

Lecture 24: Magnetic field

- Permanent magnets
- Long straight wire
- Current loop
- Solenoid

Permanent magnets

- North and South poles
- Like poles repel, opposite poles attract
- Magnetic monopoles do not exist; every magnet has both S and N poles (i.e. no magnetic equivalent to point charge)
- Earth magnetic field: the pole of a magnet (compass needle) attracted to the earth's geographic North pole is the magnet's North pole.

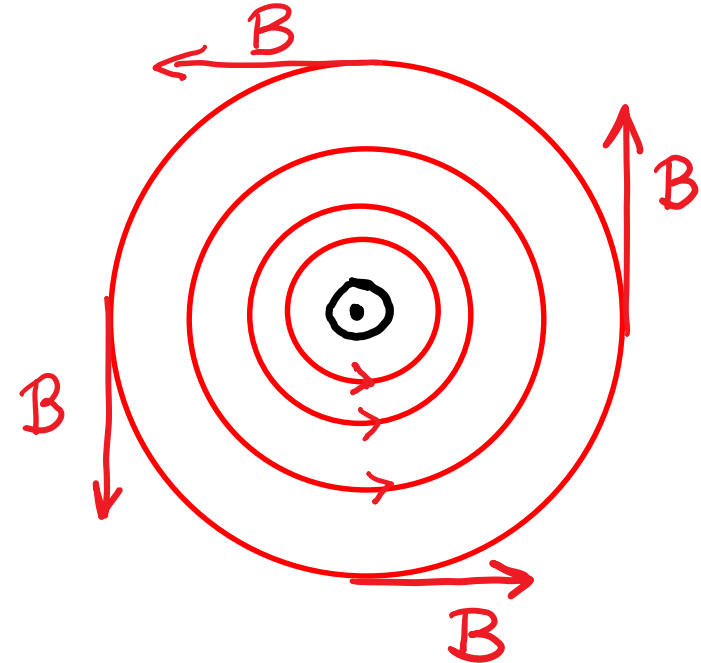
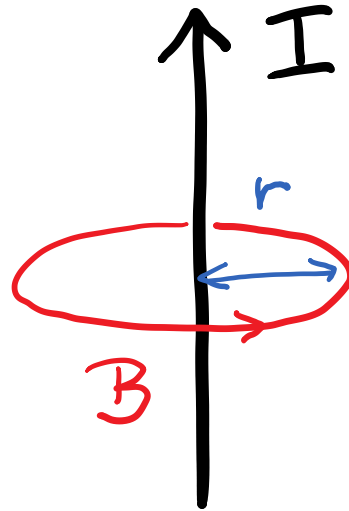
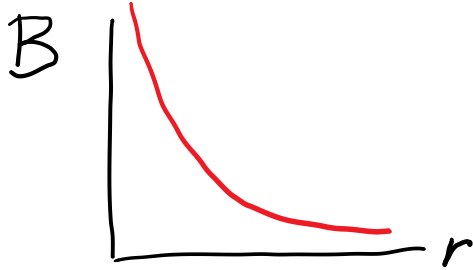
Santa Claus lives at the South Pole of the Earth' magnetic field!

Magnetic field

- Every magnet sets up a magnetic field in space
- If another magnet is brought into this field, it will feel a force
- The direction of the magnetic field is the direction in which the North pole of a compass needle will point if placed at that position
- The strength of the magnetic field is proportional to the torque the compass needle feels if it is turned slightly away from the direction of the field
- Direction: away from N, towards S
- Unit: T Tesla

Magnetic field of a long straight wire

$$B = \frac{\mu_0 I}{2\pi r}$$



Top view

$$\mu_0 = 4\pi \times 10^{-7} \frac{Tm}{A}$$

Magnetic permeability

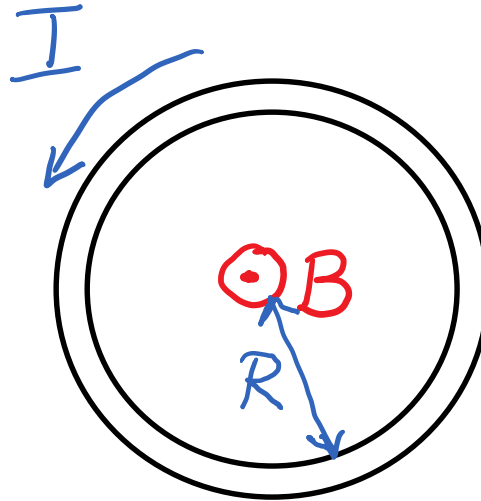
Direction: right hand rule. Current=thumb, fingers=field.

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Magnetic field at the center of a current loop

$$B = \frac{\mu_0 I}{2R}$$



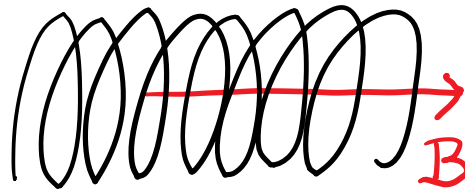
Field of current loop is not uniform.

Formula is for field strength at the center.

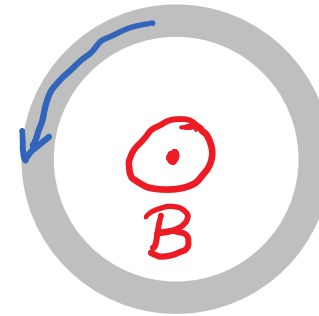
Direction: right hand rule. Current=fingers, thumb=field.

Magnetic field of a long solenoid

$$B = \frac{\mu_0 NI}{L}$$



side view



end view

Field is very small outside the solenoid.

Inside:

- field is uniform
- independent of solenoid radius
- directed along solenoid axis
- Right hand rule: fingers=current, thumb= direction of field