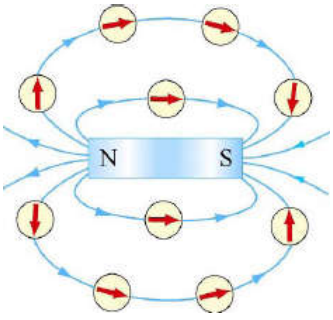
MAGNETIC FIELD

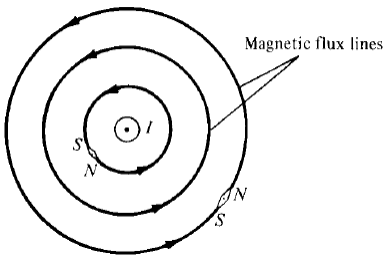
1

1

Magnetic Flux Line

- The path to which *B* is tangential at every point in a magnetic field.
- Magnetic flux lines are closed and do not cross each other.





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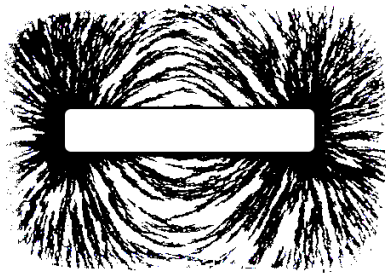
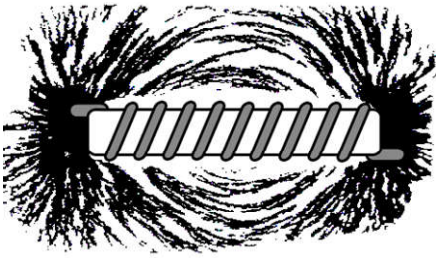
Magnetic Flux Line

MAGNETIC FIELD OF A BAR MAGNET



Flux lines close together indicate high magnetic flux density, B, near the poles

MAGNETIC FIELD OF A SOLENOID



We will find the field of a long solenoid using Ampere's law

$$\int_C \overline{H} \cdot d\overline{l} = \int_S \overline{J} \cdot d\overline{A} = I_{enclosed}$$

For long solenoid:

$$H_{inside} = n\,i$$

$$H_{outside} \approx 0$$

3

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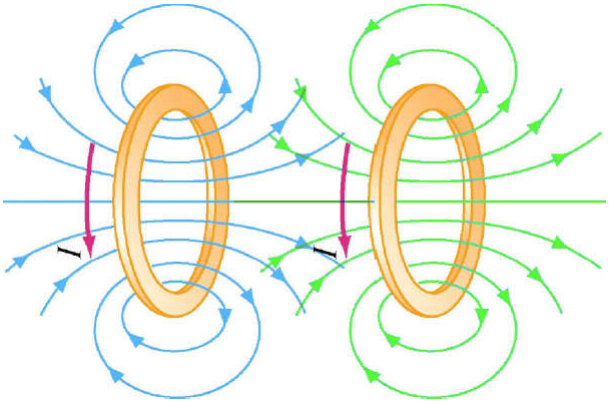
Two Loops



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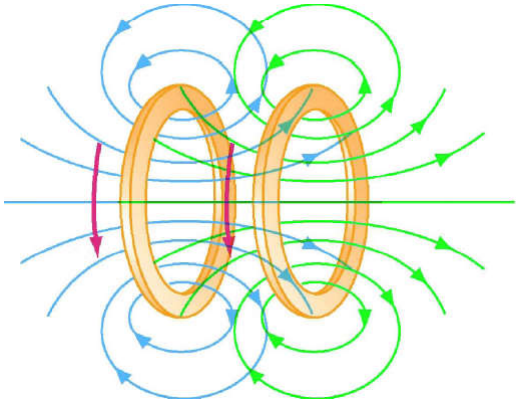
Two Loops Moved Closer



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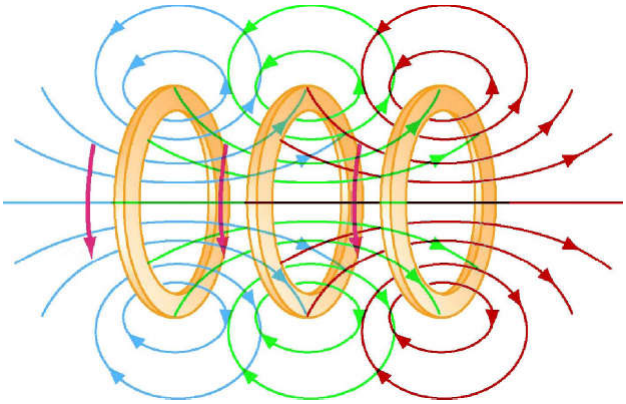
Multiple Wire Loops



