Magnetic Fields

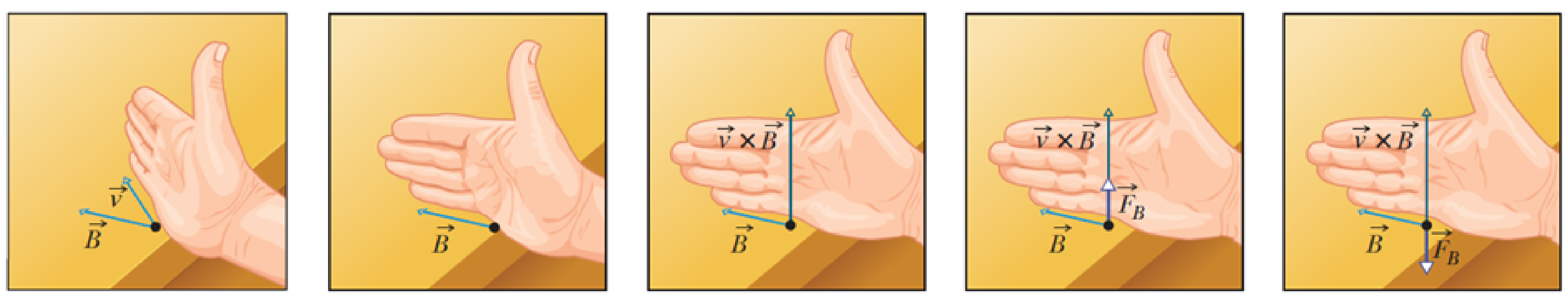
$\boxed{\vec{F} = q\vec{v} \times \vec{B}}$

Right-hand rule

Cross $\vec{v}$ into $\vec{B}$ to get the new vector $\vec{v} \times \vec{B}$.

Force on positive particle

Force on negative particle



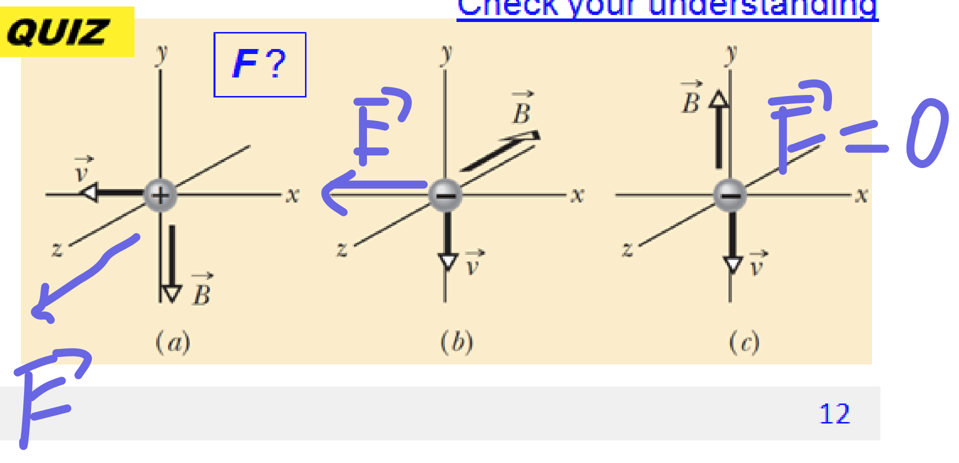
Magnetic field SI units: tesla (T) = (N / (C m/s)) = (N / A m)

gauss (1 G = 10^{-4} T)

At surface of neutron star	10^8 T
Near big electromagnet	1.5 T
Near small bar magnet	10^{-2} T
At Earth's surface	10^{-4} T
In interstellar space	10^{-10} T
Smallest value in magnetically shielded room	10^{-14} T

Check your understanding

QUIZ



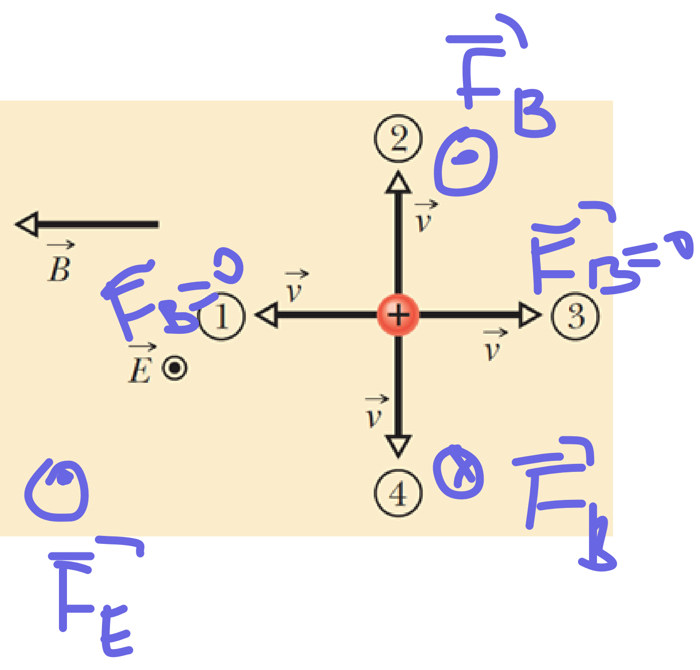
Crossed Fields

$\vec{F}_{net} = \vec{F}_E + \vec{F}_B =$

$= q(\vec{E} + \vec{v} \times \vec{B})$

QUIZ Check your understanding:

The figure shows four directions for the velocity vector $\vec{v}$ of a positively charged particle moving through a uniform electric field $\vec{E}$ (directed out of the page and represented with an encircled dot) and a uniform magnetic field $\vec{B}$. (a) Rank directions 1, 2, and 3 according to the magnitude of the net force on the particle, greatest first. (b) Of all four directions, which might result in a net force of zero?



