Classical Mechanics
Lecture 9

Today's Concepts:

a) Energy and Friction

b) Potential energy & force

Some comments about the course

What is the difference with macroscopic and microscopic forces? Is one conservative and the other non conservative?

Learning fun physics Cool demonstrations are the Reason to wake up -A scientific haiku

Are we done with springs now, or will they come back to haunt us !!?! =D

yes

Is there a way to explain the concepts without using so many formulas? It's kinda confusing when the lecture explains with derivatives and anti derivatives.

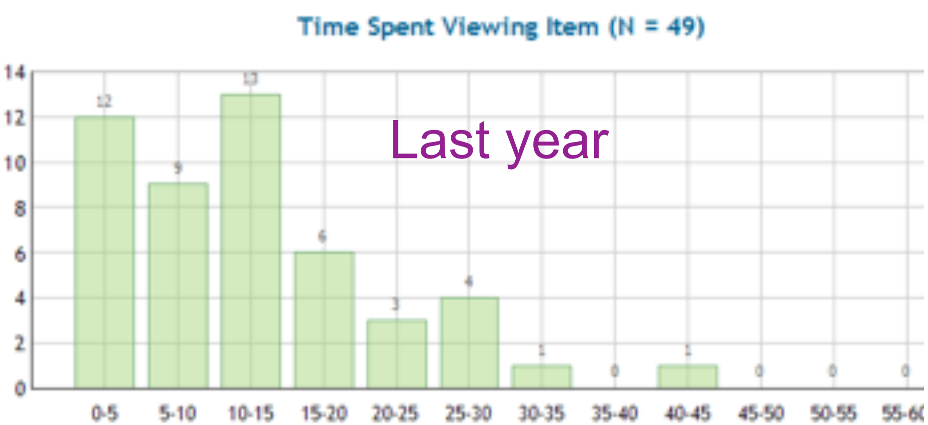
No

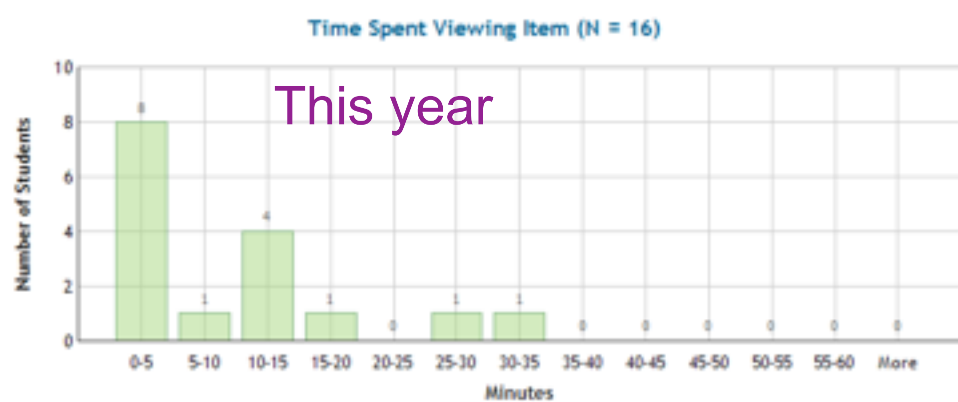
What is spacial derivative? https://ccrma.stanford.edu/~jos/pasp/Spatial_Derivatives.html
http://wiki.answers.com/Q/What_are_spatial_derivatives

the equations are so scary, can we go over them in English?

throwing equations at us doesnt help our understanding...

not really





Common Issues:

HW is harder than lecture

Need more practice materials

Don’t know how to prepare for exam

Material is getting harder

Things we can do:

Do some HW problems in class

Provide practice materials to prepare for exam

Post formula sheet

Make sure office hours are utilized

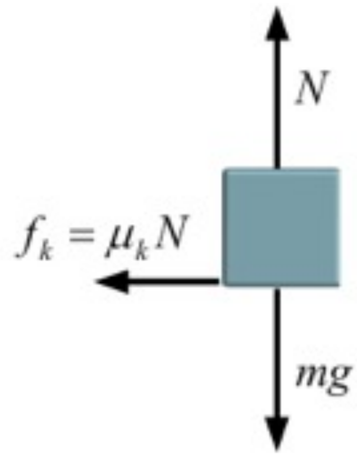
Macroscopic Work done by Friction

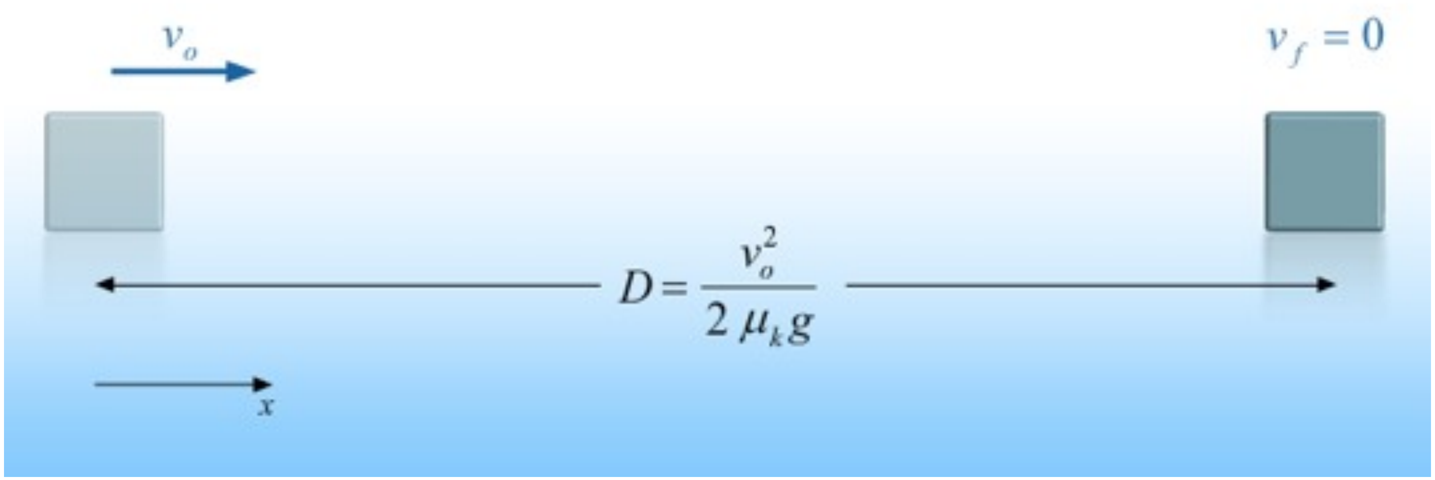
Work-Kinetic Energy Theorem

$$\Delta K = W_{Net}$$

$$-\frac{1}{2} m v_o^2 = -\mu_k m g D$$

Macroscopic Work done by Friction





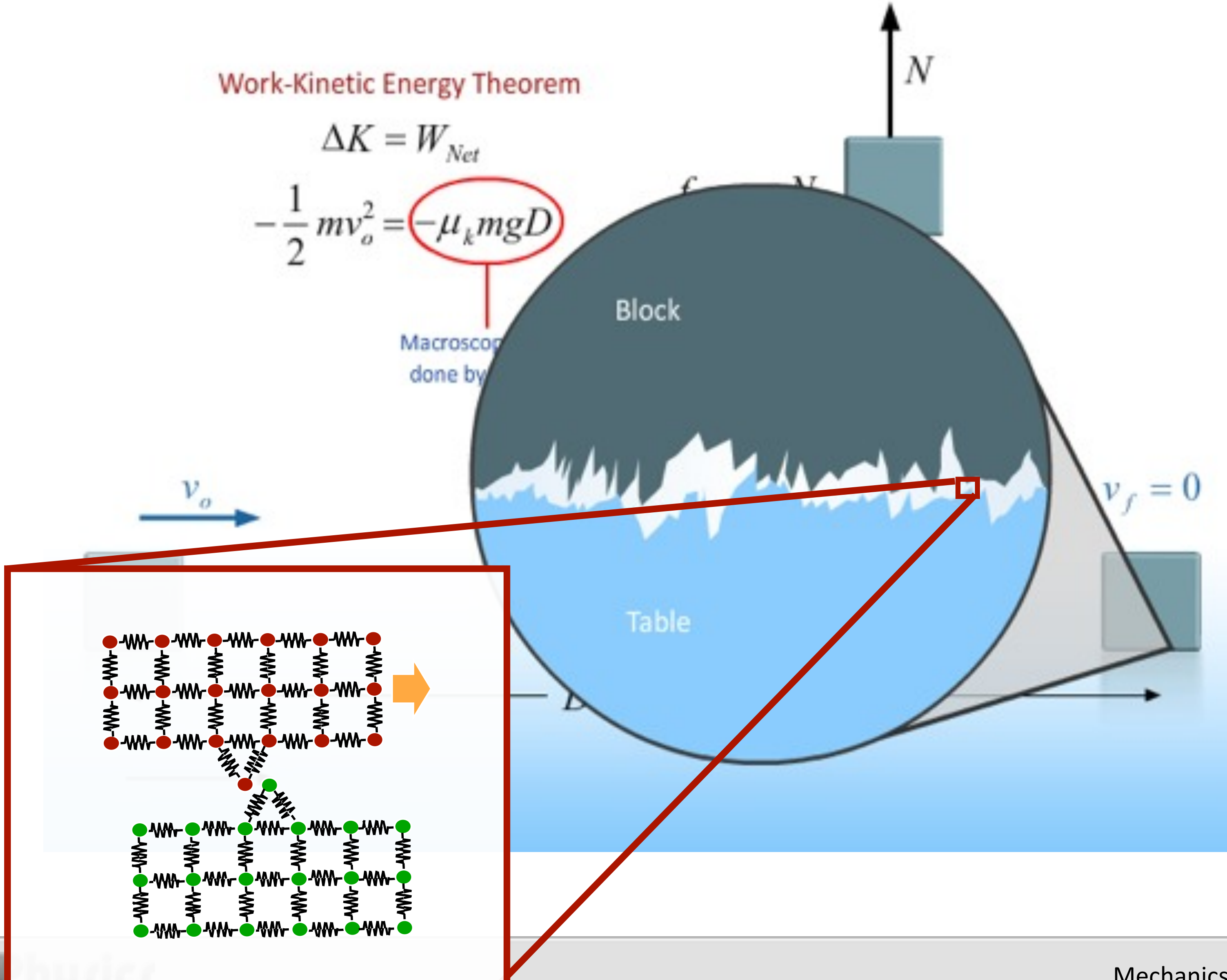
Macroscopic Work:

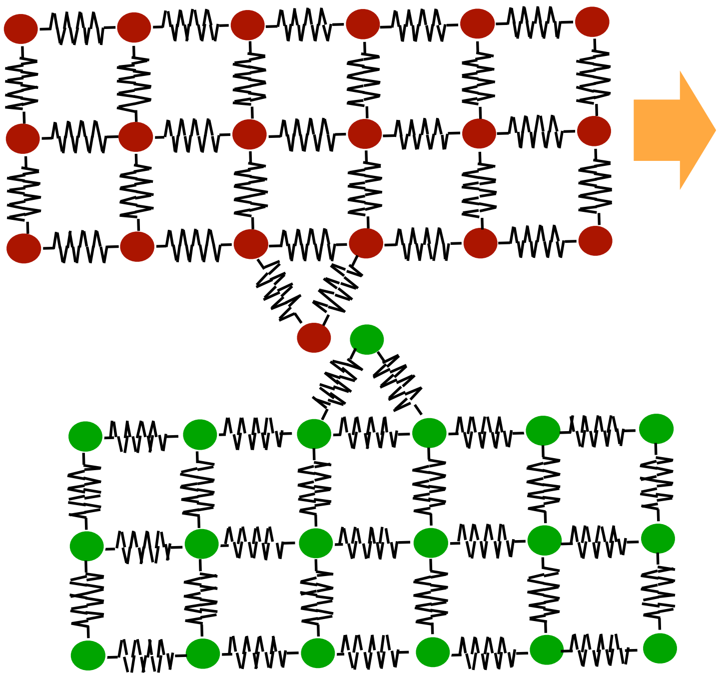
This is not a new idea – it's the same "work" you are used to.

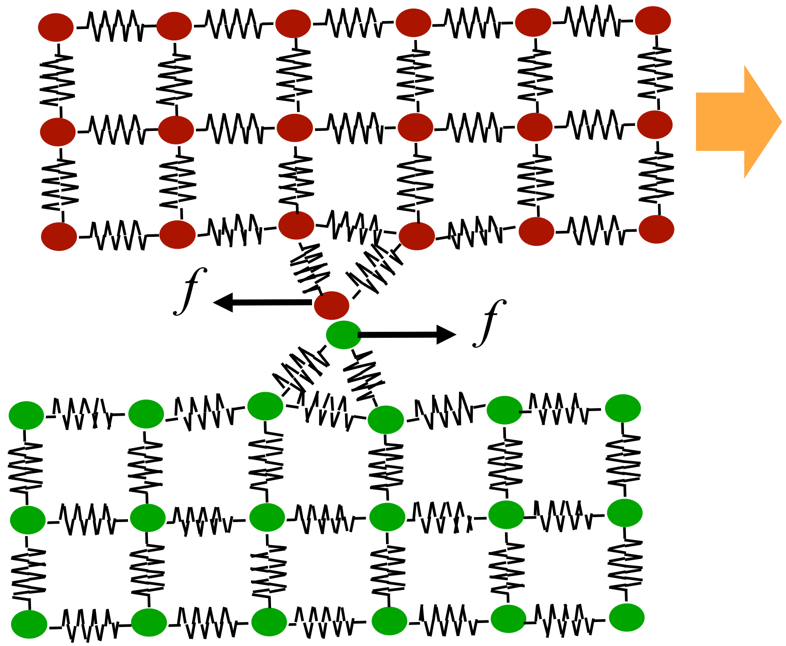
$$\Rightarrow \quad W = \int_a^b \vec{F} \cdot d\vec{l}$$

Applied to big (i.e. macroscopic) objects rather than point particles (picky detail)

