Physics 2A: Lecture 4
Today's Agenda

- Newton's 3 laws
  - Dynamics: Why do things move?
- Forces
  - Normal Force
  - Tension Force
  - Gravitational Force

Clicker Question 10:

$x_0 = y_0 = 0\ m$

$v_{0x} =$

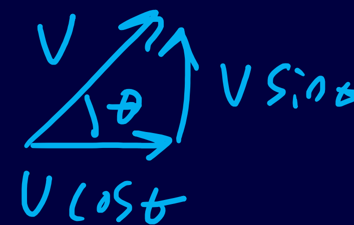
$v_{0y} =$

$a_x = 0$

$a_y = -g$

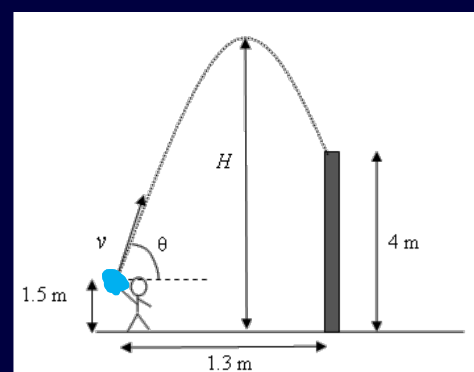
$x_F = 1.3 m$

$y_F = 4 m - 1.5 m = 2.5 m$



Eddy throws a little sand bag so that it lands on the top of a vertical post that is 4 m high. The post is 1.3 m away from Eddy. He releases the bag from a height of 1.5 m above the ground, as shown in the figure. The initial speed of the bag is v = 7.5 m/s, the angle, θ, between the velocity and the horizontal is θ = 80°. You can neglect the friction due to the air. How long does the sand bag stay in the air?

(a) t = 0.7 s
(b) t = 1.0 s
(c) t = 2.5 s



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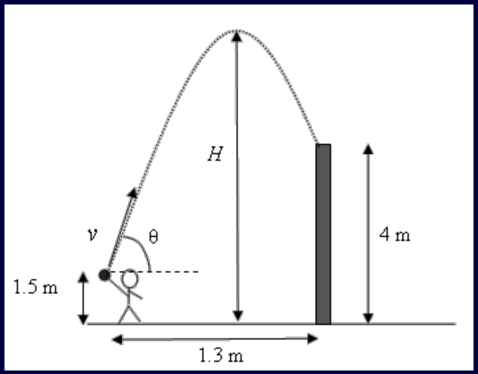
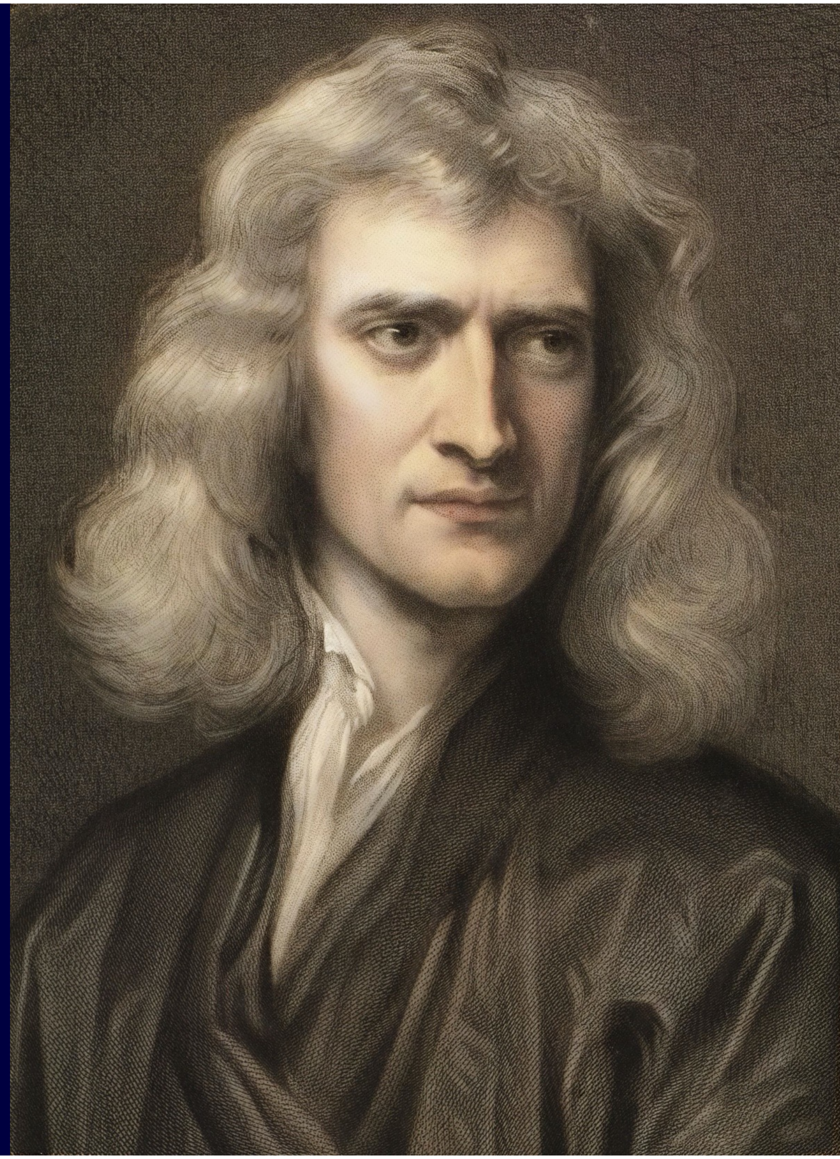




