PHYS 1441 – Section 002
Lecture #9

Wednesday, Oct. 6, 2010
*Dr. **Jaehoon Yu***

- Newton's Third Law
- Categories of forces
- Application of Newton's Laws
- Force of Friction
  - Motion with friction
- Uniform Circular Motion

Physics Department
The University of Texas at Arlington
COLLOQUIUM

Electromagnetic Energy Inputs to the high-latitude ionosphere

Dr. Arthur D. Richmond

High Altitude Observatory, National Center for Atmospheric Research

4:00p.m Wednesday October 6, 2010
At SH Rm 101

Abstract:

Electric fields and currents that connect the magnetosphere with the high-latitude ionosphere are an important energy source for the upper atmosphere. During magnetic storms Joule heating above 100 km altitude expands the upper atmosphere and drives high-speed winds, leading to significant perturbations of satellite orbits and of communication signals like GPS. The spatial and temporal variations of the energy transfer can be estimated from satellite observations of electric and magnetic fields in space, by application of Poynting's Theorem. I will describe the electromagnetic energy inputs to the high-latitude ionosphere and thermosphere and discuss how they are related to the Poynting vector above the ionosphere, and I will describe the upper atmospheric response to these energy inputs.

Refreshments will be served in the Physics Lounge at 3:30p.m

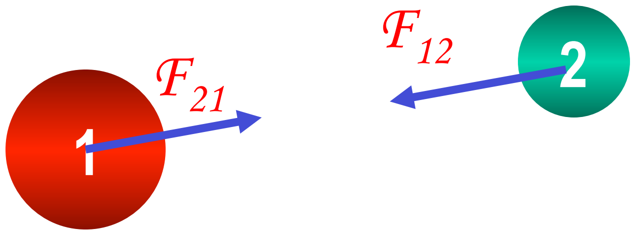
Special Project for Extra Credit

A large man and a small boy stand facing each other on **frictionless ice**. They put their hands together and push against each other so that they move apart. a) Who moves away with the higher speed and by how much? b) Who moves farther in the same elapsed time?

- Derive fomulae for the two problems above in much more detail than what is shown in this lecture note.
- Be sure to clearly define each variables used in your derivation.
- Each problem is 10 points each.
- Due is Wednesday, Oct. 14.

Newton's Third Law (Law of Action and Reaction)

If two objects interact, the force F_{21} that object 2 exerts on object 1 by object 2 is equal in magnitude and opposite in direction to the force F_{12} exerted on object 1 exerts on object 2.



$$\vec{F}_{12} = -\vec{F}_{21}$$

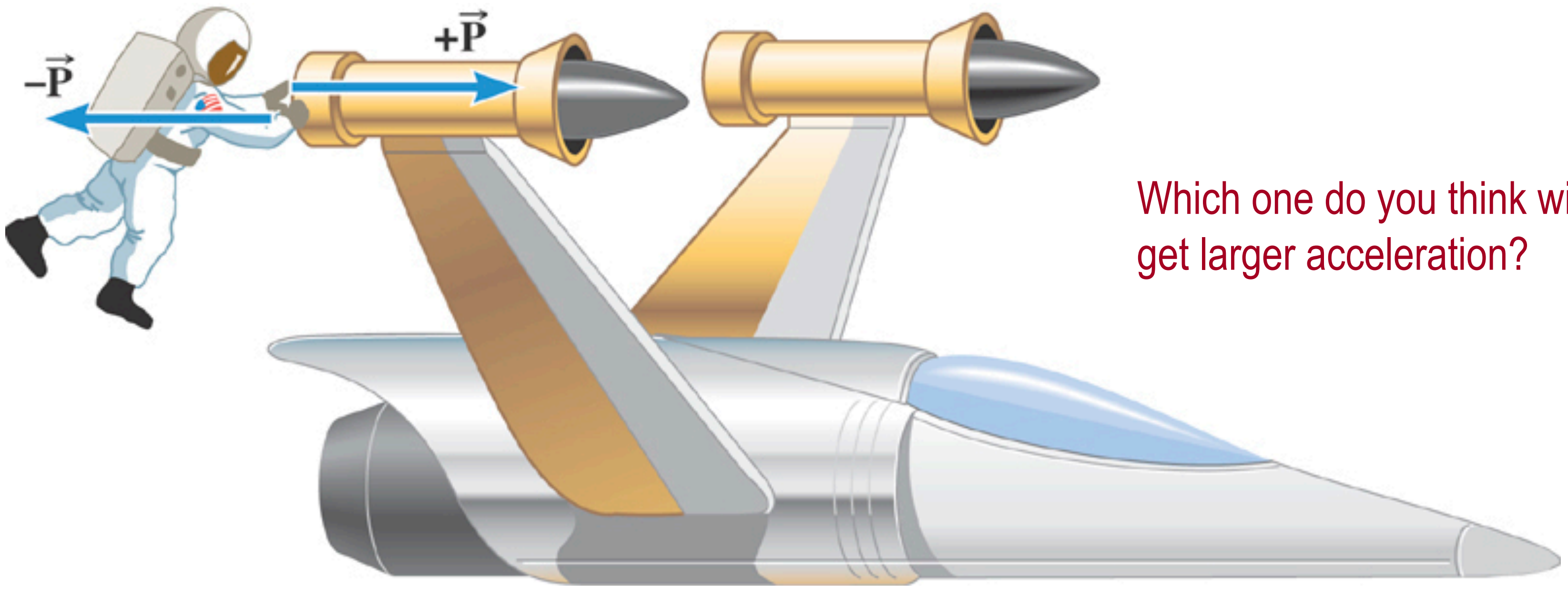
The reaction force is equal in magnitude to the action force but in opposite direction. These two forces always act ***<u>on different objects</u>***.

