Physics 101

Lecture 6.

Wed. Jan. 15, 2003.

Topics Covered: Newton's Laws of Motion.

Free-Body Diagram.

Some common forces in nature.

Ref: Ch.5. 12-1.

Newtonian Mechanics (Dynamics).

— Based on Newton's 3 Laws of Motion.

— good for Macroscopic slow motions.

(much larger than atoms.) (much slower than speed of light).

• Newton's 2nd law:

$$\vec{F} = m\vec{a}.$$

$\vec{F}$ — Net force (The sum of all forces acting on the object m)

• Newton's 1st Law: (A special case of 1st law).

when $\vec{F} = 0$.

$\vec{a} = 0$. — No acceleration.

If the object is at rest initially, it will stay at rest.

If the object is moving, it will continue to move at a constant velocity $\vec{v}$.

(same speed along a straight line).

e.g: Seat belt.

• Newton's 3rd law.

Forces always occur in pairs.

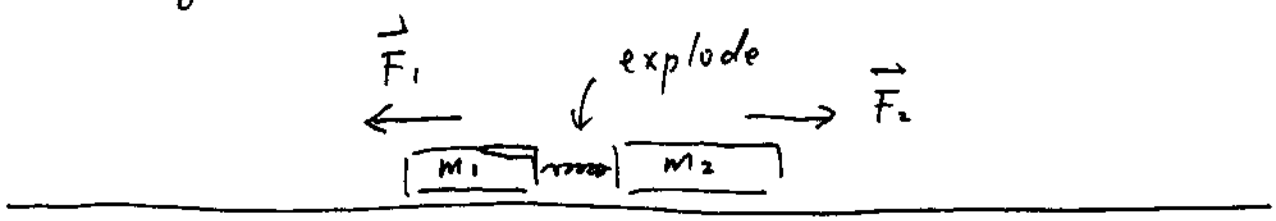
If object A exerts a force $\vec{F}$ on object B.

Then object B exerts a force $-\vec{F}$ on object B.

$\vec{F}$ and $-\vec{F}$ — same magnitude.
opposite direction.
along the same line.
act on different objects.

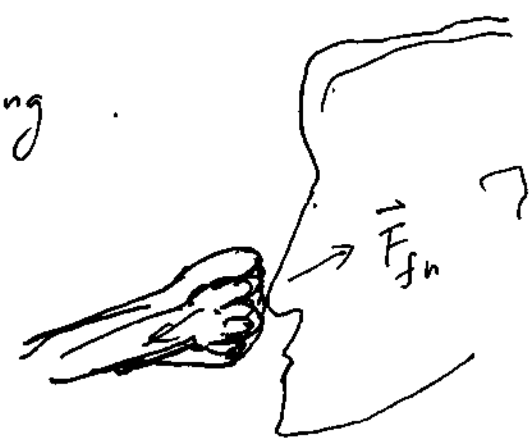
e.g : Canoeing . in the middle of a lake .

e.g :



$$\vec{F}_1 = -\vec{F}_2 .$$

e.g : Boxing .



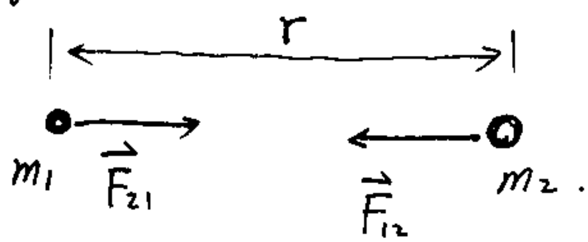
$$\vec{F}_{nf} = -\vec{F}_{fn} .$$

force of the nose exerting on the fist has the same mgnitude as the force of the fist exerting on the nose. (But the problem of the nose is, it hurts much more !)

- Common forces in nature. (Examples)

  - Gravitational force.

    (Newton's law of gravity).

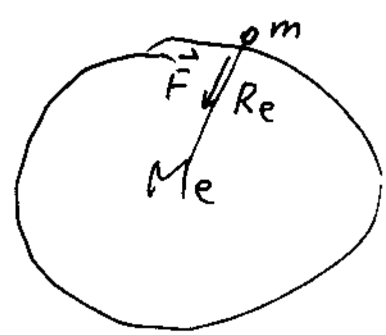


$$|\vec{F}_{21}| = |\vec{F}_{12}| = G\,\frac{m_1 m_2}{r^2}$$

$$G = 6.67 \times 10^{-11}\ N \cdot m^2/kg^2$$

Near the surface of earth.

object m experiences the gravity due to the earth.



$$F = G\,\frac{M_e \cdot m}{R_e^2} = mg.$$

where

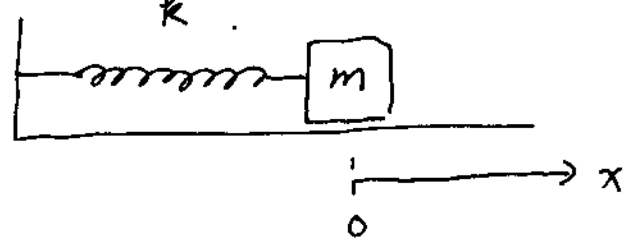
$$g = G \cdot \frac{M_e}{R_e^2} = 9.81\ m/s^2.$$

compare $\vec{F} = m\vec{a}$.

$\vec{a} = \vec{g}$. gravitational acceleration.

- Force of a spring.

x — displacement from equilibrium position ($x=0$)



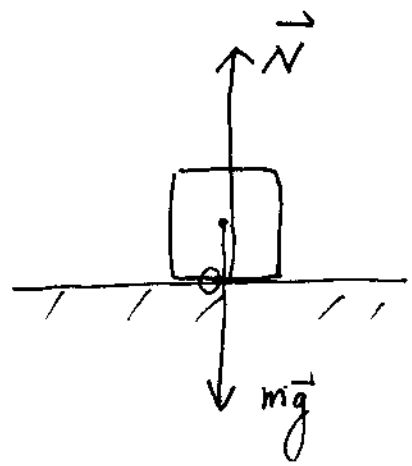
Hooke's Law: (if x is not too large).

$$F_x = -kx$$

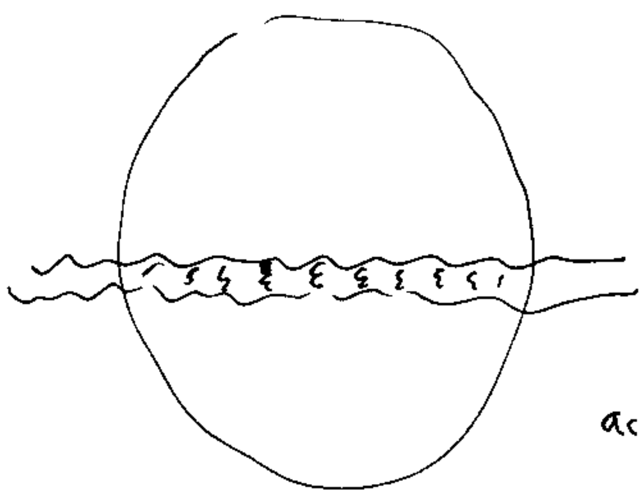
restoring force, always points toward the equilibrium position.

k — spring constant. (How strong the spring is).

- Normal force.



At the surface:



The molecules near the surface act similar to springs. They are compressed, and the force of the "springs" is perpendicular to the surface — called Normal force. $\vec{N}$