Today:

- Newton’s first two laws
  - First law: If there is no net force, there is no acceleration.
  - Second law: $\Sigma\vec{F} = m\vec{a}$

Solving Force Problems

Step 1: What forces are acting on our object?

Step 2: Draw a Free Body Diagram for each object.

Step 3: Select coordinate system.

Try to get as many forces in x-y direction

Step 4: Break all forces into x-y components

Step 5: Apply Newton's Second law.

$\Sigma F_X = ma_X$

$\Sigma F_Y = ma_Y$

Step 6: Solve for what you need.

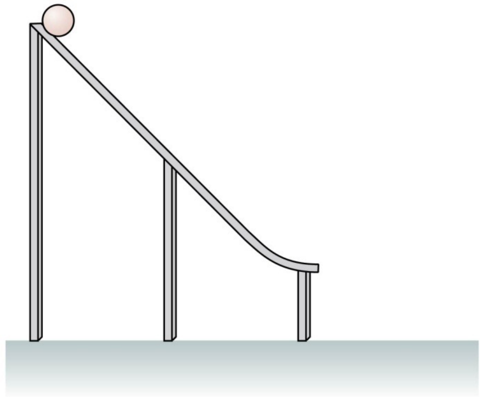
The Free Body Diagram

- Newton's 2nd Law says that for an object $\Sigma \boldsymbol{F} = m\boldsymbol{a}$.
- Key phrase here is ***for an object.***
- So before we can apply $\Sigma \boldsymbol{F} = m\boldsymbol{a}$ to any given object, we isolate the forces acting on this object:

FREE-BODY-DIAGRAM

Clicker Question 1

A ball rolls down an incline and off a horizontal ramp. Ignoring air resistance, what force or forces act on the ball as it moves through the air just after leaving the horizontal ramp?