What is the reaction force to the force of a free falling object?

The gravitational force exerted by the object to the Earth!

Stationary objects on top of a table has a reaction force (called the normal force) from table to balance the action force, the gravitational force.

Ex. The Accelerations Produced by Action and Reaction Forces



Which one do you think will get larger acceleration?

Suppose that the magnitude of the force P is 36 N. If the mass of the spacecraft is 11,000 kg and the mass of the astronaut is 92 kg, what are the accelerations?

Ex. continued

Force exerted on the space craft by the astronaut $\sum \vec{\mathbf{F}} = \vec{\mathbf{P}}$

Force exerted on the astronaut by the space craft $\sum \vec{\mathbf{F}} = -\vec{\mathbf{P}}$

space craft's acceleration

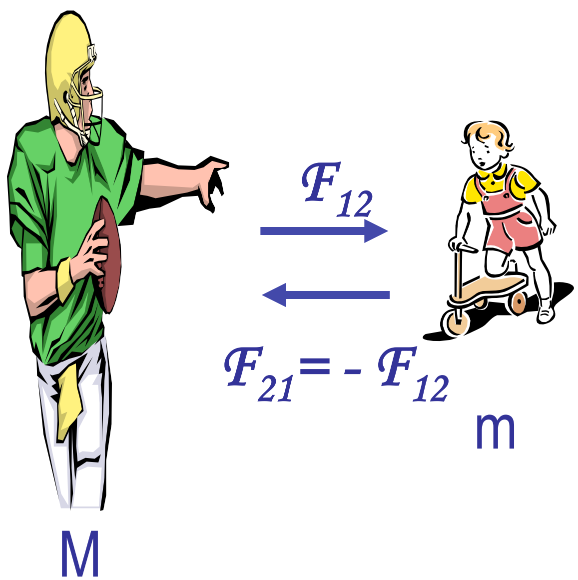
$$\vec{\mathbf{a}}_s = \frac{\vec{\mathbf{P}}}{m_s} = \frac{+36\,\vec{i}\ \text{N}}{11{,}000\ \text{kg}} = +0.0033\,\text{m/s}^2$$

astronaut's acceleration

$$\vec{\mathbf{a}}_A = \frac{-\vec{\mathbf{P}}}{m_A} = \frac{-36\,\vec{i}\ \text{N}}{92\ \text{kg}} = -0.39\,\text{m/s}^2$$

Example of Newton's 3rd Law

A large man and a small boy stand facing each other on **frictionless ice**. They put their hands together and push against each other so that they move apart. a) Who moves away with the higher speed and by how much?



$$\vec{F}_{12} = -\vec{F}_{21} \Rightarrow \left|\vec{F}_{12}\right| = \left|\vec{F}_{21}\right| = F$$

$$\vec{F}_{12} = m\vec{a}_b \Rightarrow F_{12x} = ma_{bx}, \quad F_{12y} = ma_{by} = 0$$

$$\vec{F}_{21} = M\vec{a}_M \Rightarrow F_{21x} = Ma_{Mx}, \quad F_{21y} = Ma_{My} = 0$$

