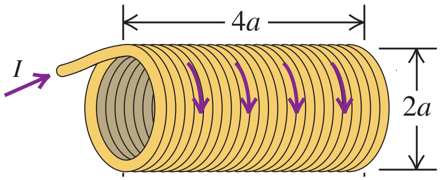
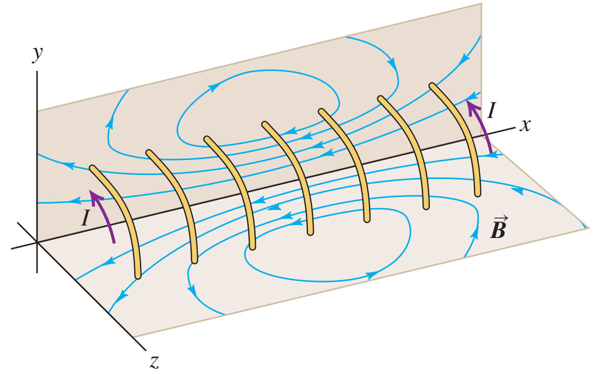
Chp 28: Sources of Magnetic Field - (III)

Field of a Solenoid





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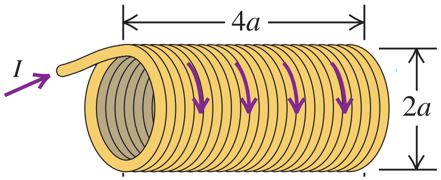

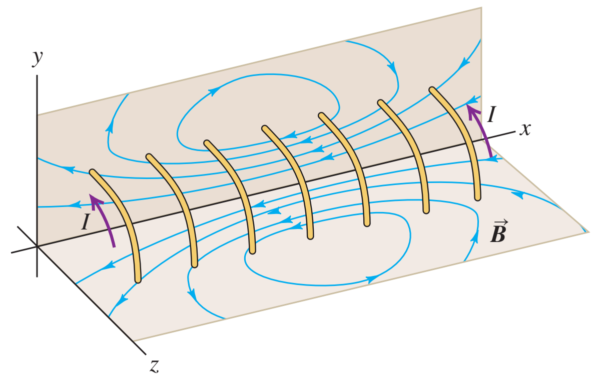

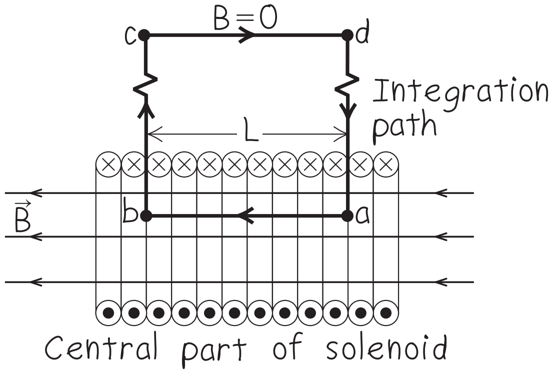

We assume that the magnetic field B is uniform inside the solenoid and zero outside (cd is very far away).

$$\int_a^b \vec{B} \cdot d\vec{l} = BL \qquad I_{\text{encl}} = nLI$$

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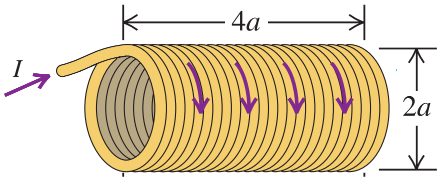