A. The weight of the ball acting vertically down.

B. A horizontal force that maintains the motion.

C. A force whose direction changes as the direction of motion changes.

D. The weight of the ball and a horizontal force.

E. The weight of the ball and a force in the direction of motion.

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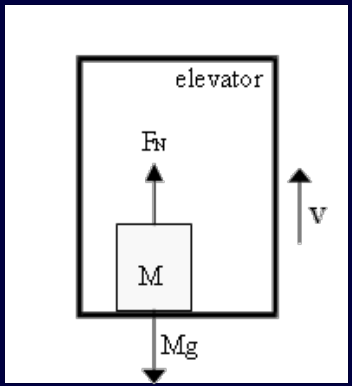
Clicker Question 2:

Suppose a box having a mass M sits on the floor of an elevator that is moving upward but is slowing down. Compare the weight of the box (Mg) to the magnitude of the normal force exerted by the elevator floor on the box (F_N).

(a) $F_N < Mg$

(b) $F_N = Mg$

(c) $F_N > Mg$



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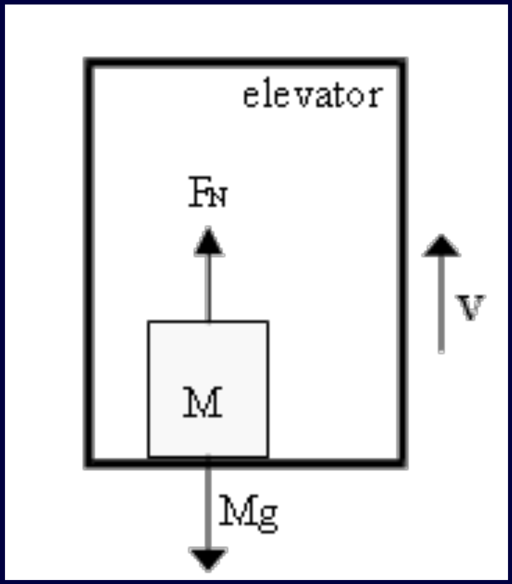
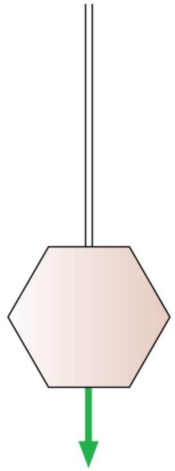


Student: In what cases will the normal force NOT be equal to mg?

Clicker 3

An object on a rope is lowered at constant speed. Which is true?



A. The rope tension is greater than the object's weight.

B. The rope tension equals the object's weight.

C. The rope tension is less than the object's weight.

D. The rope tension can't be compared to the object's weight.

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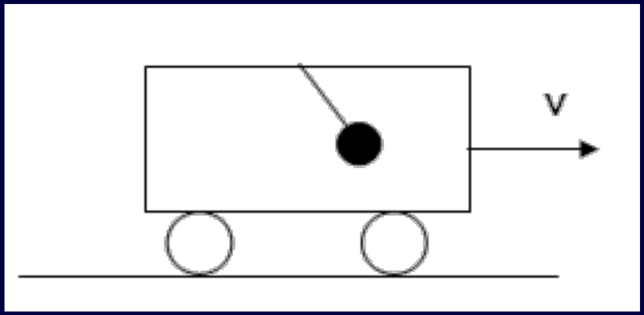
Clicker Question 4:

A car is moving to the right. A pendulum is suspended from the ceiling and hangs as shown in the figure. What can we say about the speed of the car?

(a) The car has a constant speed.

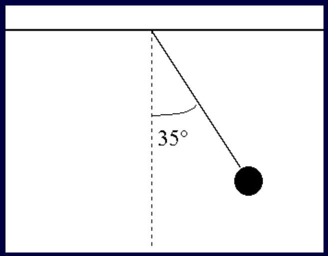
(b) The car's speed is increasing.

(c) The car's speed is decreasing.



Clicker Question 5:

A pendulum of mass 45 kg hangs from the roof of a car that is accelerating to the left as shown. Under these circumstances the pendulum hangs as shown. Find the acceleration of the car. What is true about the pendulum?



(a) $a_x = 0$, a_y = acceleration of the car

(b) a_x = acceleration of the car, $a_y = 0$

(c) There will be acceleration in both directions

(d) The pendulum does not accelerate.

