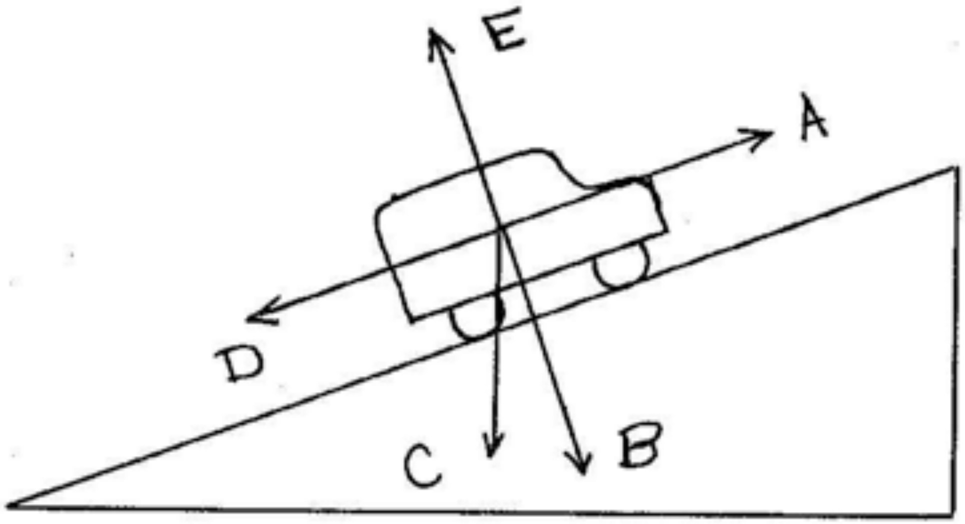
Spring 2014

PHYS-2010

Lecture 16

Clicker Question

Room Frequency BA



The driver of a car parked on a hill releases the brake and puts the car in neutral

Let

$\vec{N}$ = normal force

$\vec{F}_g$ = force of gravity

$\vec{a}$ = acceleration of the car.

Which of the following is true?

A) $A=\vec{a}, E=\vec{N}, B=\vec{F}_g$

B) $E=\vec{N}, D=\vec{a}, C=\vec{F}_g$

C) $E=\vec{N}, D=\vec{F}_g, C=\vec{a}$

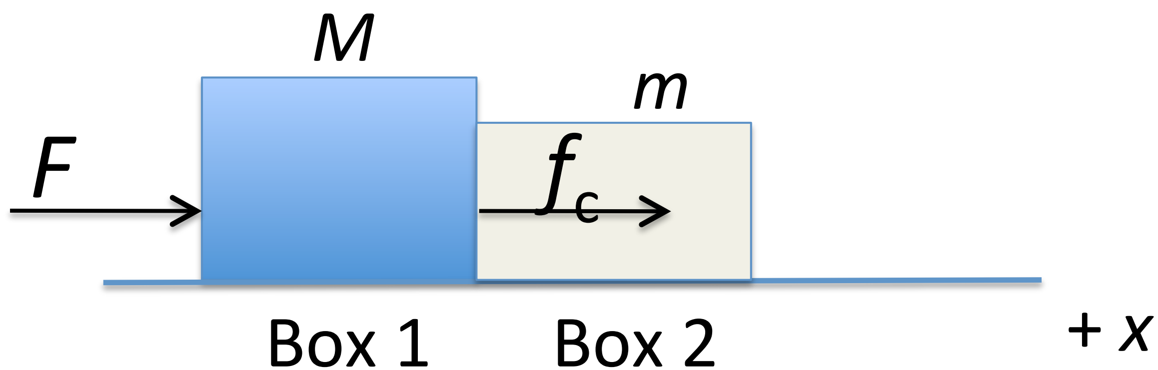
D) $A=\vec{a}, B=\vec{F}_g, E=\vec{N}$

Announcements

- Read Giancoli Chapter 4.
- **CAPA # 6** is now printed and in the CAPA dispensary:
  due next Tuesday at 11 pm.
- **Written homework # 4** due Friday at 4 pm.
- Two more **Study Sessions** by Prof. Pollock will be held on the next two Tuesdays in G125, 5-6 pm.

Two boxes with masses *M* and *m* are glued together. Force *F* is applied to Box 1 (with mass *M*).

Force f_c is the "contact force" that Box 1 exerts on Box 2.