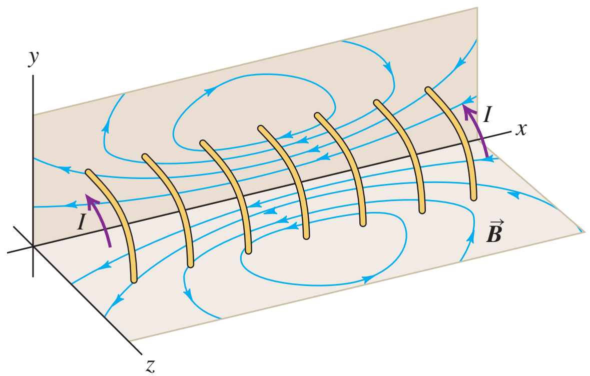

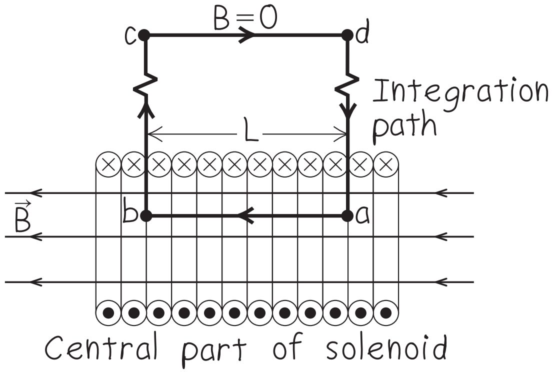

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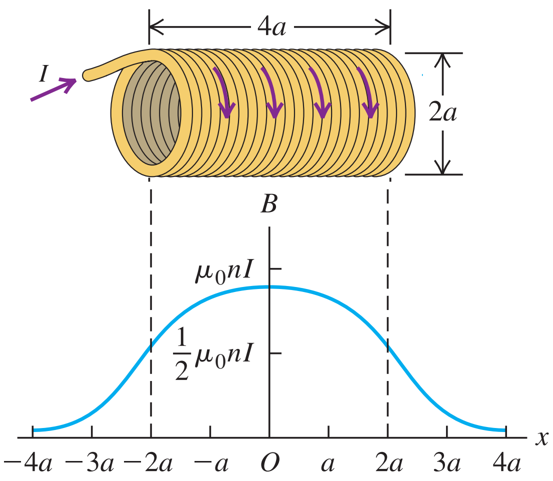
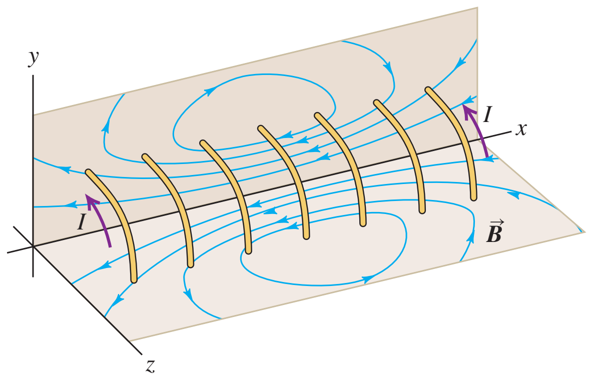
n = N/L. (density)

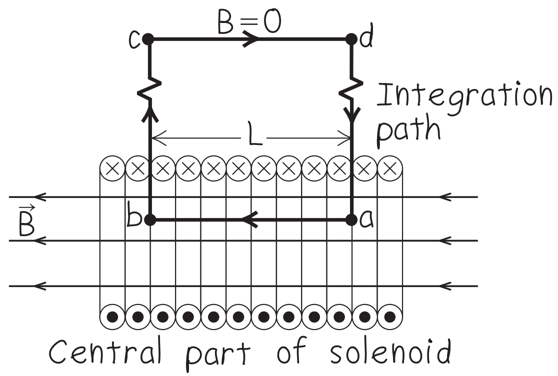
$$\Rightarrow BL = \mu_0 nLI$$

nL turns in a length *L*

Field of a Solenoid







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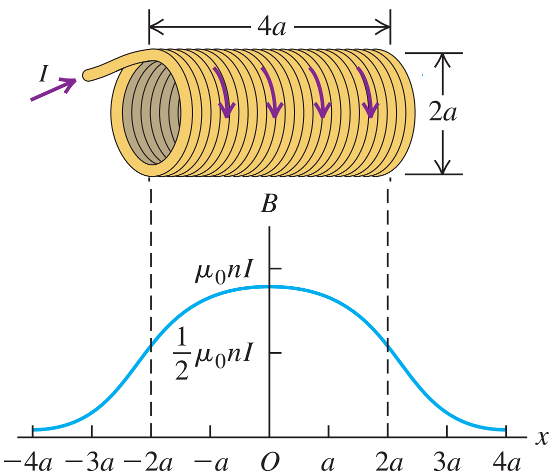

