Common exam #2: 8:30-9:45am on Mar. 2nd(Fri.) at 205 Kupfrian Hall
(arrive by 8:15am)

All of Chapters 4 and 5. Bring scientific calculators

Announcement for Review Session

Review Session for Exam 2
4 – 4:45 on Feb 28th Wednesday

Lecture Hall 1 (Room 116, across elevator) in Tiernan Hall

http://geocities.com/kenahn7

Last class we learned…

$$\vec{F}_{net} = m\vec{a}$$

$$F_{net,x} = ma_x \;;\; F_{net,y} = ma_y \;;\; F_{net,z} = ma_z$$

$\vec{F}_{net}$: Vector sum of all forces applied on the object of interest

m : Mass of the object, represent inertia
(Objects with large mass are hard to move and hard to stop)

$\vec{a}$: Acceleration of the object

Ch. 5, Force and Motion-I

(Continued)

- **Some particular forces**
  - **Gravitational force (Weight)**
  - **Normal force**
  - **Tension**
  - **Friction (→Monday & Ch.6)**
- **Newton's 3rd Law**
- **Applying Newton's Laws**

Gravitational Force:

Magnitude:

$F = mg$

(m: mass, $g = 9.8\ m/s^2$)

Direction: Pointing downward

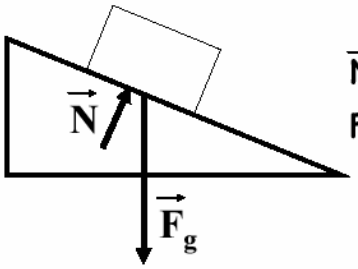
•**Weight:** The **force** that the **Earth** is pulling the **object** with. Weight is a vector quantity, it has a ***magnitude and direction (unit : N)***

(weight) = (mass) x g

"Weight is 100 N" means "mg is 100 N".

Normal Force: $\vec{N}$

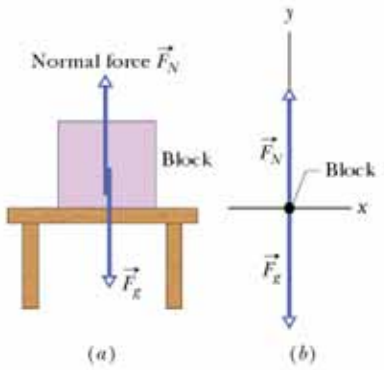
Force from a solid surface which keeps objects from falling through



$\vec{N}$ $\perp$ surface

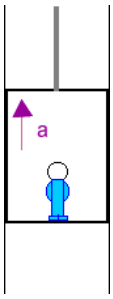
Force on surface = - $\vec{N}$

Direction : always perpendicular to the surface.
Magnitude : depends on situations &
needs analysis of Newton's 2nd law
along direction perpendicular to the surface

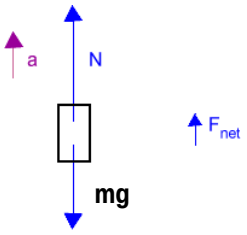


Example from last lecture: Person in a elevator

Picture of Situation



"Free Body Diagram"

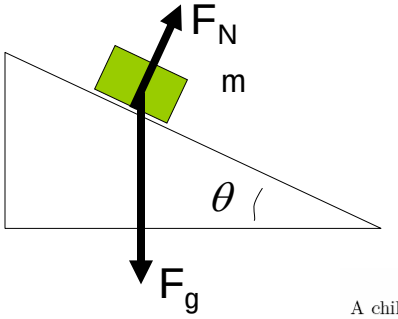


A person with a mass 50 Kg in an elevator is moving upward with an acceleration $a = 1.1\ m/s^2$

What is the magnitude of the force of the elevator on the person?

(See the last lecture note)

Object with mass m on an inclined surface at an angle θ from the horizontal



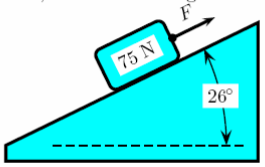
Find F_N and acceleration

Related HW problems:

003 (part 1 of 1) 10 points
You place a box weighing 293.4 N on an inclined plane that makes a 36.6° angle with the horizontal.