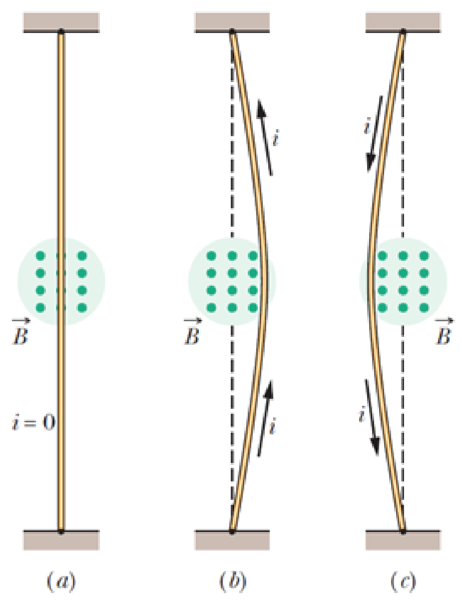
(a) 2, 1 & 3

(b) 4

Magnetic Force on a Current-Carrying Wire

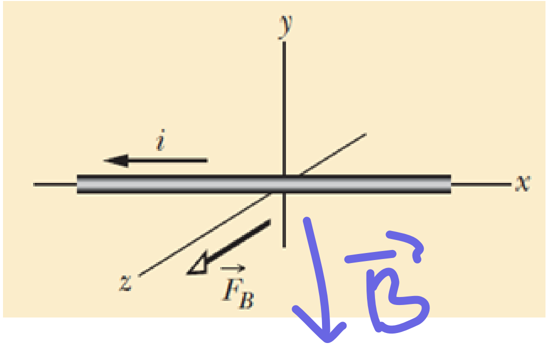
Magnetic field affects the motion of any charged particles.

electrons moving in a **wire** should also be affected by the external magnetic field. As a result, the **force** which is exerted on the electrons should be **transmitted** to the wire itself.



QUIZ Check your understanding:

The figure shows a current i through a wire in a uniform magnetic field $\vec{B}$, as well as the magnetic force $\vec{F}_B$ acting on the wire. The field is oriented so that the force is maximum. In what direction is the field?



$\vec{B}$ in (−y) direction

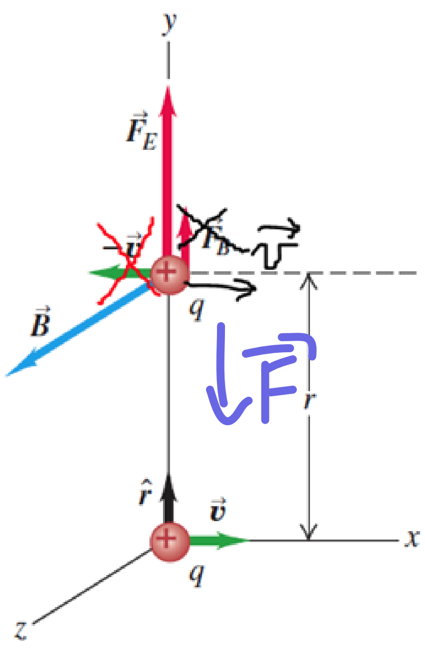
Note: it does not matter whether we consider negative charges drifting downward or positive charges drifting upward → the direction of the deflecting force on the wire is the same.

Magnetic Field of a Moving Charge

EXERCISE

Task #3: Two protons move parallel to the *x*-axis in opposite directions at the same speed (small compared to the speed of light). At the instant shown, find the electric and magnetic forces on the upper proton and compare their magnitudes.

Solution:



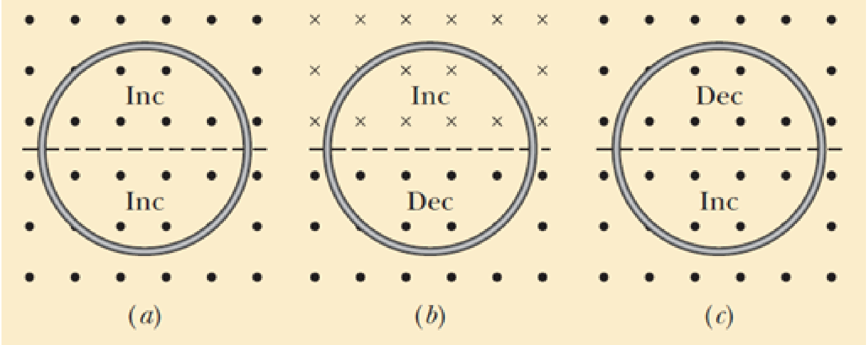
QUIZ Check your understanding:

If both protons travel in the <u>same</u> direction, is the magnetic force between them (i) attractive or (ii) repulsive?

Lenz's Law

QUIZ Check your understanding:

The figure shows three situations in which identical circular conducting loops are in uniform magnetic fields that are either increasing (Inc) or decreasing (Dec) in magnitude at identical rates. In each, the dashed line coincides with a diameter. Rank the situations according to the magnitude of the current induced in the loops, greatest first.



$i_{ind} = \frac{|\mathcal{E}_{ind}|}{R}, \quad \mathcal{E}_{ind} = -\frac{d\Phi_B}{dt}$

a & b, c