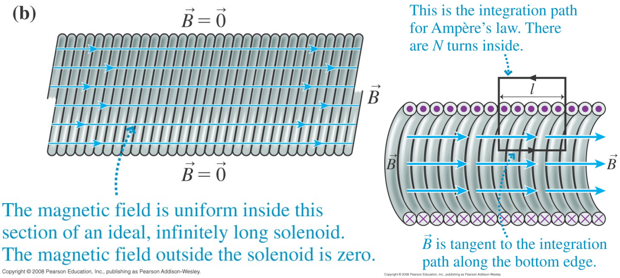
Ampere's Law and a Solenoid



- We can use Ampere's Law to calculate the magnetic field inside a solenoid.

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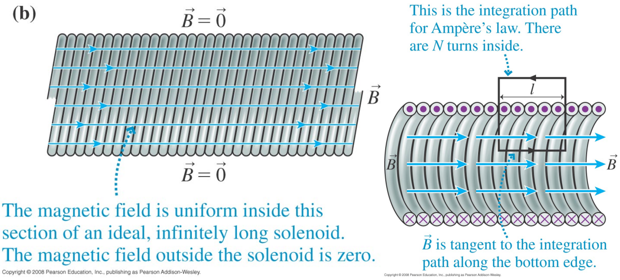

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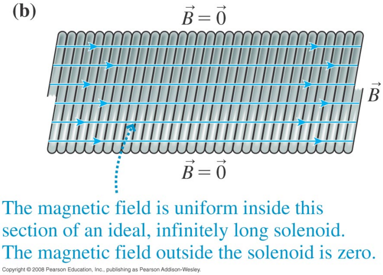
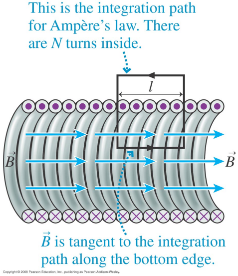
- Draw a rectangular loop through which some (N) of the current-carrying coils pass.

Ampere's Law and a Solenoid





- We can use Ampere's Law to calculate the magnetic field inside a solenoid.
- Draw a rectangular loop through which some (N) of the current-carrying coils pass.
- Each of the wires carries the same current I, so the total current through the loop is NI and:

$$\oint \vec{B} \cdot d\vec{s} = \mu I_{through} = \mu_0 NI$$

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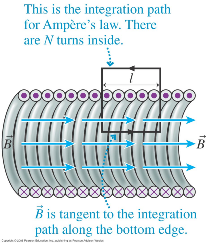

- The line integral is the sum of integrals around 4 sides of the rectangle. The top is outside, so the integral is zero, the sides are perpendicular to the field so the integrals are zero.

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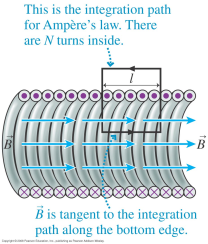

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- Only the bottom matters...and that is parallel to the field so

$$\oint \vec{B} \cdot d\vec{s} \;=\; BL = \mu_0 N I$$

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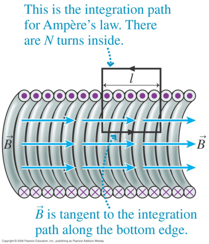

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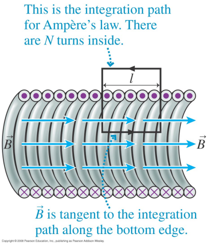

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$$\oint \vec{B} \cdot d\vec{s} = BL = \mu_0 NI$$

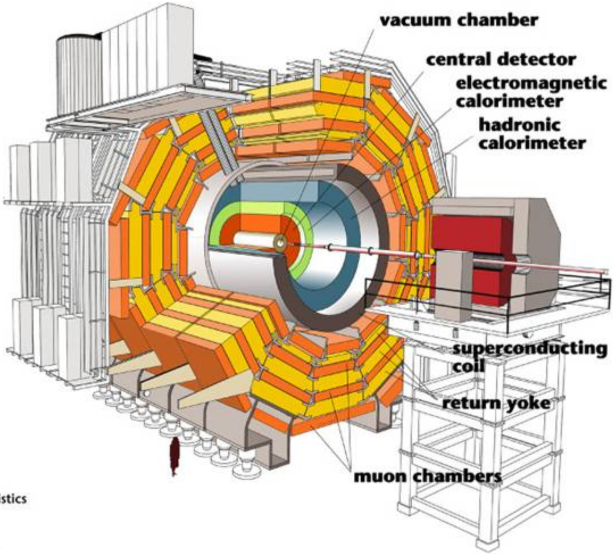
$$B_{solenoid} = \frac{\mu_0 NI}{L} = \mu_0 nI$$

