnet is moved away from the coil? Explain.
4. A straight conductor of length 25 cm is moving perpendicular to its length with a uniform of $10m/s$ making an angle of 45^0 with a uniform magnetic field of $10T$. Calculate the emf induced across its length.