* Frictionless surface

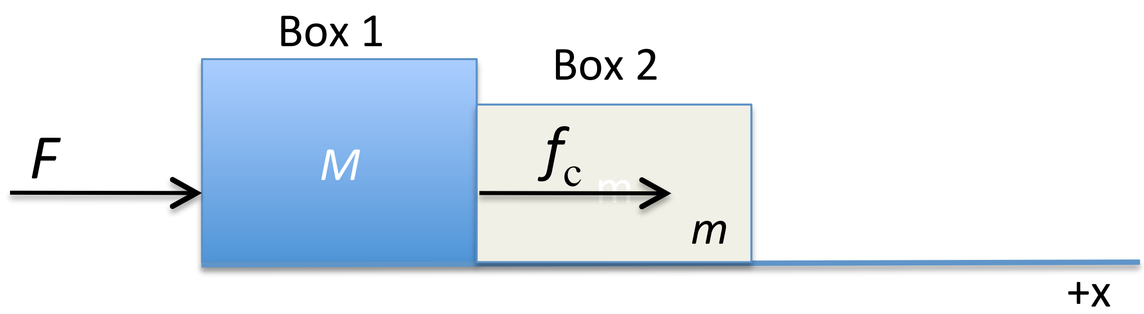
A) $F = f_c$

B) $F > f_c$

C) $F < f_c$

D) Indeterminate from information given

Draw the free-body diagram for each box!

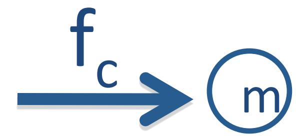


What other forces are acting on either box?

Gravitational force down on both boxes, and Normal force up on both boxes.

However, since there is no vertical motion we sometimes do not bother to write them down.

What about Newton's Third Law?



Apply $\Sigma F_x = ma$. (ignore vertical forces, no vertical motion)

$$F - f_c = M\,a_M \qquad f_c = m\,a_m$$

Since the boxes are fixed (glued) together → $a_M = a_m$

$$a_M = (F - f_c)/M \;=\; a_m = f_c/m$$

$$Fm - f_c m = f_c M$$

$$f_c(M + m) = Fm$$

$$f_c = \frac{m}{M + m}F \quad \Rightarrow \quad f_c < F$$

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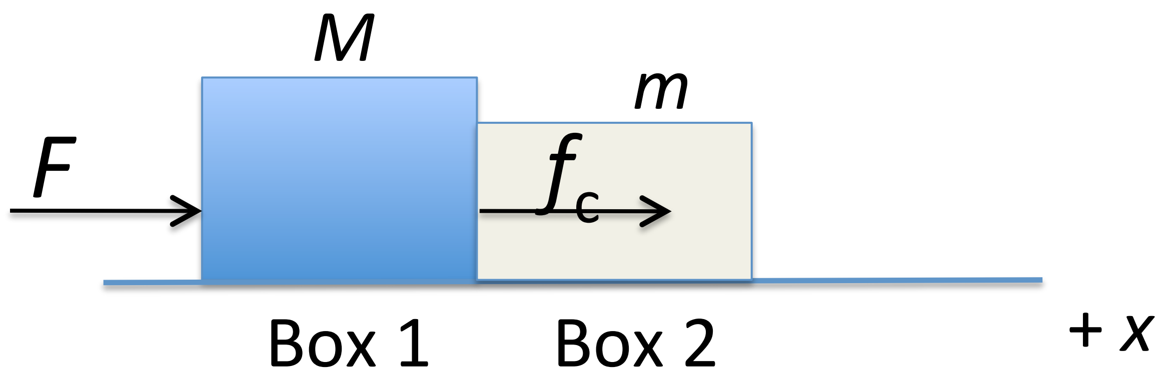

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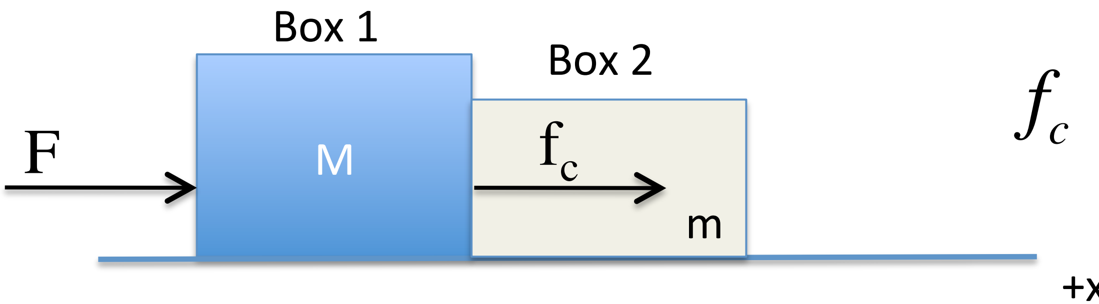

$$f_c = \left(\frac{m}{M+m}\right)F$$

Assume Box 1 has a mass of 2 kg and Box 2 has a mass of 1 kg. If a force of 1 N is applied to Box 1, what is the magnitude of the contact force between the boxes?