(where n is turns per unit length)

Large Solenoids

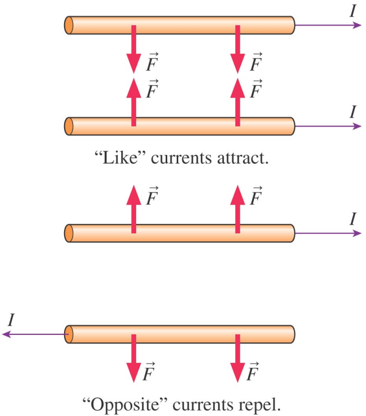
0.5-3T magnet with a bore big enough for a human

Large Solenoids



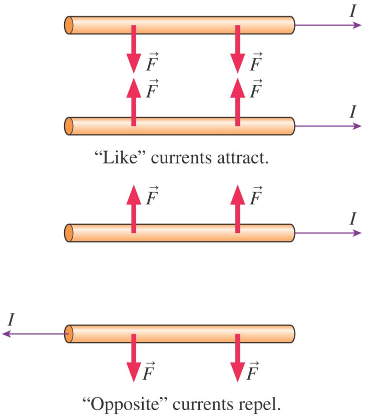
Detector characteristics

Width: 22m
Diameter: 15m
Weight: 14'500t



- Since we know that current in a wire causes a magnetic field, two wires should act like two magnets...they should attract or repel.

The Magnetic Force on a Moving Charge (33.7)



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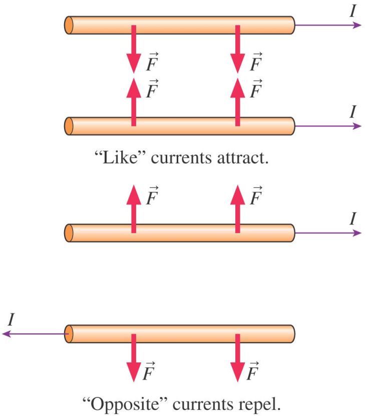
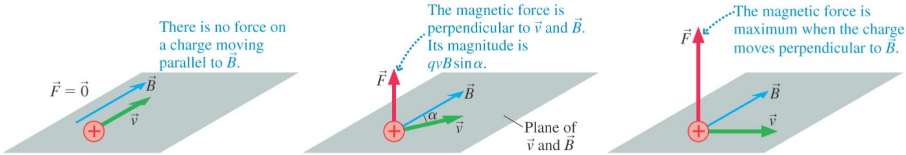


- Since we know that current in a wire causes a magnetic field, two wires should act like two magnets...they should attract or repel.
- Ampere did the experiment and voila!
- Current flowing in the same direction will attract, opposite directions will repel.

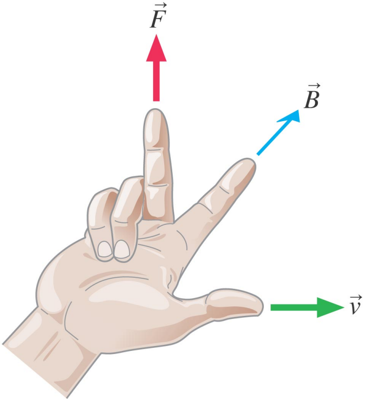


$$\vec{F}_{\text{on q}} = q\vec{v} \times \vec{B}$$

Magnitude:

$$F_{\text{on q}} = qvB\sin\alpha$$

The Relationship between $\vec{v}$, $\vec{B}$ and $\vec{F}$



Properties of the magnetic force:

1. Only a moving charge feels a magnetic force

Magnetism is some sort of interaction between moving charges.

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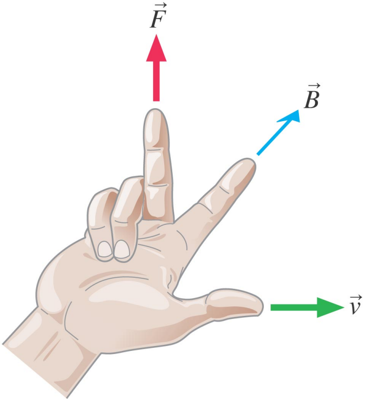

