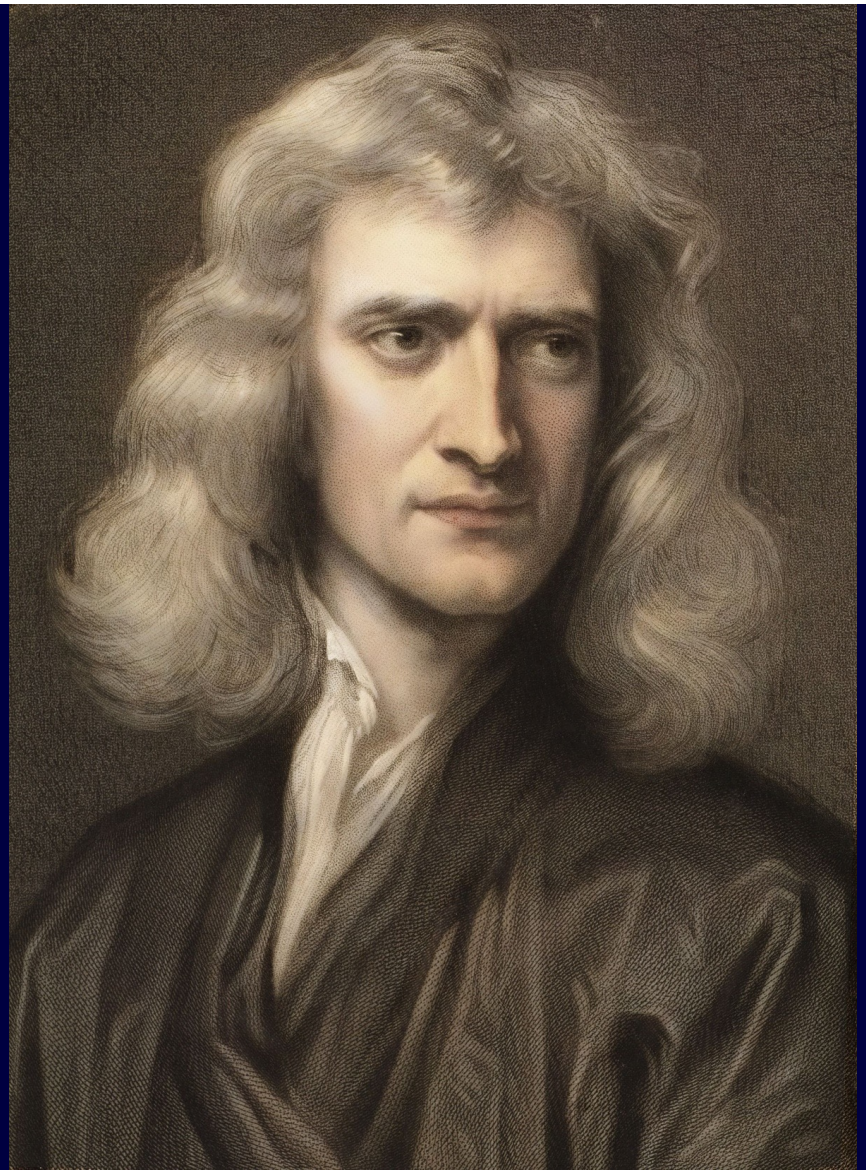
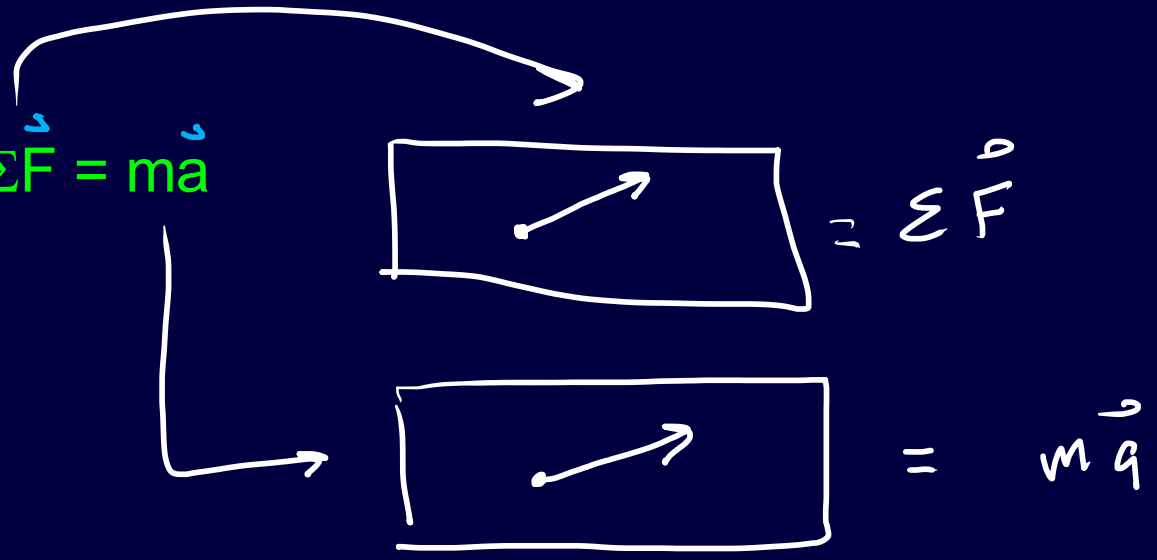
Physics 2A: Lecture 5
Today's Agenda

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



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.