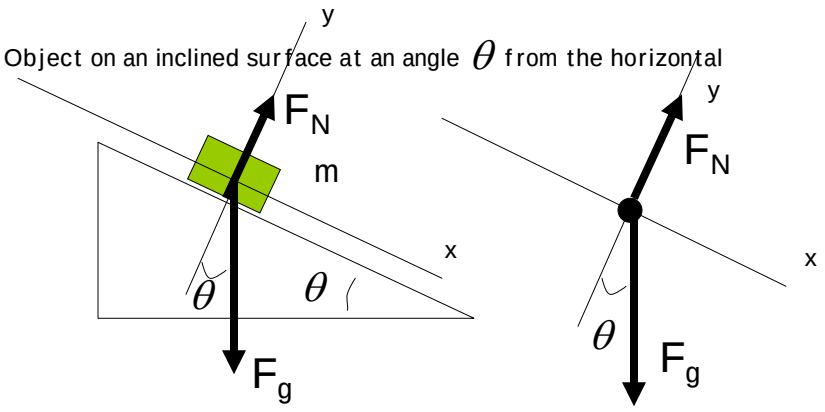
Compute the component of the gravitational force acting down the inclined plane. Answer in units of N.

006 (part 1 of 2) 10 points
A child holds a sled on a frictionless, snow-covered hill, inclined at an angle of 26°.



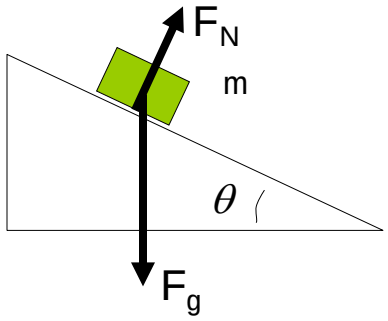
If the sled weighs 75 N, find the force exerted on the rope by the child. Answer in units of N.

Object on an inclined surface at an angle θ from the horizontal



1. Choose x and y axes, parallel and perpendicular to the surface.
2. Find the net force along x and y direction
3. Set up equations using Newton's 2nd law and use given conditions, e.g., $a_y = 0$ in this problem.
4. Find the answer.

Object with mass m on an inclined surface at an angle θ from the horizontal



Find F_N and acceleration

$$F_N = mg\cos\theta$$

$$a_x = g\sin\theta$$

003 (part 1 of 1) 10 points
You place a box weighing 293.4 N on an inclined plane that makes a 36.6° angle with the horizontal.

Compute the component of the gravitational force acting down the inclined plane. Answer in units of N.

"Weight is 100 N" means "Gravitational force, mg, is 100 N".

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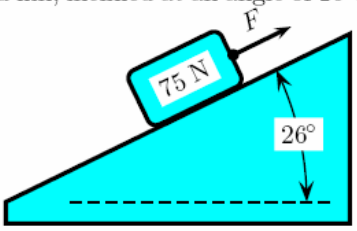

If the sled weighs 75 N, find the force exerted on the rope by the child. Answer in units of N.

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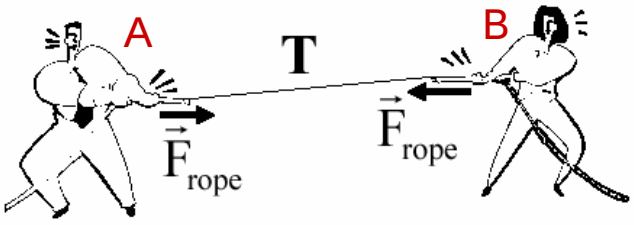
Ch. 5, Force and Motion-I

(Continued)

- **Some particular forces**
  - **Gravitational force (Weight)**
  - **Normal force** — Last class
  - **Tension** — Today
  - **Friction**
- **Newton's 3rd Law**
- **Applying Newton's Laws**