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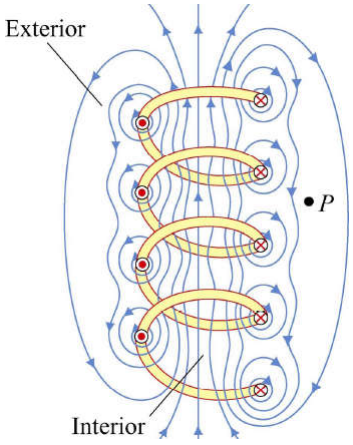
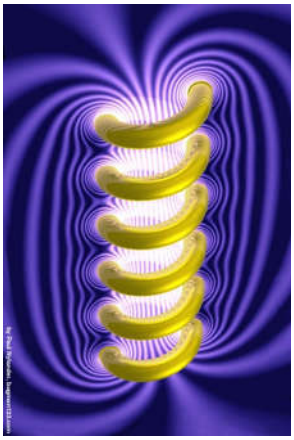
Multiple Wire Loops - Solenoid





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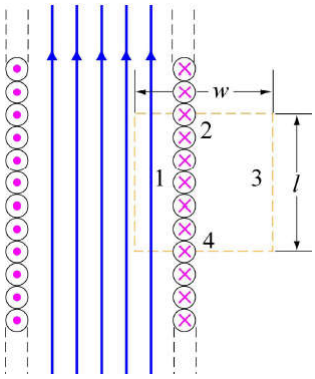
Magnetic Field of Ideal Solenoid



$$I_{\text{enc}} = \oint_L \vec{\mathrm{H}} \cdot d\vec{\mathrm{l}}$$

$$\oint_L \vec{\mathrm{H}} \cdot d\vec{\mathrm{l}} = \int_1 \vec{\mathrm{H}} \cdot d\vec{\mathrm{l}} + \int_2 \vec{\mathrm{H}} \cdot d\vec{\mathrm{l}} + \int_3 \vec{\mathrm{H}} \cdot d\vec{\mathrm{l}} + \int_4 \vec{\mathrm{H}} \cdot d\vec{\mathrm{l}} = Hl$$

$$I_{\text{enc}} = nlI$$

n: number of turns per unit length

$$H = nI$$

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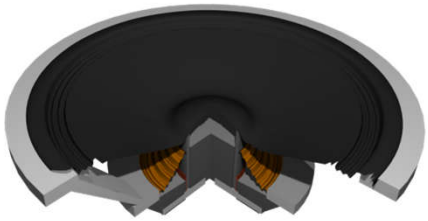
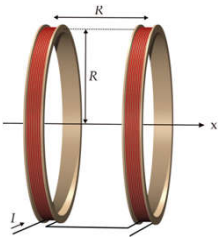
Uses of Solenoids

TRANSFORMER

SPEAKER



HELMHOLTZ COIL



DOORBELL

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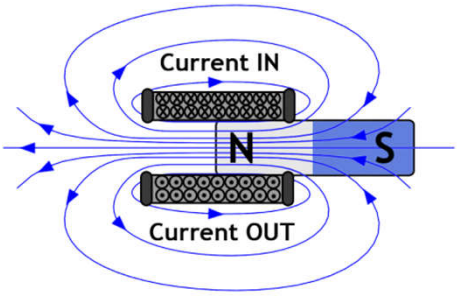
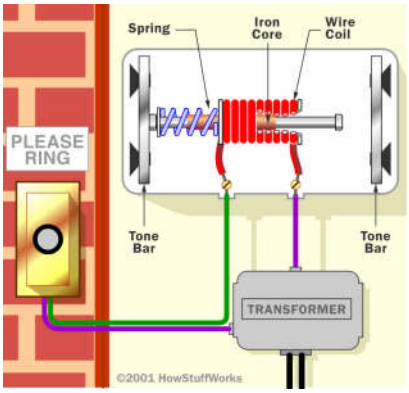
Ding Dong!