A) 1 N

B) ½ N

C) 1/3 N

D) 2 N

E) 3 N

$$f_c = \left(\frac{m}{M+m}\right)F = \left(\frac{1kg}{2kg+1kg}\right)1N = \frac{1}{3}N$$

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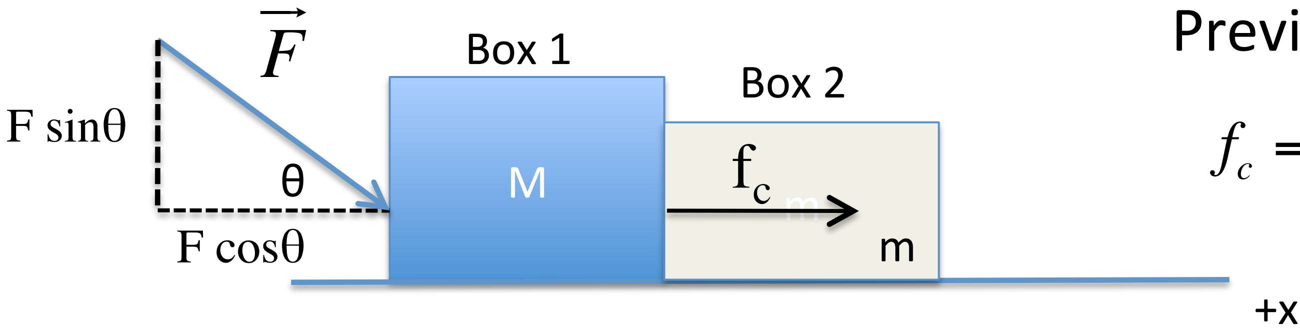


Previous equation:

$$f_c = \left(\frac{m}{M+m}\right)F$$

Assume a force *F* is applied to Box 1 at an angle θ from the horizontal. What will be the equation for the contact force f_c?

$$A)\, f_c = \left(\frac{m+M}{m}\right)F\tan\theta$$

$$B)\, f_c = \left(\frac{m}{M+m}\right)F\sin\theta$$

$$C)\, f_c = \left(\frac{m}{M+m}\right)F\cos\theta$$

$$D)\, f_c = \left(\frac{m(M+M)}{F\cos\theta}\right)$$

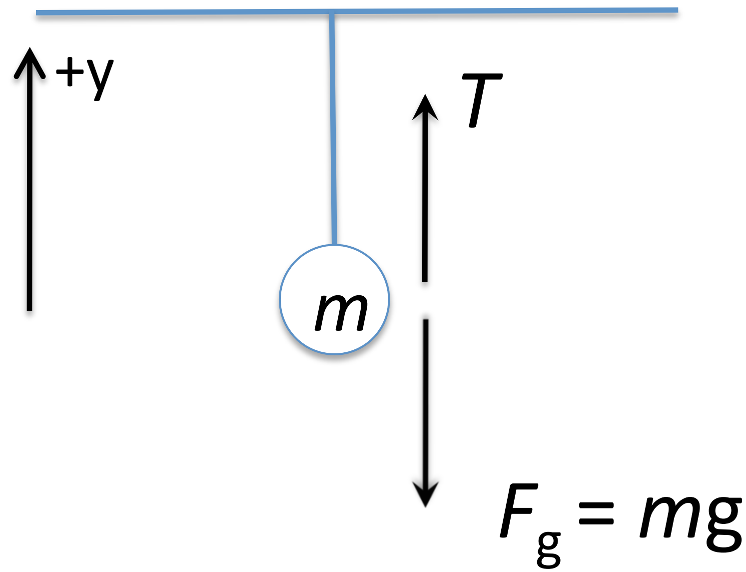
The horizontal component of $\vec{F}$ produces horizontal motion.

Terminology Clarification: what is "weight"?

- Weight is a force, so it is measured in Newtons, not kilograms!
- In this class we shall adopt the convention that weight is the force of gravity on an object: $|F_g| = mg$, always directed down.
- Then, weight does not depend on the motion of the object (e.g., whether it rests on a table, or in an elevator, or in a free fall).
- But it still depends on the planet: e.g., my weight on the Moon is about 1/6th of that on the Earth.
- Sometimes, by "weight" people mean the force that the object exerts on the supporting structure (i.e., measured by a scale):
    - *normal force on the table*
    - *tension force on the rope*
    - *zero weight for freely falling objects (weightlessness).*
- We shall refer to that force as an *"apparent weight"* – it depends on the vertical acceleration of the object.

