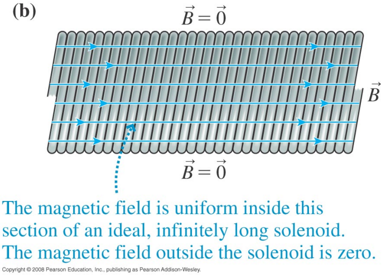
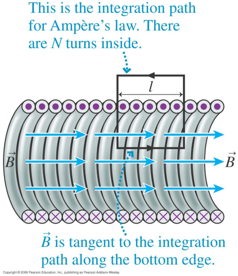
Ampere's Law and a Solenoid





- We can use Ampère'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:

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

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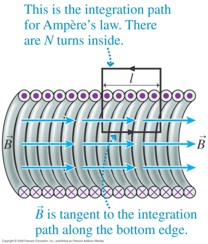


- The line integral is the sum of integrals around 4 sides of the rectangle. The top is outside, so the integral is zero, the sides are perpendicular to the field so the integrals are zero.
- Only the bottom matters...and that is parallel to the field so

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

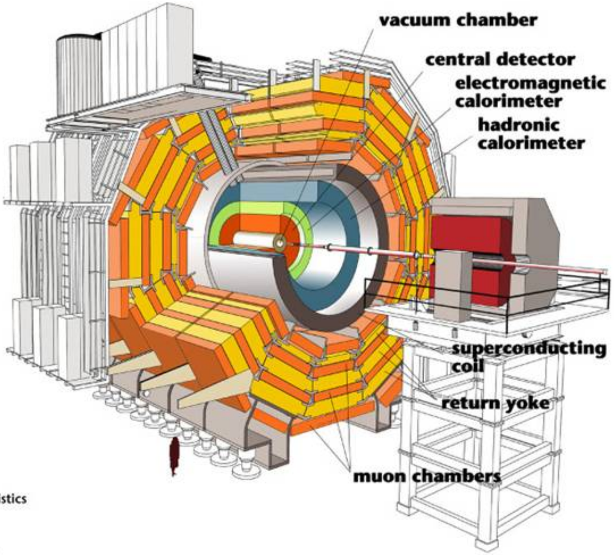
$$B_{solenoid} = \frac{\mu_0 NI}{L} = \mu_0 nI$$

(where n is turns per unit length)

Large Solenoids

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

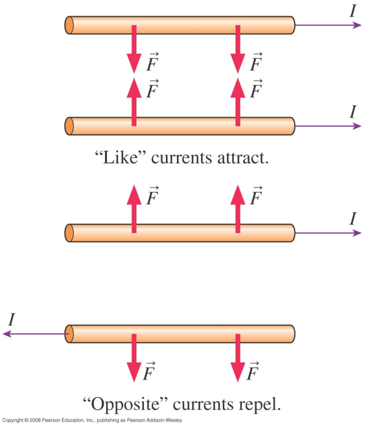
Large Solenoids



Detector characteristics

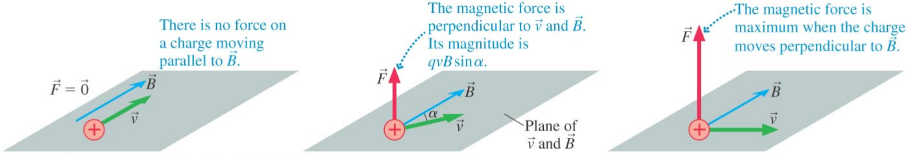
Width: 22m
Diameter: 15m
Weight: 14'500t

The Magnetic Force on a Moving Charge (33.7)



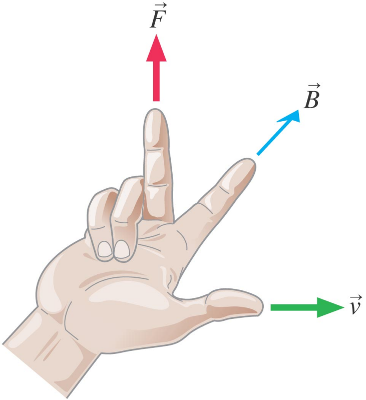
- Since we know that current in a wire causes a magnetic field, two wires should act like two magnets...they should attract or repel.
- Ampère did the experiment and voilà!
- Current flowing in the same direction will attract, opposite directions will repel.

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



$$\vec{F}_{\text{on q}} = q\vec{v} \times \vec{B} = (magnitude = qvB \sin\alpha)$$

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

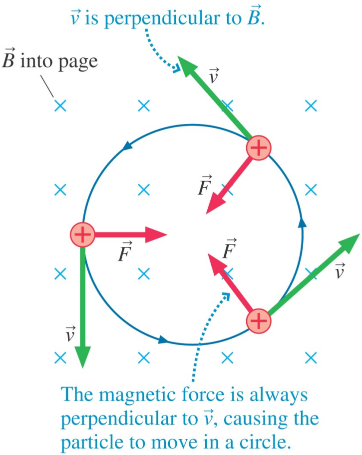


Properties of the magnetic force:

1. Only a moving charge feels a magnetic force
2. There is no force on a charge moving parallel (or anti-parallel) to a magnetic field.
3. When there is a force, it is perpendicular to both $\vec{v}$ and $\vec{B}$
4. The force on a negative charge is opposite to $\vec{v} \times \vec{B}$
5. For a charge moving perpendicular to $\vec{B}$, the magnitude of the force is $F = |q|vB$.

Magnetism is some sort of interaction between moving charges.

Cyclotron Motion



- If you put a moving charged particle in a uniform magnetic field you get the picture at the left.
- cyclotron motion should remind you a lot of planetary motion...or a ball on a string...
- Using Newton's Law we get

$$F = qvB = ma_r = \frac{mv^2}{r}$$

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

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