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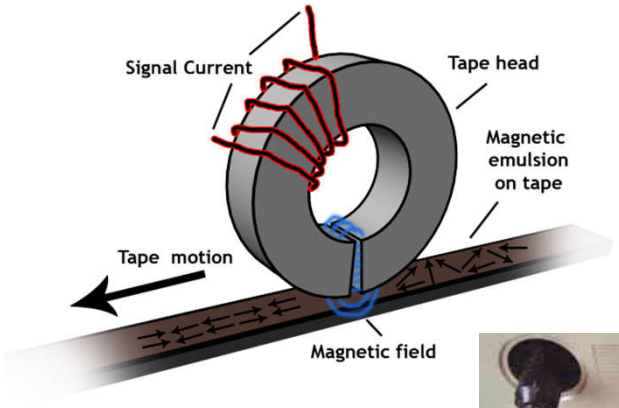
Toroid – Tape Reader



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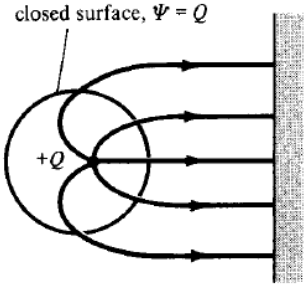
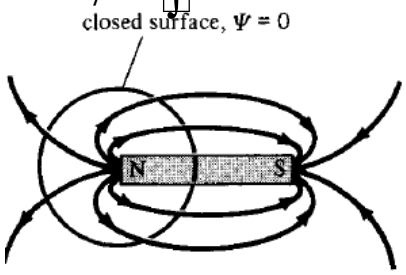
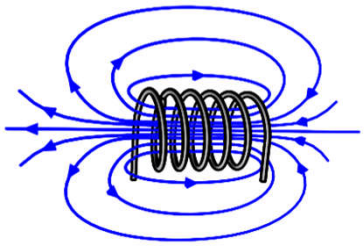
Magnetic Flux Line



$$\psi = \oint\!\!\oint \vec{D} \cdot d\vec{S} = Q$$

$$\psi = \oint\!\!\oint \vec{B} \cdot d\vec{S} = 0$$





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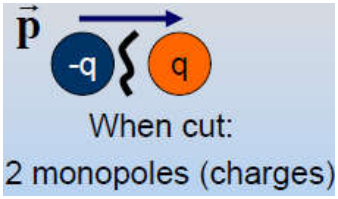
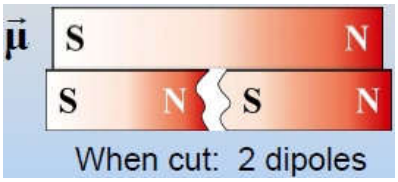
Magnetic Monopoles

Electric Dipole



Magnetic Dipole



Magnetic monopoles do not exist in isolation!

$$\psi = \oint\!\!\oint \vec{D} \cdot d\vec{S} = Q \qquad \psi = \oint\!\!\oint \vec{B} \cdot d\vec{S} = 0$$

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Conservation of Magnetic Flux

$$\psi = \oint\!\!\oint \vec{B} \cdot d\vec{S} = 0$$

Using Divergence theorem

$$\oint\!\!\oint \vec{B} \cdot d\vec{S} = \int_v \nabla \cdot \vec{B}\, dv = 0$$

$\nabla \cdot \vec{B} = 0$ → Fourth Maxwell's Equation

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Maxwell's Equations

Differential Form	**Integral Form**	
$\nabla \cdot \vec{D} = \rho_v$	$\oint_S \vec{D} \cdot d\vec{S} = \int_v \rho_v \, dv$	→ Gauss's law
$\nabla \cdot \vec{B} = 0$	$\oint_S \vec{B} \cdot d\vec{S} = 0$	→ Conservation of magnetic flux
$\nabla \times \vec{E} = 0$	$\oint_L \vec{E} \cdot d\vec{l} = 0$	→ Conservation of electric field
$\nabla \times \vec{H} = \vec{J}$	$\oint_L \vec{H} \cdot d\vec{l} = \int_S \vec{J} \cdot d\vec{S}$	→ Ampere's law

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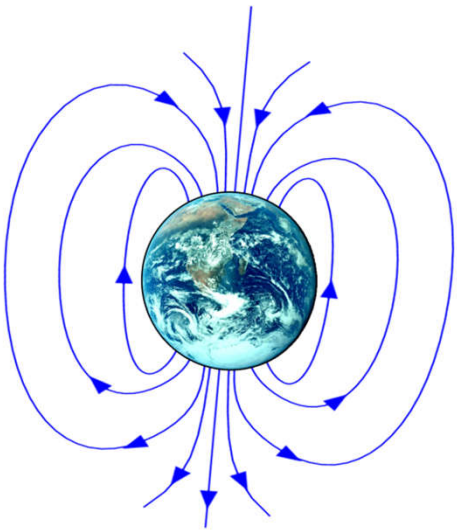
Earth's Magnetic Field



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