Clicker Question 6:

A car is moving to the right. A pendulum is suspended from the ceiling and hangs as shown in the figure. How many forces act on the pendulum?

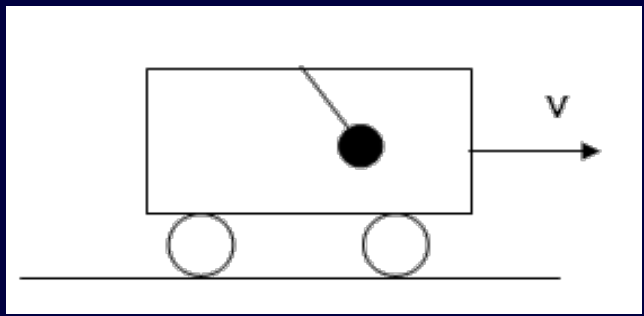
(a) 1

(b) 2

(c) 3

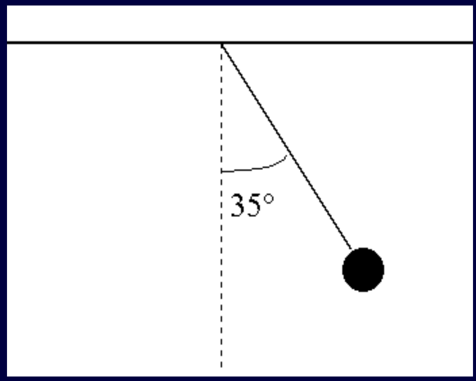
(d) 4

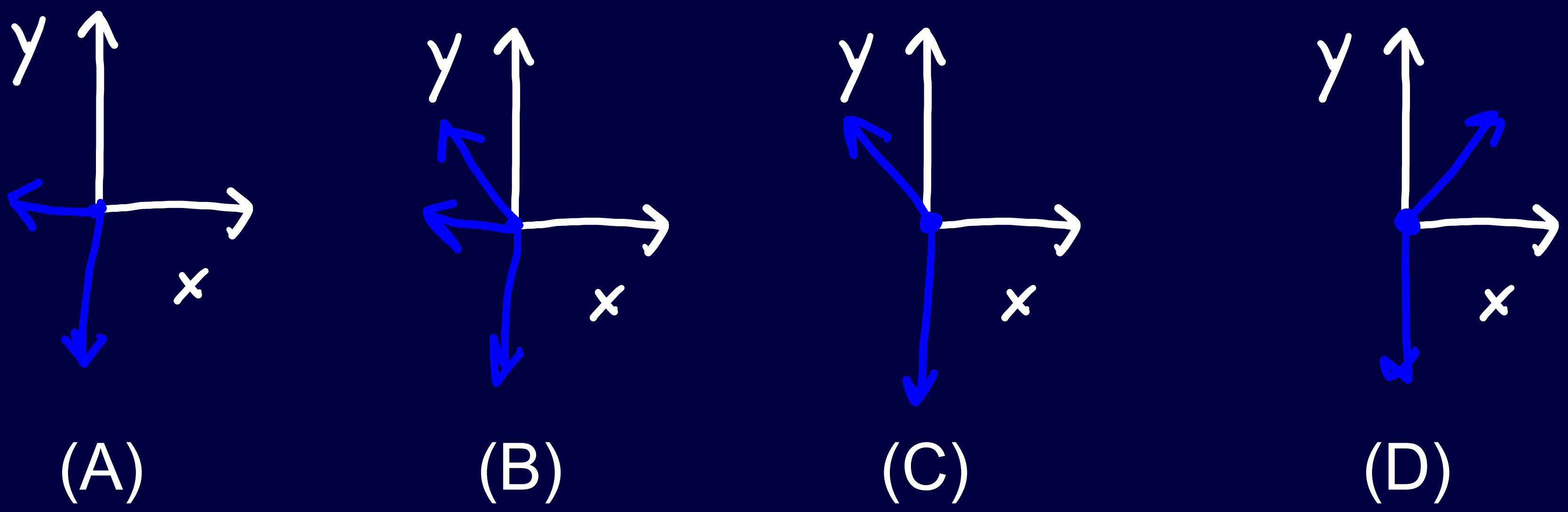
(e) 5



Clicker Question 7:

A pendulum of mass 45 kg hangs from the roof of a car that is accelerating to the left as shown. Under these circumstances the pendulum hangs as shown. Which is the correct free-body diagram?