Rock climber hanging by rope

Object of mass ***m*** suspended by a cord.



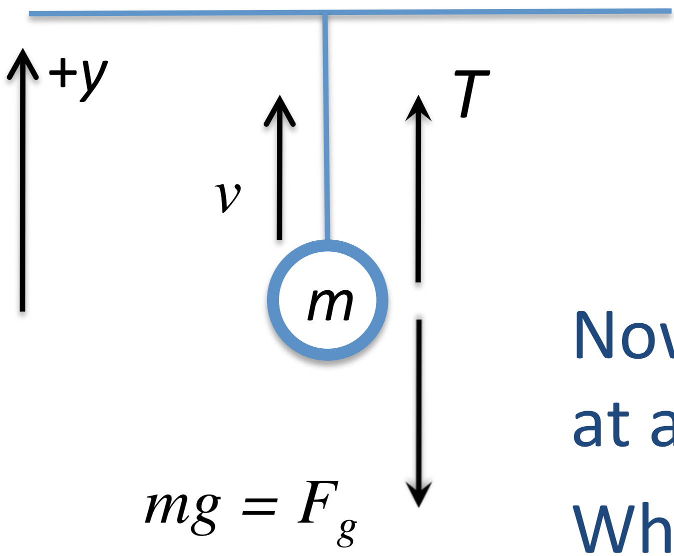
Stationary: $v = 0$ and $a = 0$.

$$0 = ma = F_{net}$$

$$0 = T - mg$$

$$T = mg$$

Tension in the cord is equal to the force of gravity on the object.



Person of mass ***m*** suspended by a rope.

If *v*=0: $\rightarrow \quad T = mg = F_g$

Now, imagine the person is being raised at a constant velocity $v > 0$.

What's the relation between *T* and *mg*?

A) $T = mg$

B) $T > mg$

C) $T < mg$

D) Indeterminate from information given.

v = constant, $a = 0$ again, as in the stationary case.

$$0 = ma = T + F_g = T - mg$$

$$\rightarrow \quad T = mg$$

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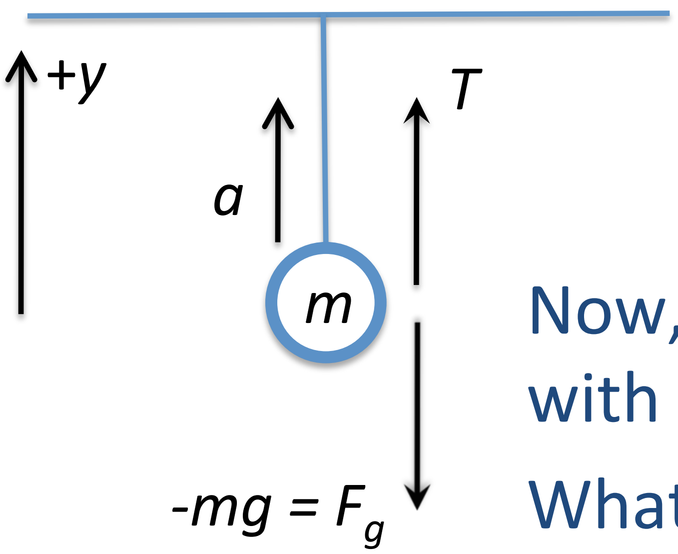


Object of mass ***m*** suspended by a cord.

Before: v = constant $\rightarrow \quad T = mg = F_g$

Now, imagine the object is being raised with an acceleration $a > 0$.

What's the relation between T and mg?

$$0 \neq ma = T + F_g = T - mg$$

$$\rightarrow \quad T = m(a+g) > mg$$

A) $T = mg$

B) $T > mg$

C) $T < mg$

D) Indeterminate from information given.

The **Atwood machine** was invented in 1784 by Rev. George Atwood as a laboratory experiment to verify the mechanical laws of motion with constant acceleration.