Since $\vec{F}_{12} = -\vec{F}_{21}$ and $\left|\vec{F}_{12}\right| = \left|-\vec{F}_{21}\right| = F$

Establish the equation $\Rightarrow$ $ma_{bx} = F = Ma_{Mx}$ Divide by m $\Rightarrow$ $a_{bx} = \frac{F}{m} = \frac{M}{m} a_{Mx}$

Example of Newton's 3rd Law, cnt'd

Man's velocity

$$v_{Mxf} = v_{Mxi} + a_{Mx}t = a_{Mx}t$$

Boy's velocity

$$v_{bxf} = v_{bxi} + a_{bx}t = a_{bx}t = \frac{M}{m}a_{Mx}t = \frac{M}{m}v_{Mxf}$$

So boy's velocity is higher than man's, if M>m, by the ratio of the masses.

b) Who moves farther while their hands are in contact?

Boy's displacement

$$x_b = v_{bxi}t + \frac{1}{2}a_{bx}t^2 = \frac{M}{2m}a_{Mx}t^2$$

$$x_b = \frac{M}{m}\left(\frac{1}{2}a_{Mx}t^2\right) = \frac{M}{m}x_M$$

Man's displacement

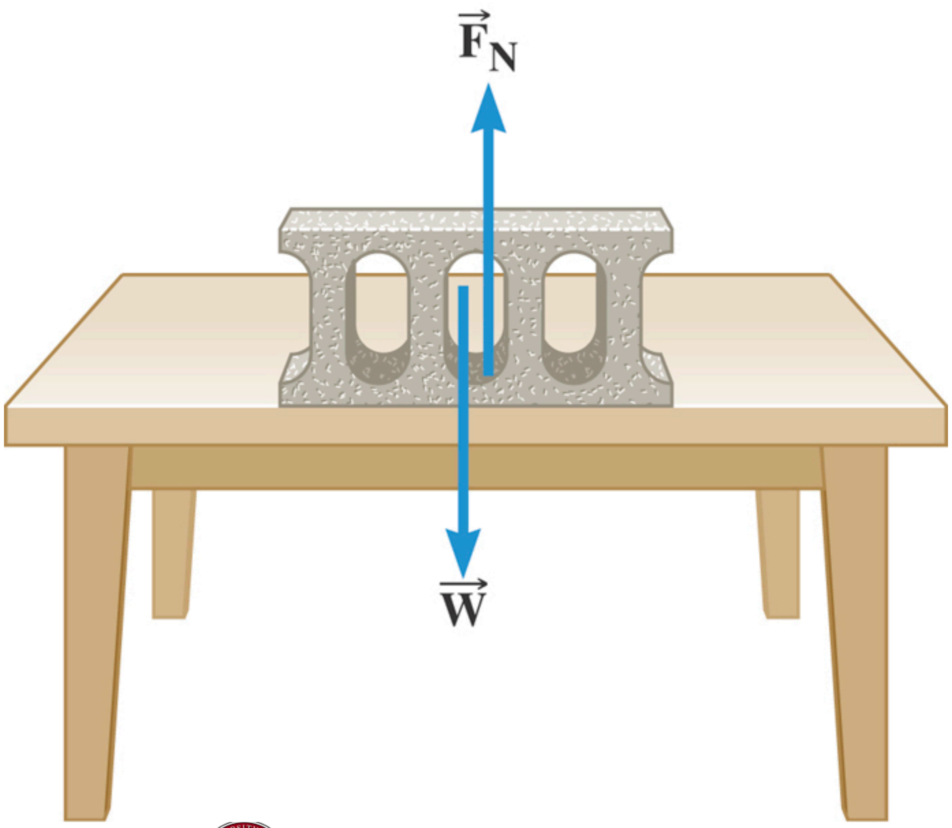
Given in the same time interval, since the boy has higher acceleration and thereby higher speed, he moves farther than the man.