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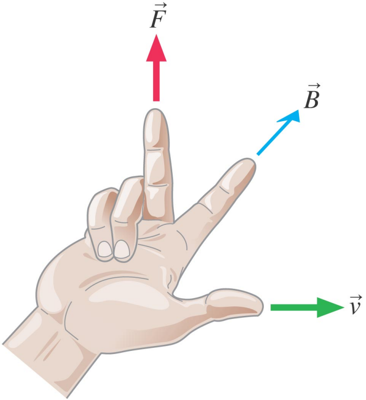

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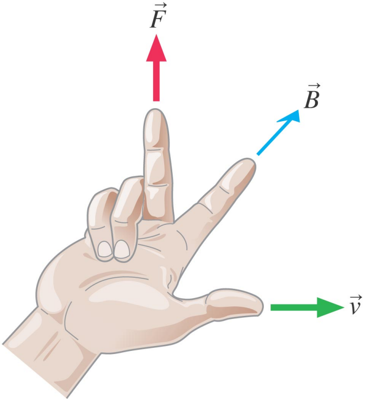

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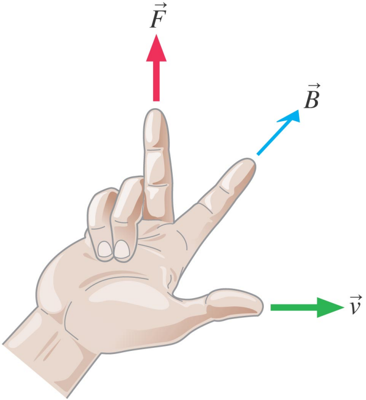

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5. For a charge moving perpendicular to $\vec{B}$, the magnitude of the force is $F = |q|vB$.

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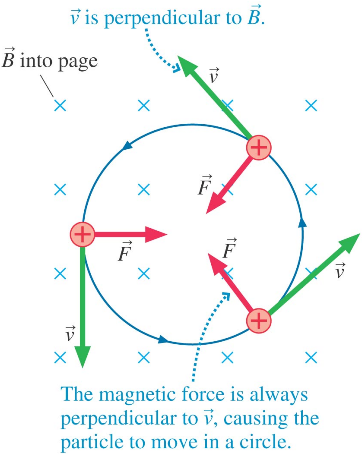
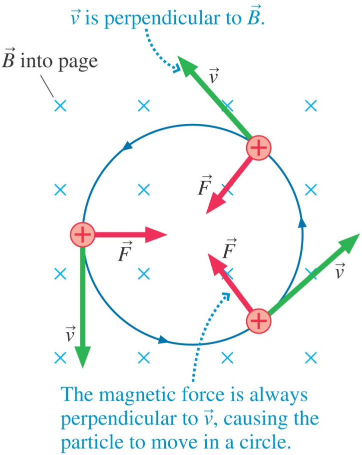


- If you put a moving charged particle in a uniform magnetic field you get the picture at the left.

Cyclotron Motion



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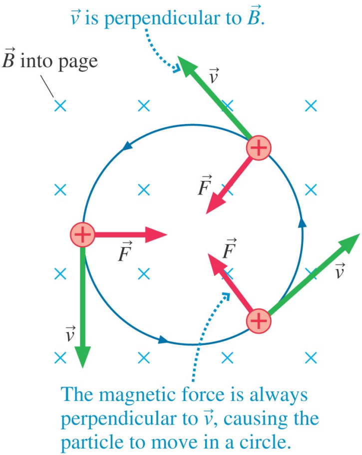

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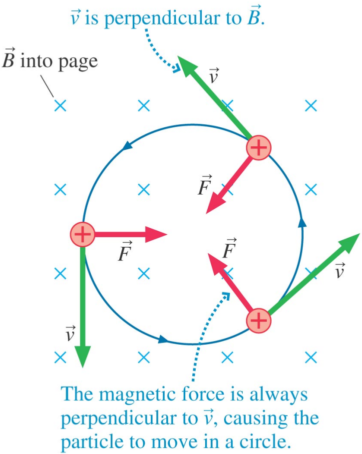

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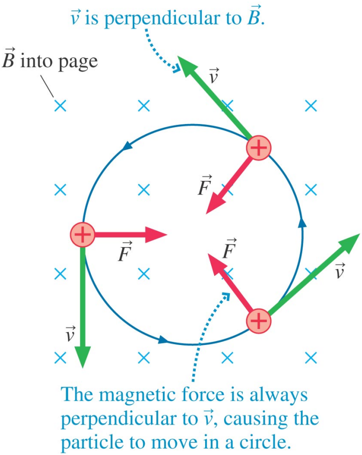

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$$r_{cyc} = \frac{mv}{qB}$$

Notice that the size of the orbit can shrink if you increase the magnetic field.