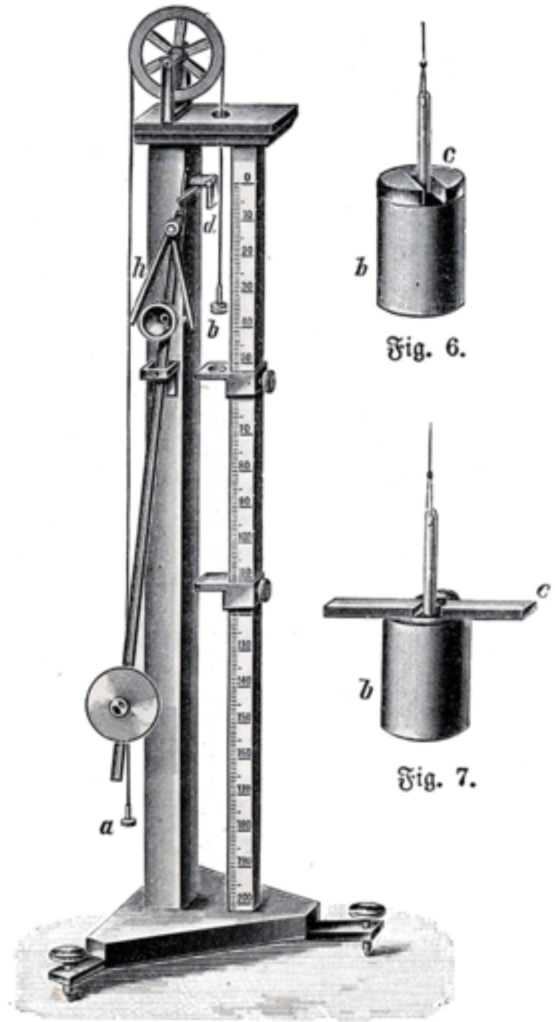
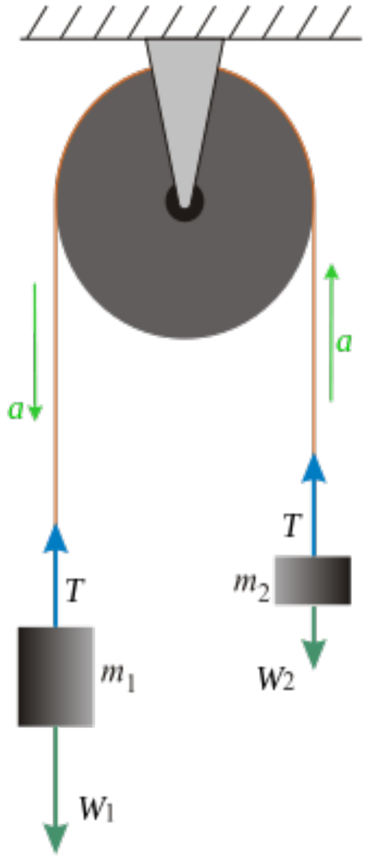
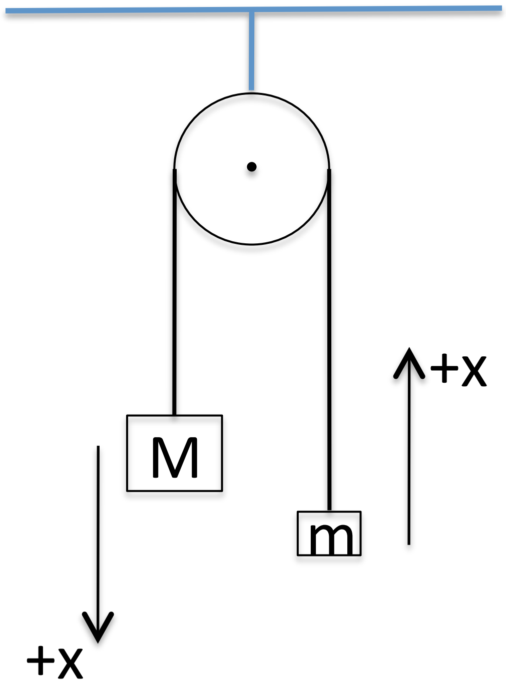


Fig. 5.
Atwoodsche Fallmaschine



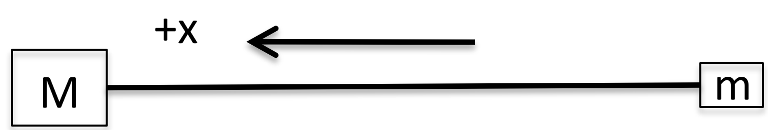
http://en.wikipedia.org/wiki/Atwood_machine

Atwood Machine (Pulley)



Two objects with masses $M > m$ suspended from a stationary pulley.

Step #1: Choose a coordinate system.



Odd coordinate system (curves around pulley). This choice means that the acceleration ***a*** for both masses will be the same (**direction + magnitude**).