Tension: T

A taut rope exerts forces on whatever holds its ends

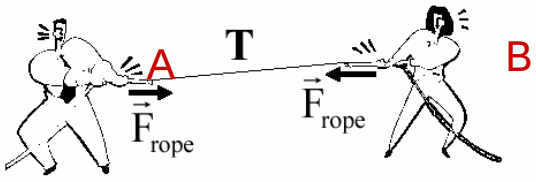


Tension in rope = Force on ends

$$\left|\vec{F}_{on\ A}\right| = T = \left|\vec{F}_{on\ B}\right|$$

Tension: T

A taut rope exerts forces on whatever holds its ends

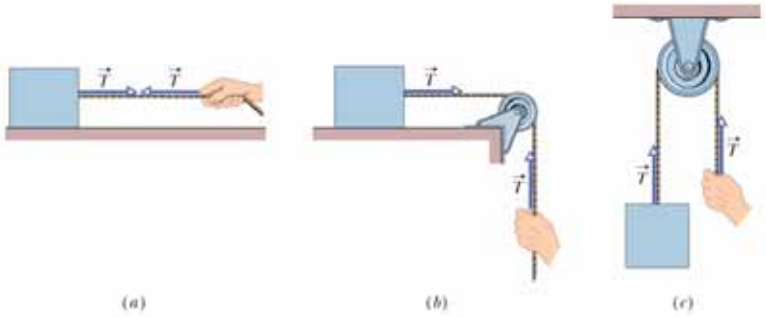


Tension in rope = Force on ends

$$\left|\vec{F}_{on\ A}\right| = T = \left|\vec{F}_{on\ B}\right|$$

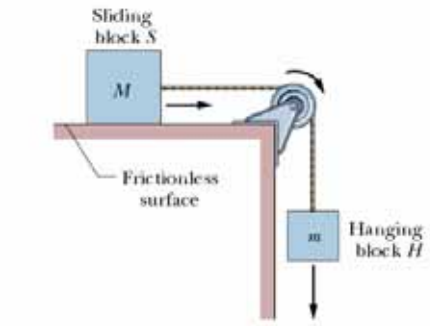
Direction: pulls (never pushes) the objects at both ends along the rope, even with pulleys

Magnitude : Constant along a single rope, even with pulleys



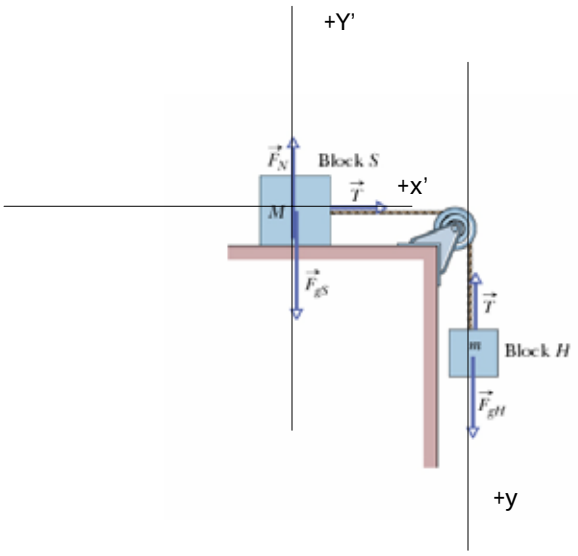
Applying Newton's Law
Sample Problem 5-6

Object(s) attached to rope(s)



Find acceleration and tension

1. For each object attached to ropes, choose axes along the rope
2. Find the net force for each object, with the tension T included
3. Use Newton's 2nd law to set up equations
4. Find answers

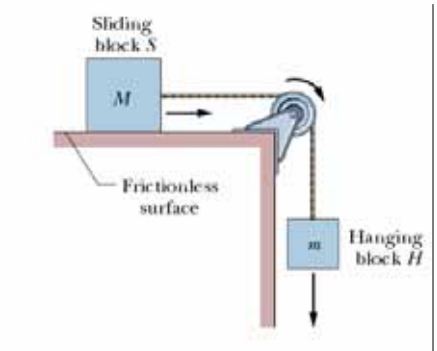


Better to choose +x' and +y directions in the way shown.

Note that the magnitudes of the accelerations are the same.

Applying Newton's Law
Sample Problem 5-6

Object(s) attached to rope(s)



Find acceleration and tension

$$a = \frac{m}{m+M} g$$

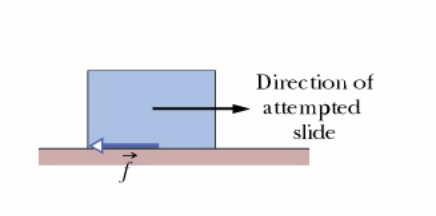
$$T = \frac{Mm}{M+m} g$$

Friction

Friction between an object and a surface:
oppose the attempted slide of a body over a surface

Direction : parallel to surface, but still needs further analysis

Magnitude : Needs analysis



Frictionless surface : Friction is zero.