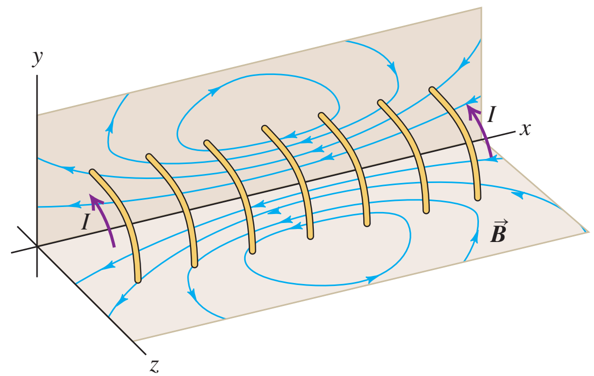

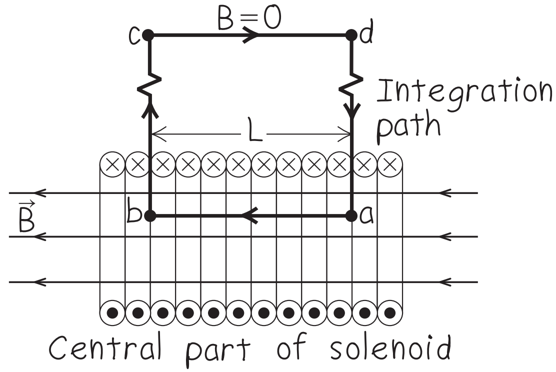

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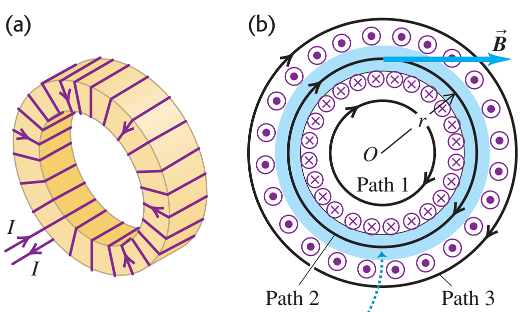
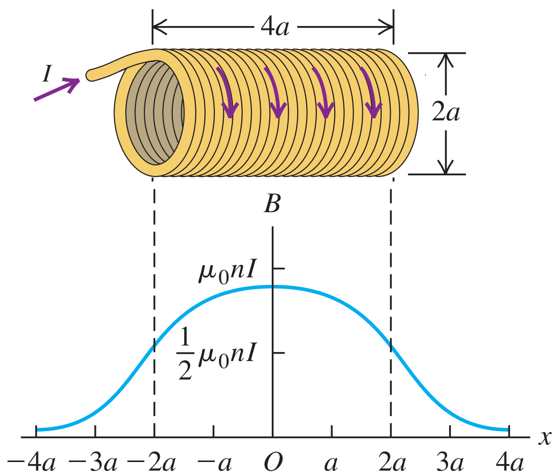
Toroidal Solenoid