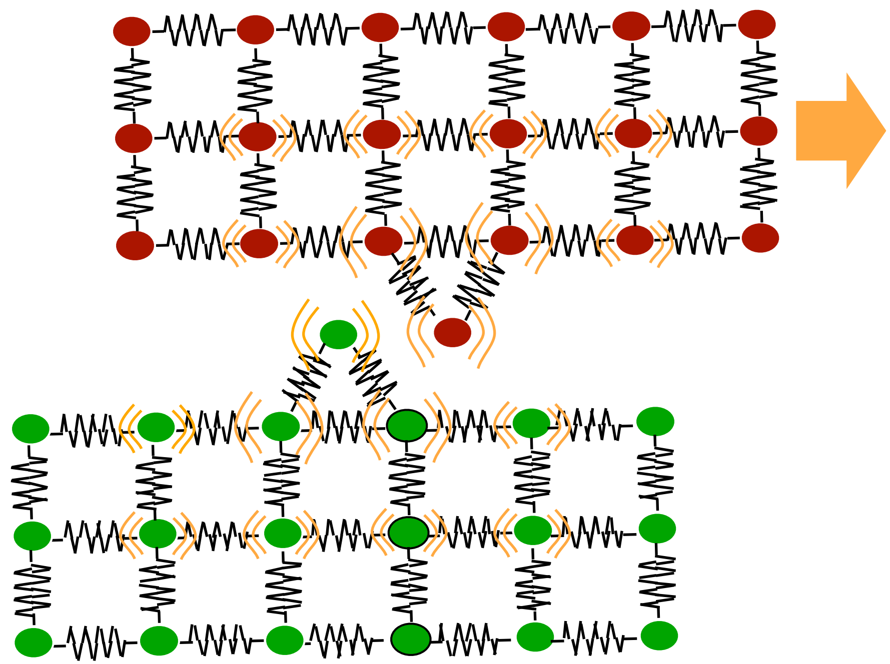
We call it "macroscopic" to distinguish it from "microscopic".


Work-Kinetic Energy Theorem
$\Delta K = W_{Net}$
$-\frac{1}{2} m v_o^2 = -\mu_k m g D$
Macroscop
done by
N
Block
Table
v_o
$v_f = 0$




f
f

“Heat” is just the kinetic energy of the atoms!



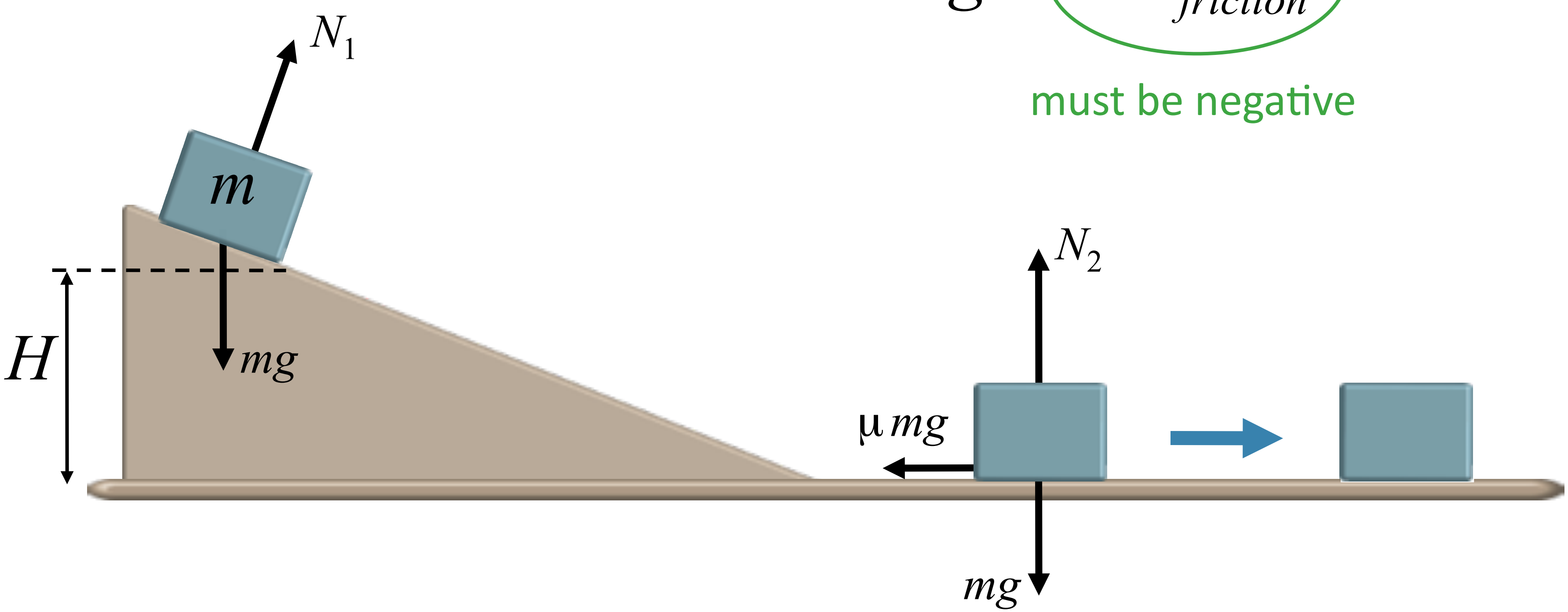
Do spinning Heat Demo

$$\Delta K = W_{tot} = W_{gravity} + W_{friction}$$

$$0 = W_{gravity} + W_{friction}$$

$$0 = mgH + W_{friction}$$

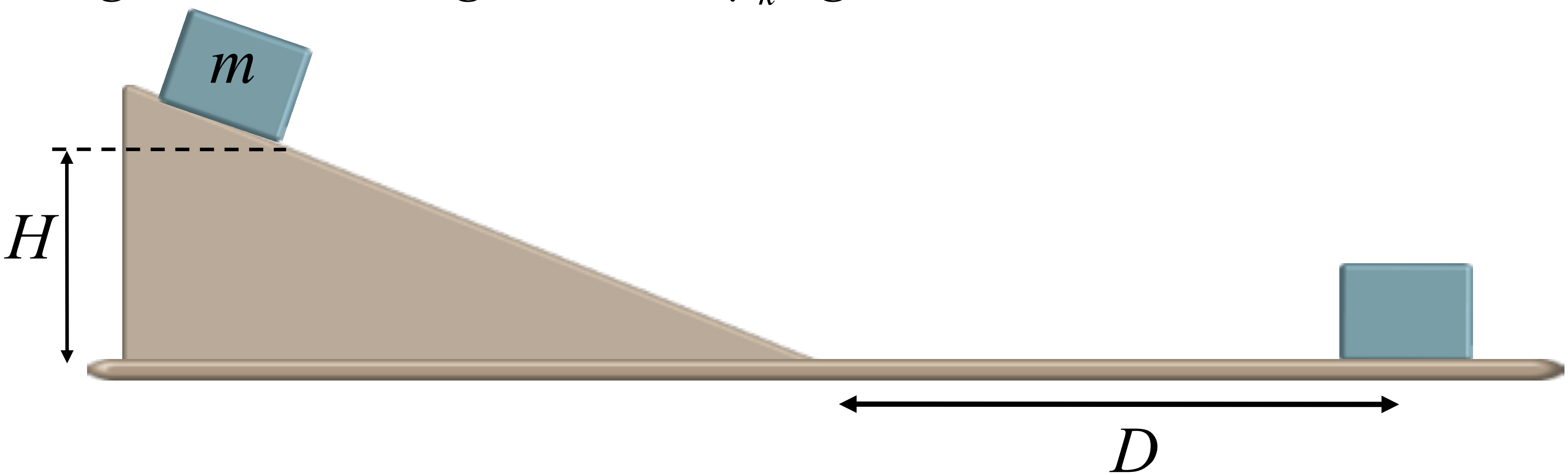
must be negative



CheckPoint

A block of mass m, initially held at rest on a frictionless ramp a vertical distance H above the floor, slides down the ramp and onto a floor where friction causes it to stop a distance r from the bottom of the ramp. The coefficient of kinetic friction between the box and the floor is μ_k. What is the macroscopic work done on the block by friction during this process?