More on friction in Chapter 6

Some particular forces

- **Gravitational force (Weight)**
- **Normal force**
- **Tension**
- **Friction**

Of course, there are many other forces……

$\vec{F}_{net}$: Vector sum of all forces applied on the object of interest

$$\vec{F}_{net} = m\vec{a}$$

m : Mass of the object, represent inertia

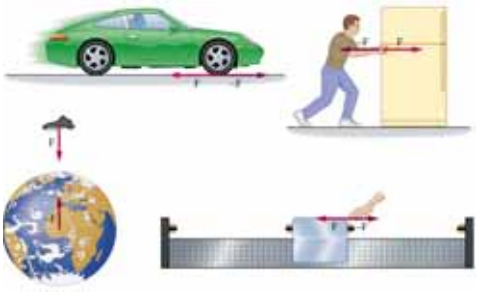
$\vec{a}$: Acceleration of the object

Newton's Third Law of Motion

- Forces always appear in pairs: for every force exerted by object A on object B there is an equal and opposite force exerted by B on A (action-reaction pair).
- The 3rd law pair of forces are always applied to different objects!

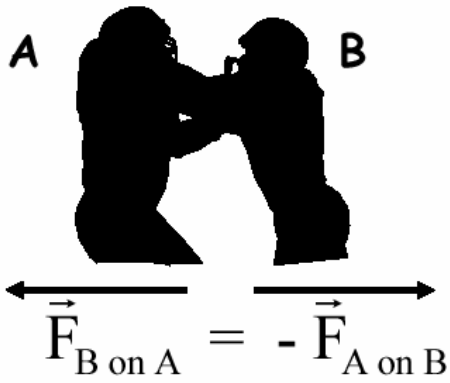
$$\vec{F}_{\text{A on B}} = -\vec{F}_{\text{B on A}}$$

Always put indices so you will be able to identify the pair of forces easily!

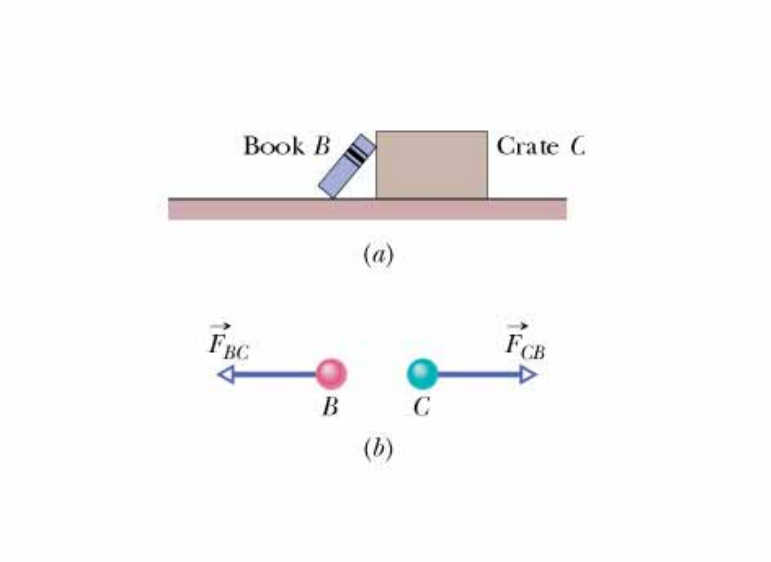


Newton's 3rd Law

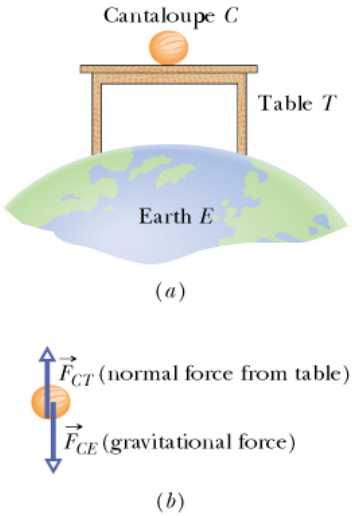
When object A exerts a force $\vec{F}$ on object B, then object B exerts force $-\vec{F}$ on object A