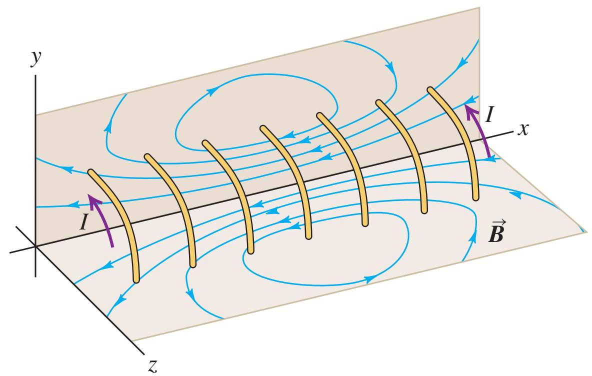


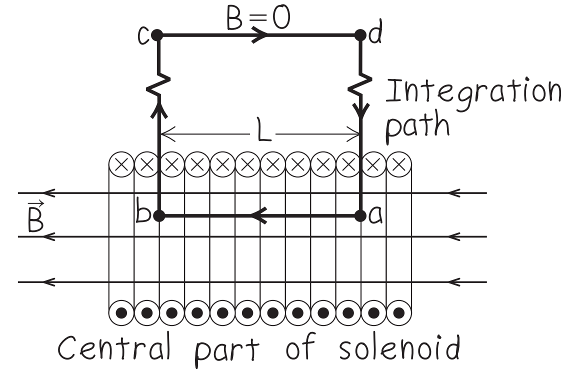
The magnetic field is confined almost entirely to the space enclosed by the windings (in blue).

Along each path $\oint \vec{B}\cdot d\vec{l}$ equals the product of *B* and the path circumference $l = 2\pi r$

Field of a Solenoid







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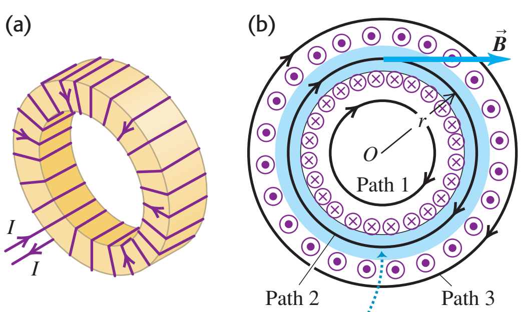
nL turns in a length *L*

Toroidal Solenoid



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$$\oint \vec{B}\cdot d\vec{l} = 2\pi rB \quad \Rightarrow \quad 2\pi rB = \mu_0 NI$$

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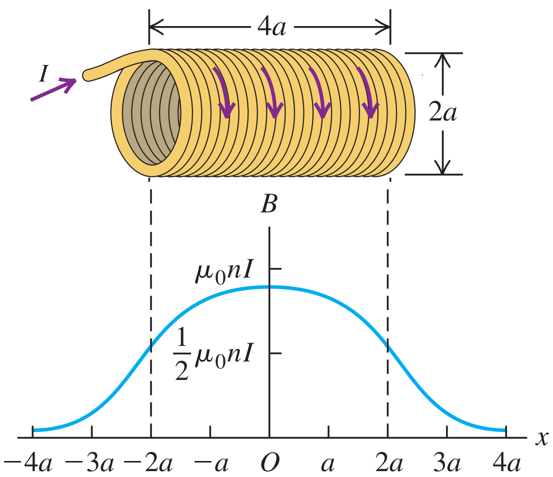

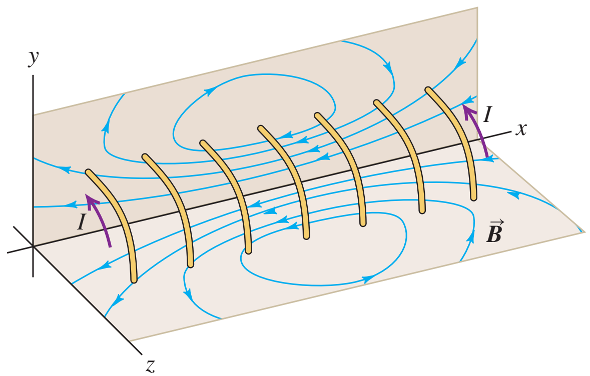

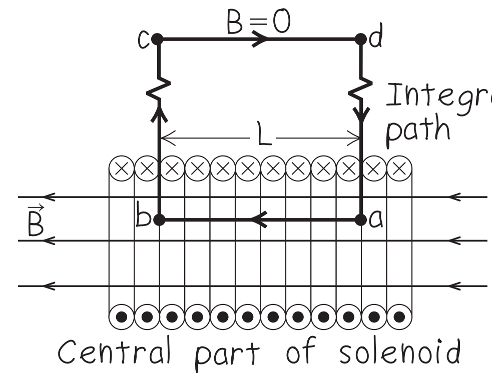

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nL turns in a length L

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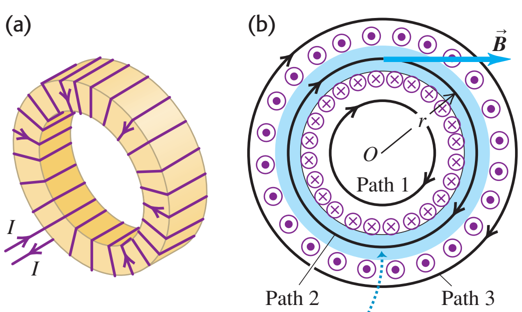