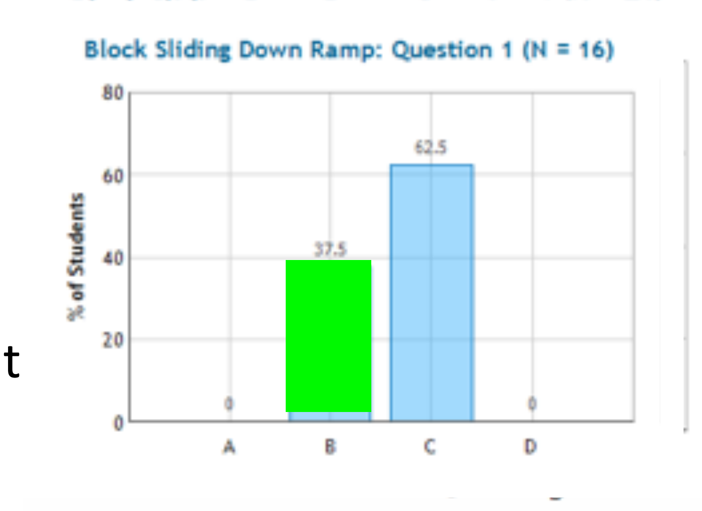
A) mgH B) $-mgH$ C) $\mu_k mgD$ D) 0



CheckPoint

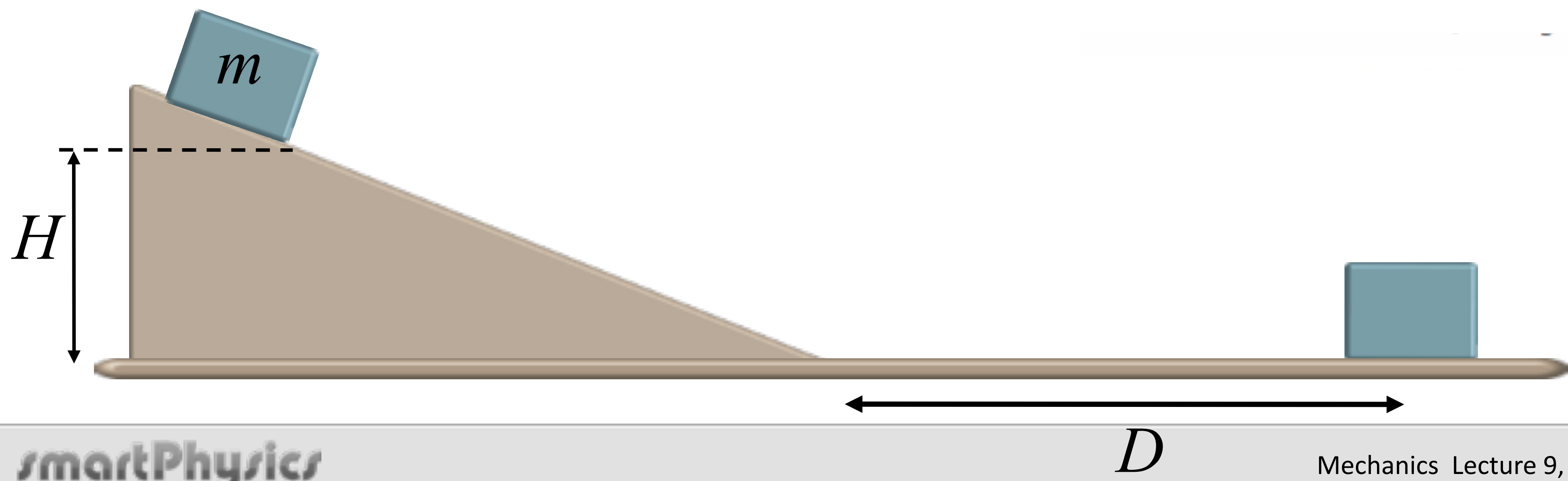
What is the macroscopic work done on the block by friction during this process?

A) mgH　　B) $-mgH$　　C) $\mu_k mgD$　　D) 0



B) All of the potential energy goes to kinetic as it slides down the ramp, then the friction does negative work to slow the box to stop

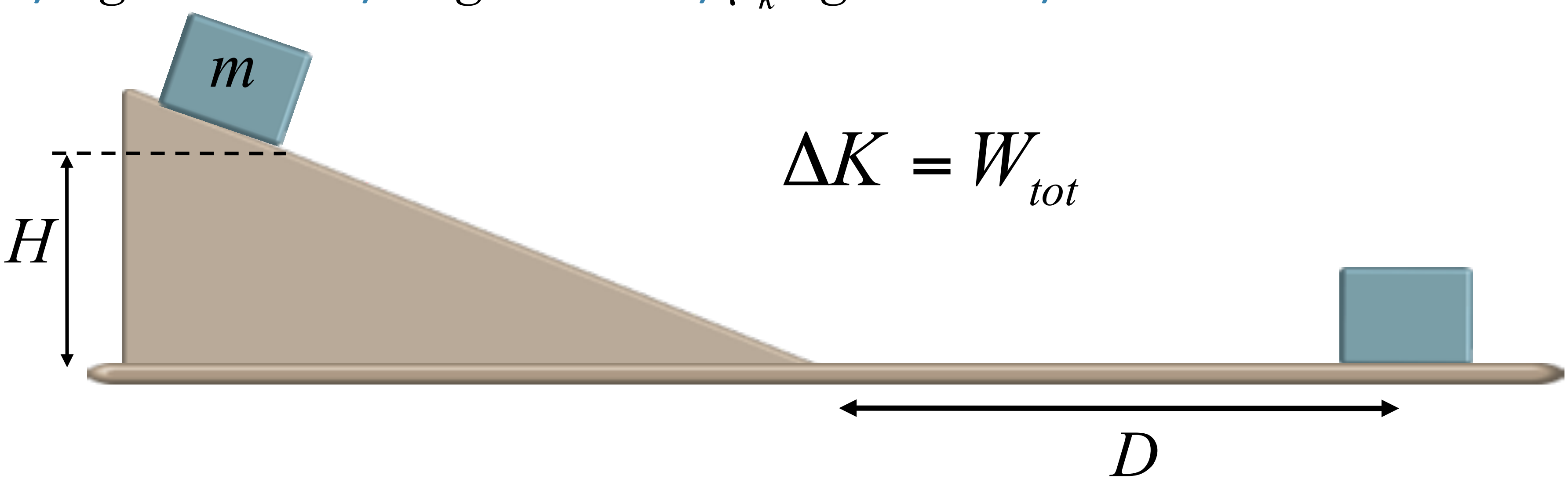
C) Since the floor has friction, the work done by the block by friction is the normal force ~~times the~~ coefficient of kinetic friction times the distance.