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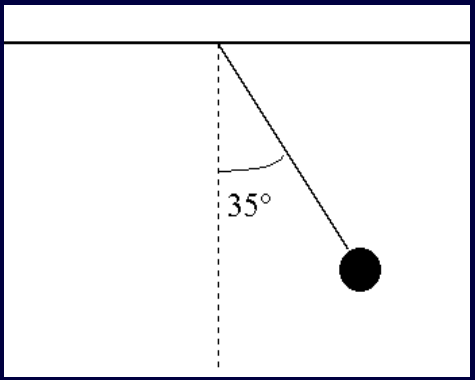

Static Friction

- Static friction force has a *maximum* possible size $f_{s\ max}$.
- An object remains at rest as long as $f_s < f_{s\ max}$.
- The object just begins to slip when $f_s = f_{s\ max}$.
- A static friction force $f_s > f_{s\ max}$ is not physically possible:

$$f_{s\ max} = \mu_s n$$

where the proportionality constant μ_s is called the **coefficient of static friction**.

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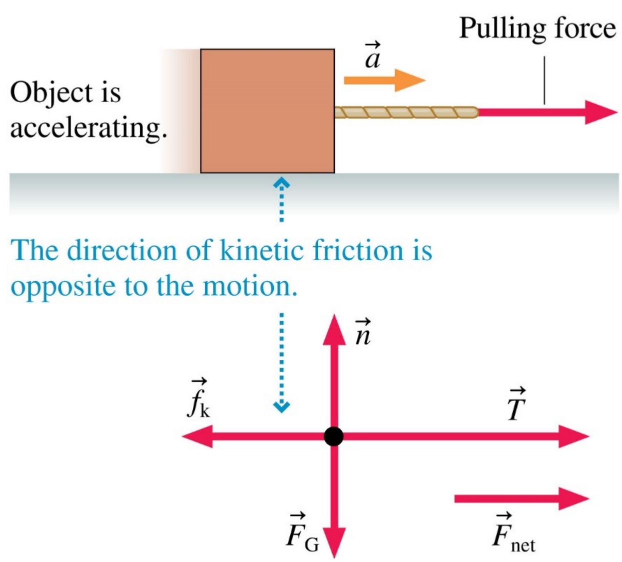
Kinetic Friction



- The **kinetic friction** force is proportional to the magnitude of the normal force:

$$f_k = \mu_k n = \mu_k F_N$$

where the proportionality constant μ_k is called the **coefficient of kinetic friction.**

- The kinetic friction direction is opposite to the velocity of the object relative to the surface.
- For any particular pair of surfaces, $\mu_k < \mu_s$.

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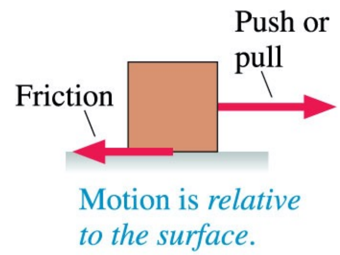
A Model of Friction