Categories of Forces

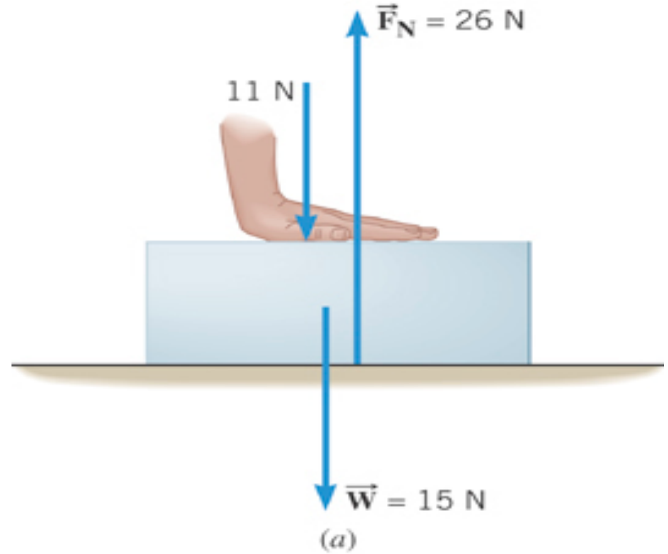
- Fundamental Forces: Truly unique forces that cannot be derived from any other forces
  - Total of three fundamental forces
    - Gravitational Force
    - Electro-Weak Force
    - Strong Nuclear Force
- Non-fundamental forces: Forces that can be derived from fundamental forces
  - Friction
  - Tension in a rope
  - Normal or support forces

The Normal Force

The normal force is one component of the force that a surface exerts on an object with which it is in contact – namely, the component that is **perpendicular to the surface**.



Some normal force exercises



Case 1: Hand pushing down on the book

$$F_N - 11\text{ N} - 15\text{ N} = 0$$

$$F_N = 26\text{ N}$$

Case 2: Hand pulling up the book

$$F_N + 11\text{ N} - 15\text{ N} = 0$$

$$F_N = 4\text{ N}$$

Some Basic Information

When Newton's laws are applied, *external forces* are only of interest!!

Why?

Because, as described in Newton's first law, an object will keep its current motion unless non-zero net external force is applied.

Normal Force, ***n***:

The force that reacts to action forces due to the surface structure of an object. Its direction is perpendicular to the surface.

Tension, ***T***:

The reactionary force by a stringy object against an external force exerted on it.

Free-body diagram

*A graphical tool which is a **diagram of external forces on an object** and is extremely useful analyzing forces and motion!! Drawn only on an object.*

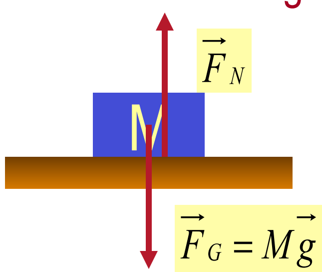
Free Body Diagrams and Solving Problems

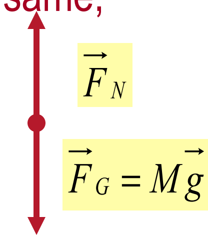
- Free-body diagram: A diagram of vector forces acting on an object

Þ A great tool to solve a problem using forces or using dynamics

1. Select a point on an object in the problem
2. Identify all the forces acting only on the selected object
3. Define a reference frame with positive and negative axes specified
4. Draw arrows to represent the force vectors on the selected point
5. Write down net force vector equation
6. Write down the forces in components to solve the problem

Þ No matter which one we choose to draw the diagram on, the results should be the same, as long as they are from the same motion



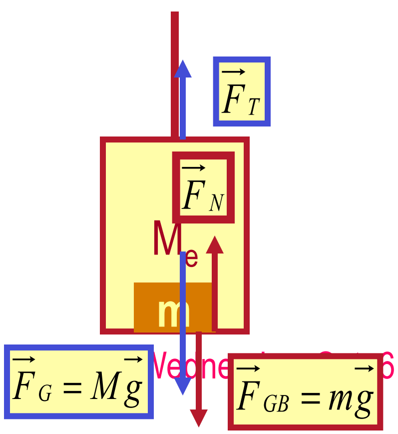


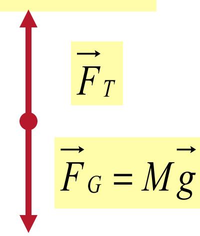
Which one would you like to select to draw FBD? Let's take box!

What do you think are the forces acting on this object?

Gravitational force

the force supporting the object exerted by the floor





Which one would you like to select to draw FBD?

What do you think are the forces acting on this elevator?

Gravitational force

The force pulling the elevator (Tension)

What about the box in the elevator?

Gravitational force

Normal force