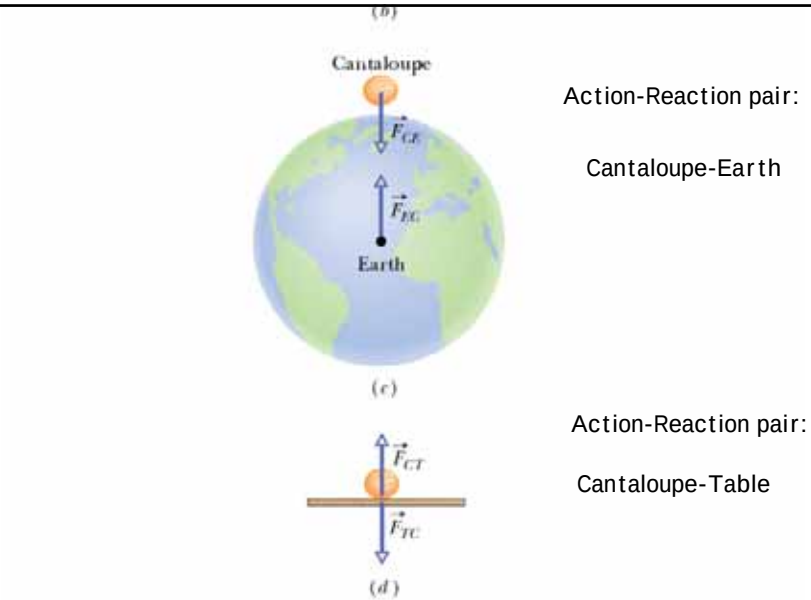
$$\vec{F}_{\text{B on A}} = -\vec{F}_{\text{A on B}}$$



Find action and reaction pairs



Not the action-reaction pair



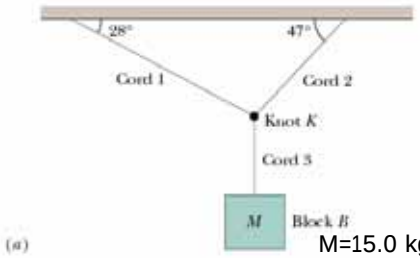
Action-Reaction pair:

Cantaloupe-Earth

Action-Reaction pair:

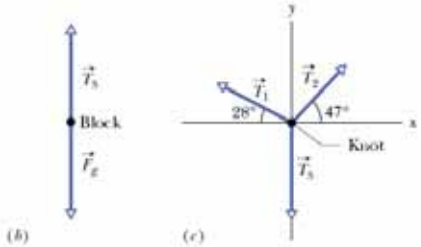
Cantaloupe-Table

More application of Newton's Laws: Sample Problem 5-6



What are the tensions?

M=15.0 kg



Well…choice of axes depends on problems, of course.

Find most convenient axes set to analyze the net force components

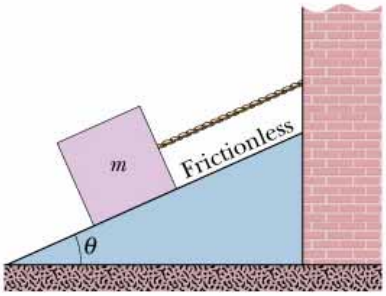
Another application of Newton's Laws: Sample Problem 5-7

A cord holds a 15 kg block stationary on a frictionless plane inclined at angle $\theta = 27^{o}$

(a)

Magnitude of the force $\vec{T}$ on the block from the cord ?

Magnitude of the normal force on the block from the plane?

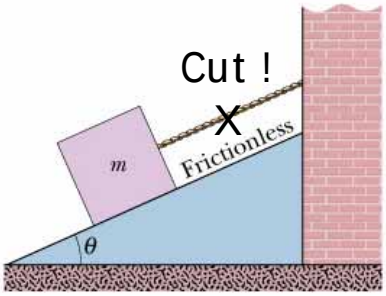


(a)

Another application of Newton's Laws: Sample Problem 5-7

A cord holds a 15 kg block stationary on a frictionless plane inclined at angle $\theta = 27^{o}$

(b) Now we cut the cord.
What is the acceleration of the block?



(a)

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