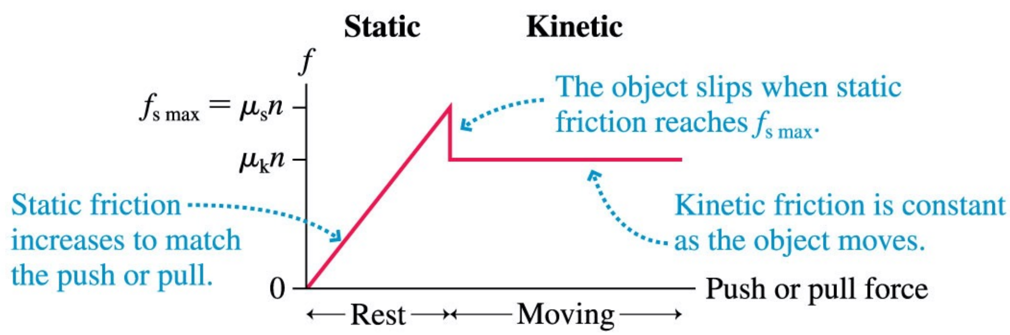
MODEL 6.3

Friction

The friction force is *parallel* to the surface.

- Static friction: Acts as needed to prevent motion. Can have *any* magnitude up to $f_{s\,max} = \mu_s n$.
- Kinetic friction: Opposes motion with $f_k = \mu_k n$.
- Rolling friction: Opposes motion with $f_r = \mu_r n$.
- Graphically:





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Clicker Question 8:

A truck accelerates with a heavy box on its trailer. The box does not slip; which direction does the frictional force point during the acceleration?

(a) In the same direction as the acceleration

(b) In the direction opposite the acceleration

(c) There is no frictional force because the box does not slip

Clicker Question 9:

A 50-kg crate rests on the bed of a truck which is accelerating to the right with $a = 3.9\ m/s^2$. What is the minimum coefficient of static friction between the surface of the truck and the crate such that the crate does not slip?

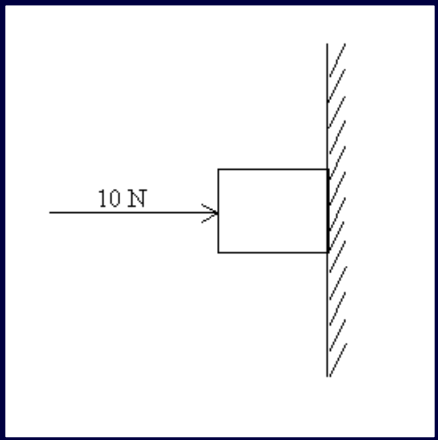
(a) 0.1
(b) 0.2
(c) 0.3
(d) 0.4
(e) 0.5

A 50-kg crate rests on the bed of a truck which is accelerating to the right with a = 3.9 m/s^2. What is the minimum coefficient of static friction between the surface of the truck and the crate such that the crate does not slip?

Clicker Question 10:

A horizontal force of 10 N pushes a block against a vertical wall, holding it in place as shown in the figure. The coefficient of static friction between the block and the wall is μ_s = 0.59. How many different forces act on the block?

(a) 2
(b) 3
(c) 4



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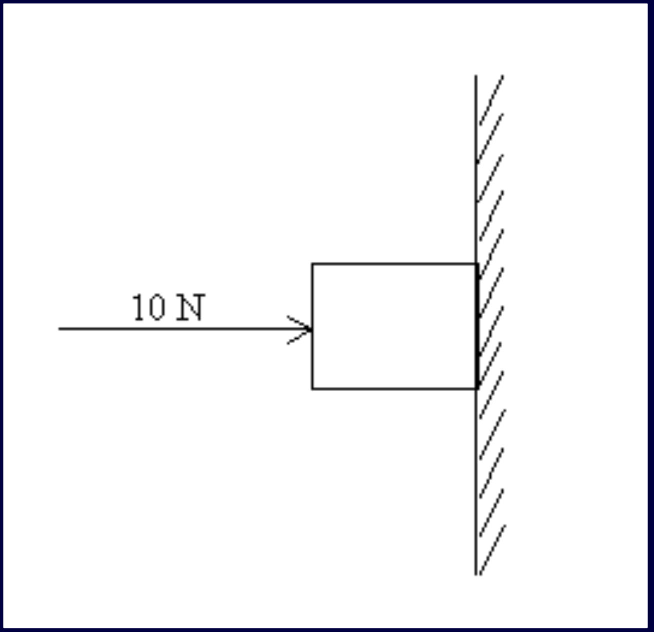
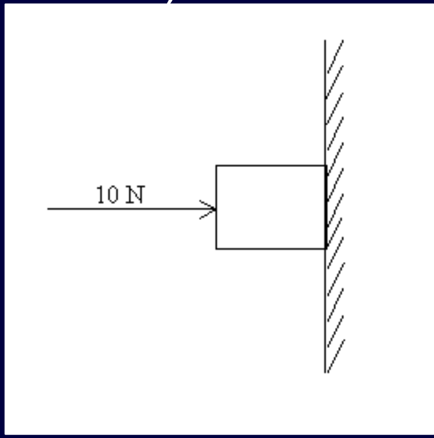