CheckPoint

A block of mass m, initially held at rest on a frictionless ramp a vertical distance H above the floor, slides down the ramp and onto a floor where friction causes it to stop a distance D from the bottom of the ramp. The coefficient of kinetic friction between the box and the floor is μ_k. What is the total macroscopic work done on the block by all forces during this process?

A) mgH B) $-mgH$ C) $\mu_k mgD$ D) 0

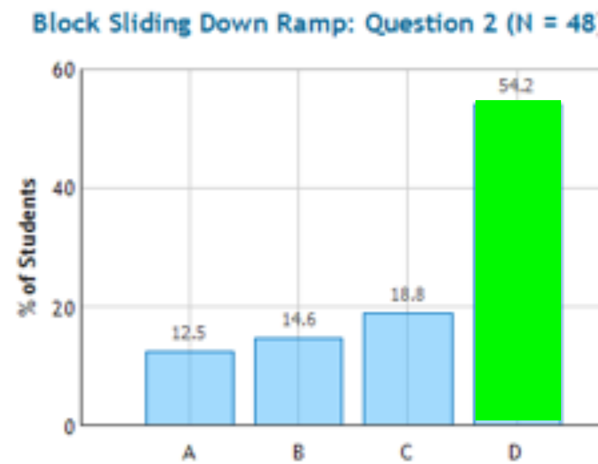


$$\Delta K = W_{tot}$$

CheckPoint

What is the total macroscopic work done on the block by all forces during this process?

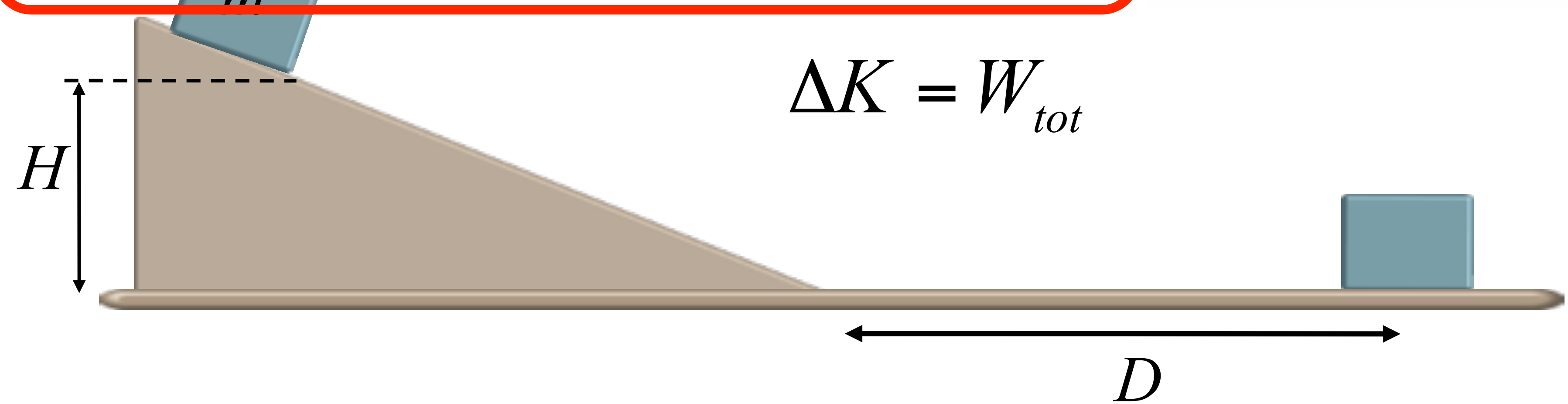
A) mgH B) $-mgH$ C) $\mu_k mgD$ D) 0



B) work= change in potential energy

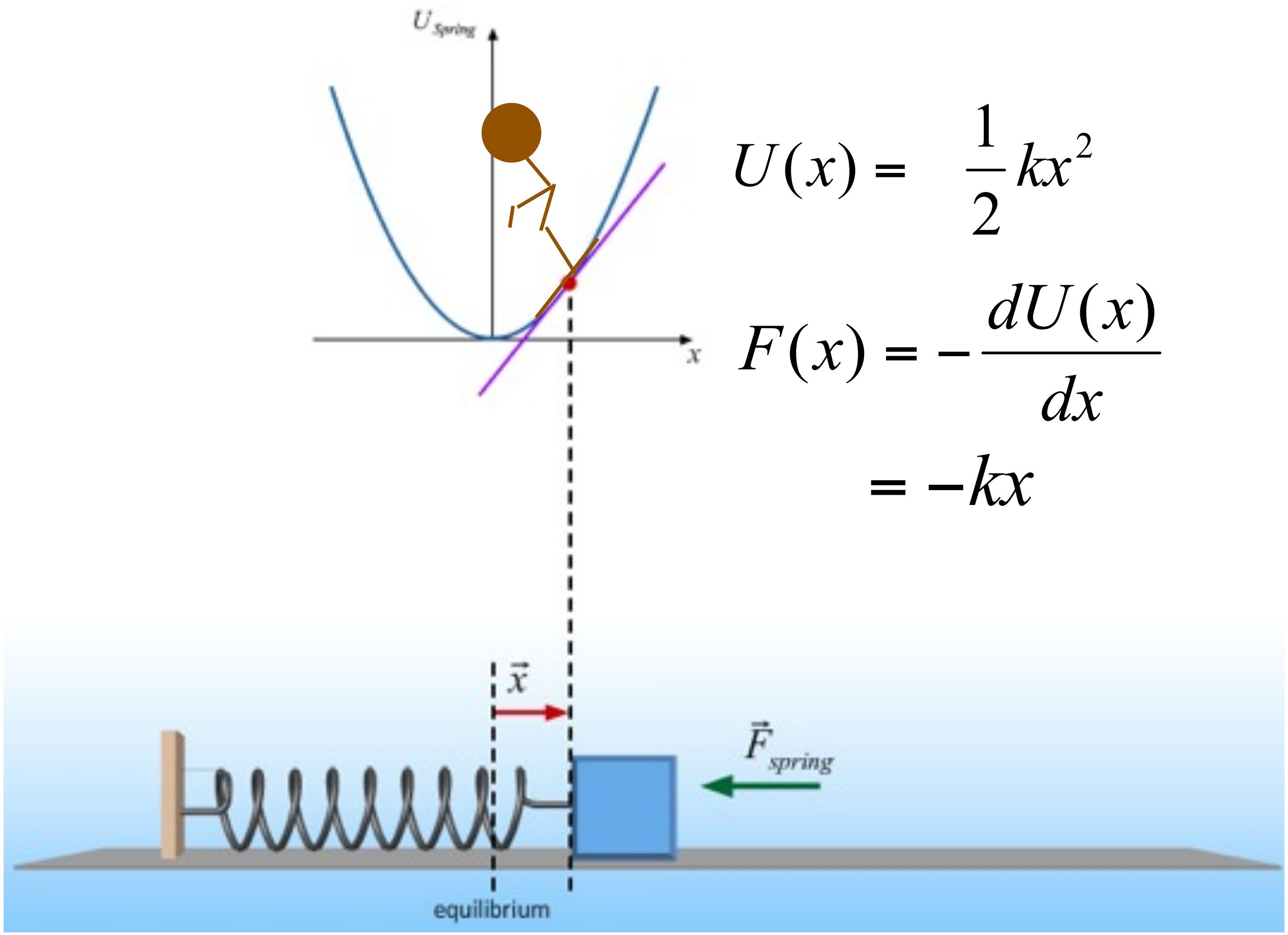
C) The only work being done on the object is by the friction force