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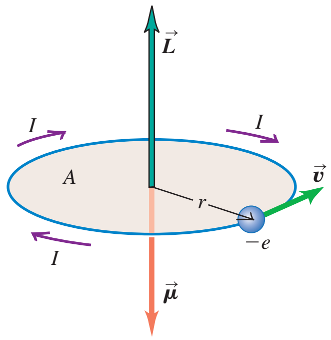
$$\Rightarrow B = \frac{\mu_0 NI}{2\pi r}$$

The Bohr Magneton



The electrons inside the atom form microscopic current loops that produce magnetic fields of their own.

In many materials these currents are randomly oriented and cause no net magnetic field.

But in some materials an external magnetic field can cause these loops to become oriented preferentially with the field, so their magnetic fields *add* to the external field. We then say that the material is *magnetized.*

One can compute the potential energy for a magnetic moment in a magnetic field.

$$U = -\vec{\boldsymbol{\mu}} \cdot \vec{\boldsymbol{B}}$$

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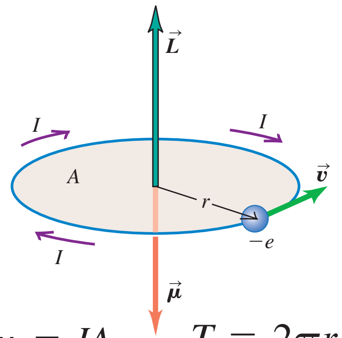

$\mu = IA \qquad T = 2\pi r/v$

$$I = \frac{e}{T} = \frac{ev}{2\pi r}$$

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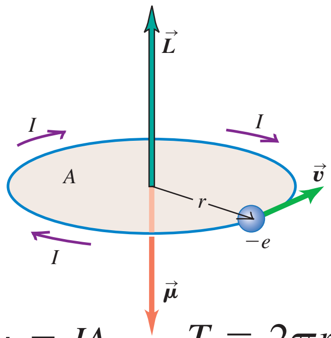

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$$I = \frac{e}{T} = \frac{ev}{2\pi r}$$

$$\mu = \frac{ev}{2\pi r}(\pi r^2) = \frac{evr}{2}$$

$L = mvr$ (Angular momentum)

$$\mu = \frac{e}{2m}L$$

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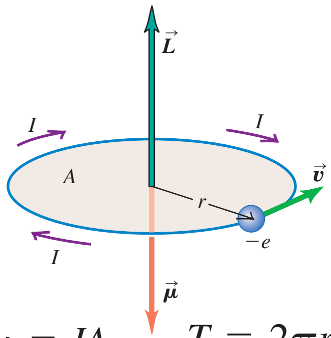

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Quantum Mechanics ➔ Angular momentum is quantized as integer multiples of $h/2\pi$

$$h = 6.626 \times 10^{-34}\ \mathrm{J \cdot s}$$

$$\Rightarrow \quad \mu = \frac{e}{2m}\left(\frac{h}{2\pi}\right) = \frac{eh}{4\pi m}$$

Bohr magneton: $\mu_B = 9.274 \times 10^{-24}\ \mathrm{A \cdot m^2} = 9.274 \times 10^{-24}\ \mathrm{J/T}$

Usefull videos

Electric train:
https://www.youtube.com/watch?v=J9b0J29OzAU

Electrodynamics
https://www.youtube.com/watch?v=-bVi1w0m8x8

Voltage, Current, Electricity, Magnetism
https://www.youtube.com/watch?v=XiHVe8U5PhU

Lecture:
https://www.youtube.com/watch?v=SeaW8nvIoMA&list=PLd2HW1Wc-MswIOwpFIAkoPgmWXQichduW