Clicker Question 11:

A horizontal force of 10 N pushes a block against a vertical wall, holding it in place as shown in the figure. The coefficient of static friction between the block and the wall is μ_s = 0.59. What are correct x and y component equations for this block? (F_S is the static frictional force, and F_N is the normal force)



(a) $F_N = mg$, $F_S = 10$ N
(b) $F_N = 10$ N, $F_S = mg$
(c) $F_S = 10$ N, $F_N = mg$
(d) $F_S = F_N$, $mg = 10$ N
(e) $F_S = 10$ N $- mg$, $F_N = 0$

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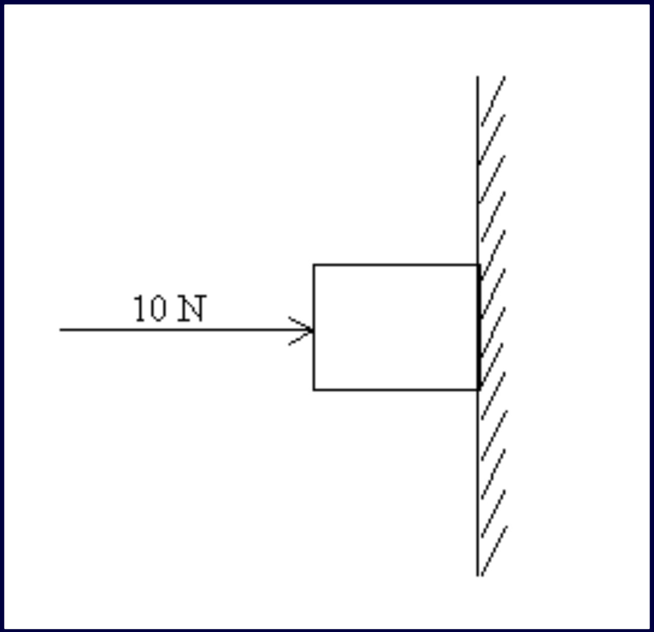
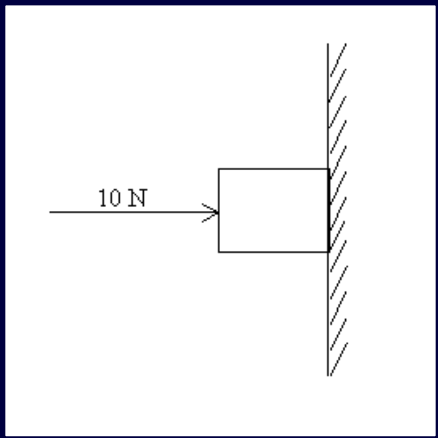


Clicker Question 12:

In the preceding problem, what is the maximum mass of the block such that it does not slip?

(a) 2.4 kg
(b) 9.8 kg
(c) 3.0 kg
(d) 0.6 kg
(e) 10 kg



Clicker Question:

Two blocks with different masses but the same speed are moving over a frictionless surface. They then enter a region with a rough surface and eventually come to a stop. Which block will travel a further distance before stopping? As the blocks are made from the same material assume that they have the same coefficient of kinetic friction with this rough surface.

a) The heavier block

b) The lighter block

c) They will travel the same distance before stopping

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