D) total work is equal to the change in kinetic energy. since the box starts and ends at rest, the change in kinetic energy is zero.



$$\Delta K = W_{tot}$$

Potential Energy vs. Force



$$U(x) = \frac{1}{2}kx^2$$

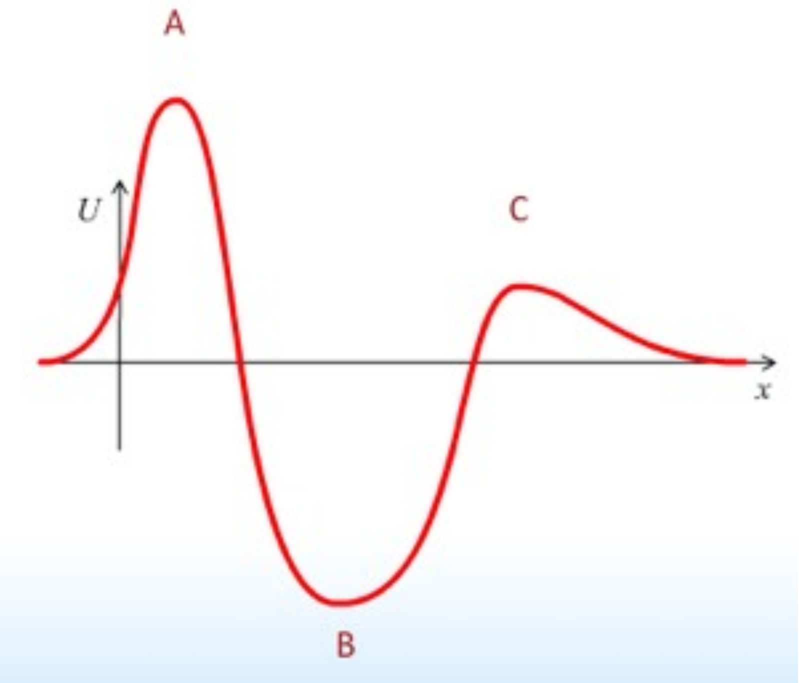
$$F(x) = -\frac{dU(x)}{dx}$$

$$= -kx$$

Potential Energy vs. Force

$$F(x) = -\frac{dU(x)}{dx}$$

	P.E. Function U	Force $\vec{F}$
Gravity (Near Earth)	$mgh + U_o$	$m\vec{g}$
Gravity (General Expression)	$-G\frac{m_1 m_2}{r} + U_o$	$-G\frac{m_1 m_2}{r^2}\hat{r}$
Spring	$\frac{1}{2}kx^2 + U_o$	$-k\vec{x}$



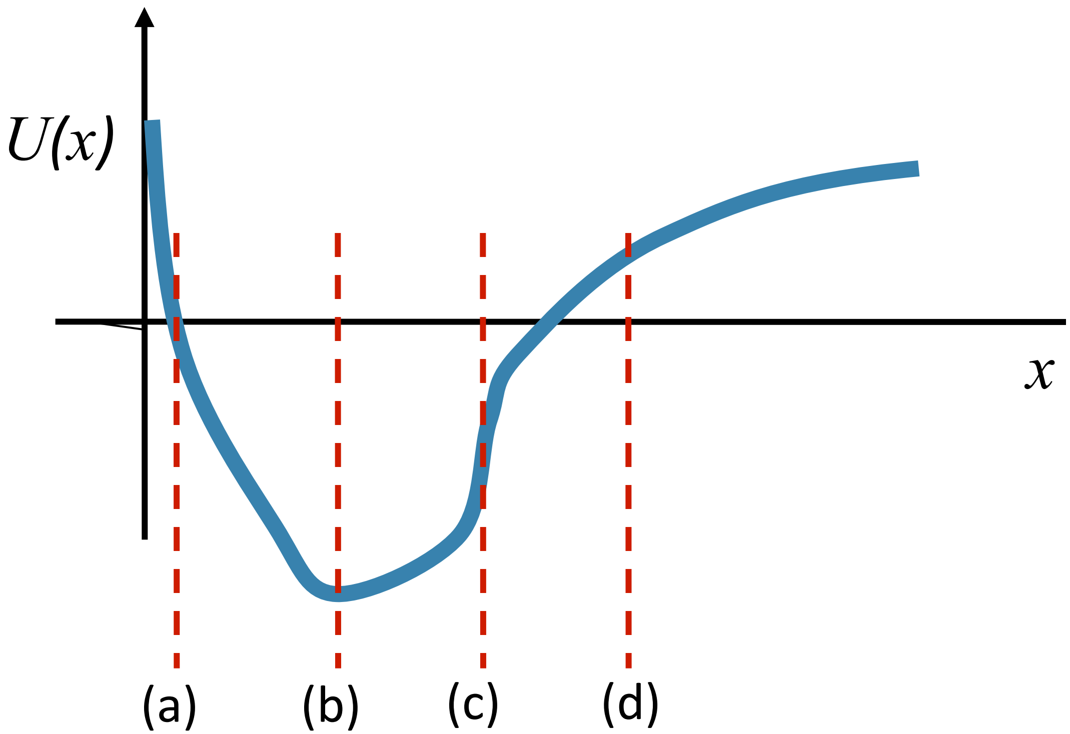
Demo

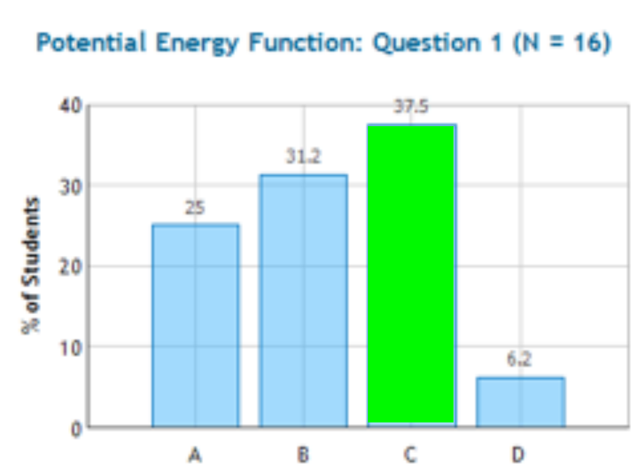
CheckPoint

Suppose the potential energy of some object U as a function of x looks like the plot shown below.

Where is the force on the object biggest in the $-x$ direction?

A) (a) B) (b) C) (c) D) (d)





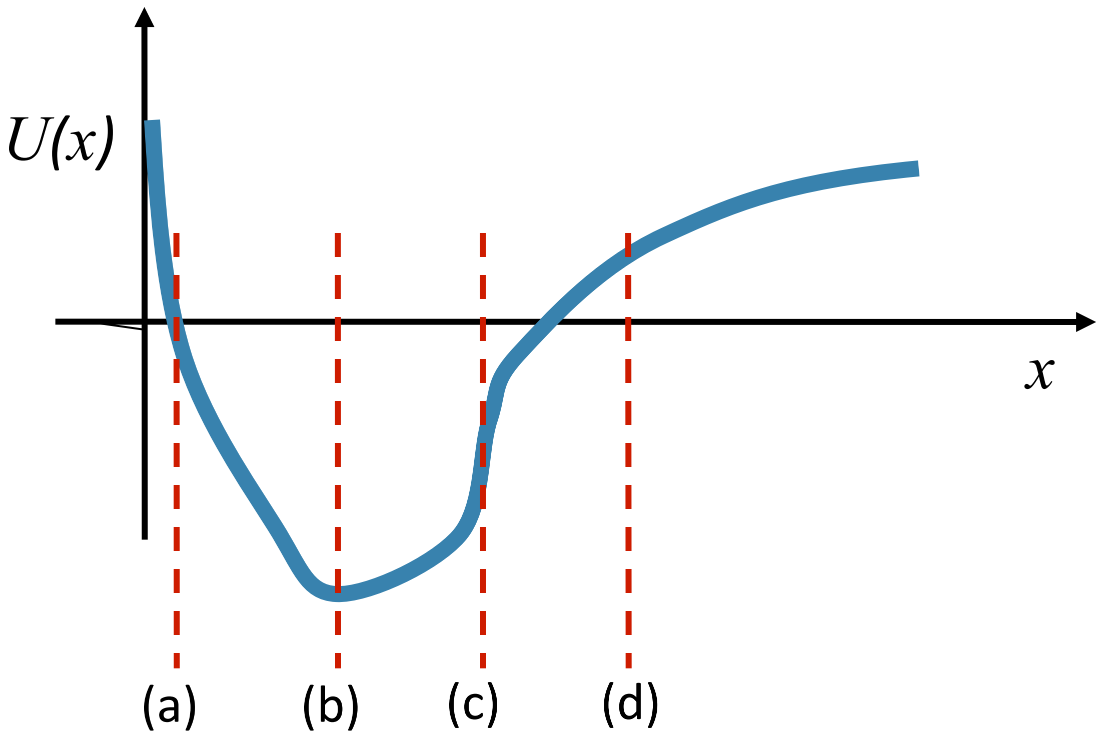
$$F(x) = -\frac{dU(x)}{dx}$$

Clicker Question

Suppose the potential energy of some object U as a function of x looks like the plot shown below.

Where is the force on the object zero?

A) (a) B) (b) C) (c) D) (d)

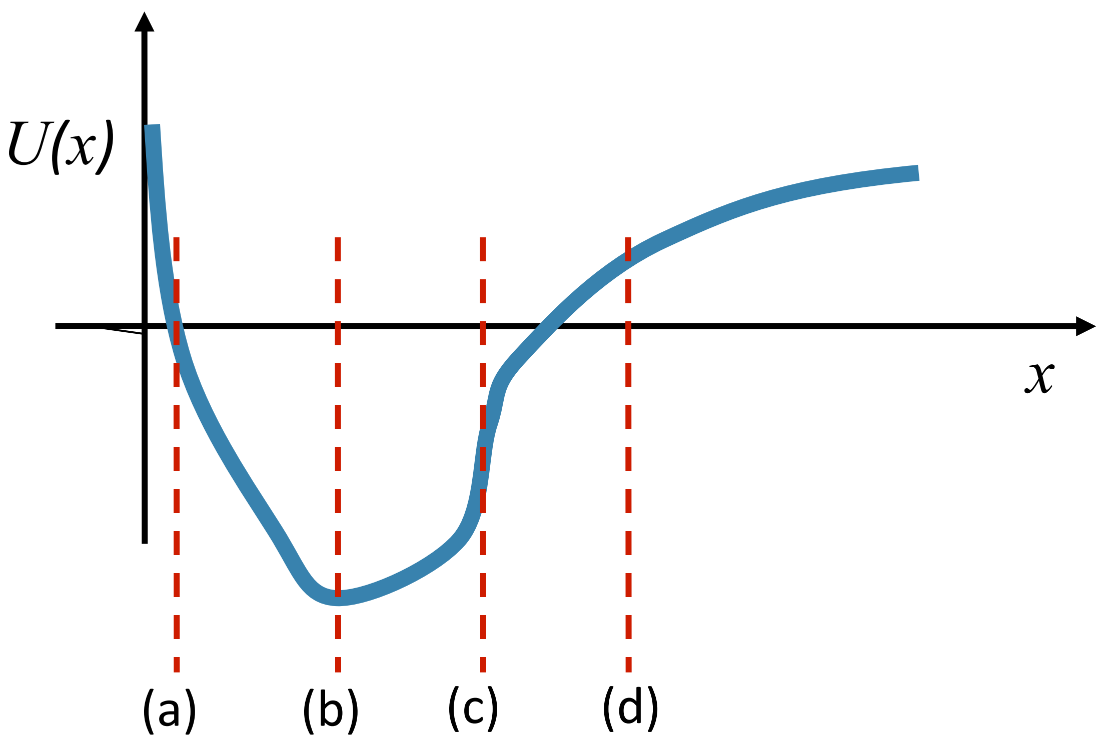


$$F(x) = -\frac{dU(x)}{dx}$$

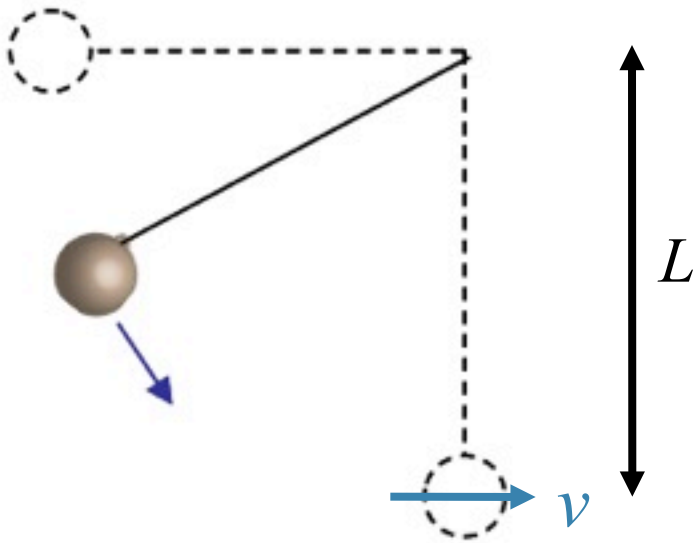
Suppose the potential energy of some object U as a function of x looks like the plot shown below.

Where is the force on the object in the $+x$ direction?

A) To the left of (b) B) To the right of (b) C) Nowhere



$$F(x) = -\frac{dU(x)}{dx}$$

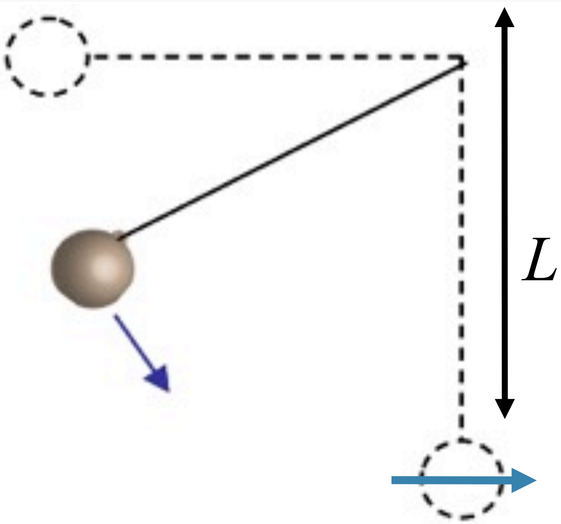


A mass m = 5.8 kg hangs on the end of a massless rope L = 1.97 m long. The pendulum is held horizontal and released from rest.

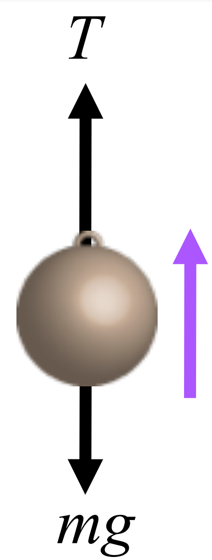
1) How fast is the mass moving at the bottom of its path? [ ] m/s Submit

Conserve Energy from initial to final position

$$mgL = \frac{1}{2}mv^2 \longrightarrow v = \sqrt{2gL}$$



$$v = \sqrt{2gL}$$



$$a = \frac{v^2}{L}$$

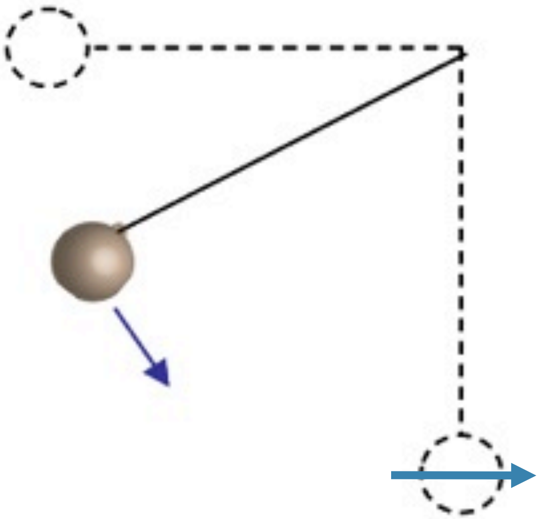
A mass m = 5.8 kg hangs on the end of a massless rope L = 1.97 m long. The pendulum is held horizontal and released from rest.

1) How fast is the mass moving at the bottom of its path? m/s Submit

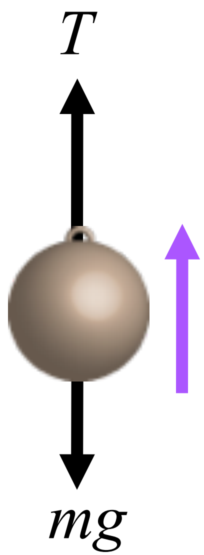
2) What is the magnitude of the tension in the string at the bottom of the path?

N Submit

$$T - mg = \frac{mv^2}{L} \quad \rightarrow \quad T = mg + \frac{mv^2}{L}$$



$$v = \sqrt{2gL}$$



$$a = \frac{v^2}{L}$$

A mass m = 5.8 kg hangs on the end of a massless rope L = 1.97 m long. The pendulum is held horizontal and released from rest.

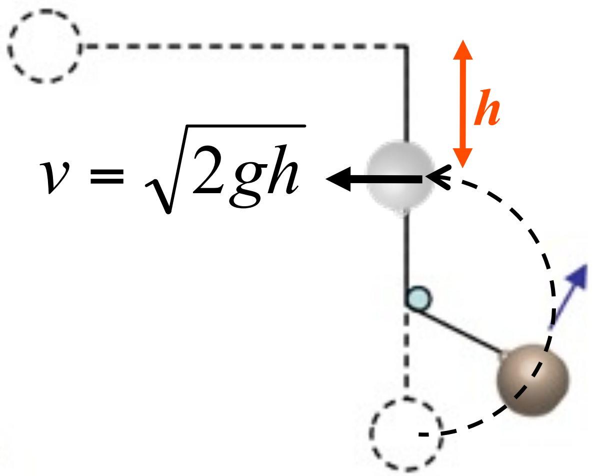
1) How fast is the mass moving at the bottom of its path? [ ] m/s [Submit]

2) What is the magnitude of the tension in the string at the bottom of the path?

[ ] N [Submit]

3) If the maximum tension the string can take without breaking is T_{max} = 500 N, what is the maximum mass that can be used? (Assuming that the mass is still released from the horizontal and swings down to its lowest point.) [ ] kg [Submit]

$$T = mg + \frac{mv^2}{L} \rightarrow T = mg + \frac{m2gL}{L} \rightarrow T = 3mg$$



4)

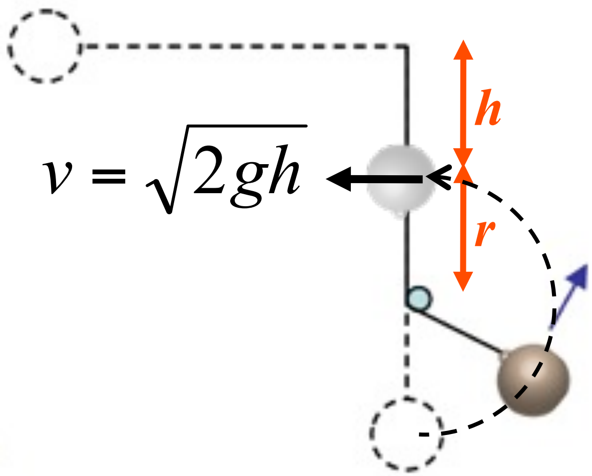
Now a peg is placed 4/5 of the way down the pendulum's path so that when the mass falls to its vertical position it hits and wraps around the peg. As it wraps around the peg and attains its maximum height it ends a distance of 3/5 L below its starting point (or 2/5 L from its lowest point).

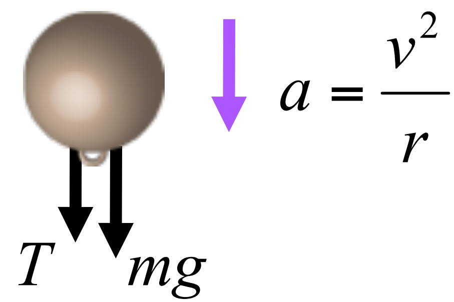
How fast is the mass moving at the top of its new path (directly above the peg)?

m/s Submit

Conserve Energy from initial to final position.

$$mgh = \frac{1}{2}mv^2 \rightarrow v = \sqrt{2gh}$$





4)

Now a peg is placed 4/5 of the way down the pendulum's path so that when the mass falls to its vertical position it hits and wraps around the peg. As it wraps around the peg and attains its maximum height it ends a distance of 3/5 L below its starting point (or 2/5 L from its lowest point).

How fast is the mass moving at the top of its new path (directly above the peg)?

m/s Submit

---

5) Using the original mass of m = 5.8 kg, what is the magnitude of the tension in the string at the top of the new path (directly above the peg)? N Submit

$$T + mg = \frac{mv^2}{r} \quad \rightarrow \quad T = \frac{mv^2}{r} - mg$$

Suicide Pendulum