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

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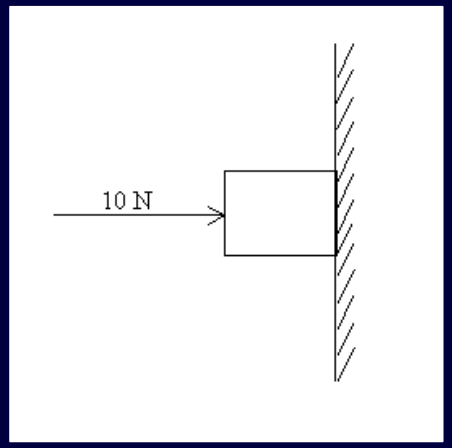
Clicker Question 10:

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 $\mu_s = 0.59$. How many different forces act on the block?

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



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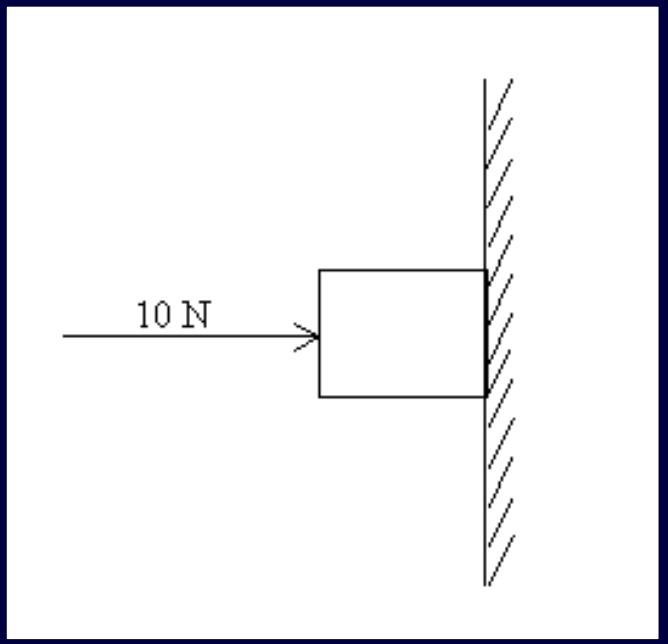
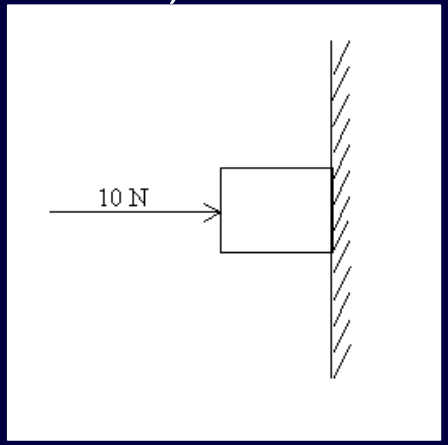


Clicker Question 11:

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 $\mu_s = 0.59$. 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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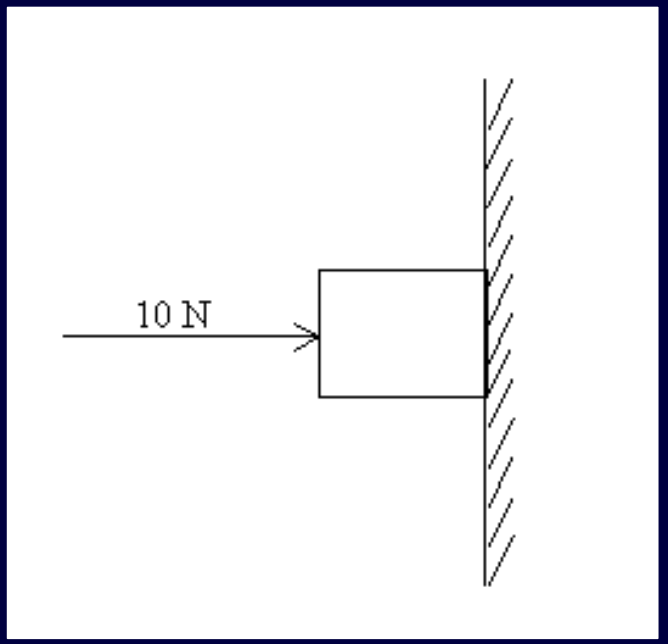
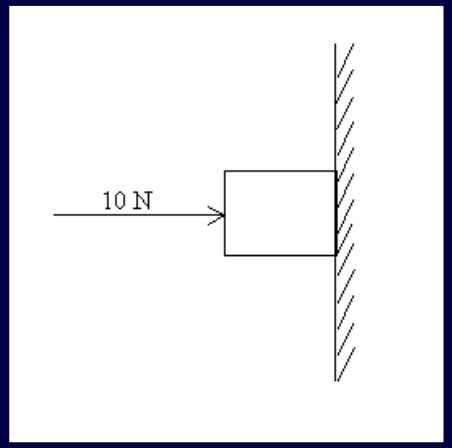


Clicker Question 12:

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 1:

A 10 kg box is sliding with constant velocity down a ramp that makes an angle of 10° with the horizontal. What is the magnitude of the frictional force between the ramp and the box?

(a) 7 N
(b) 17 N
(c) 34N
(d) 98 N
(e) 10 3N

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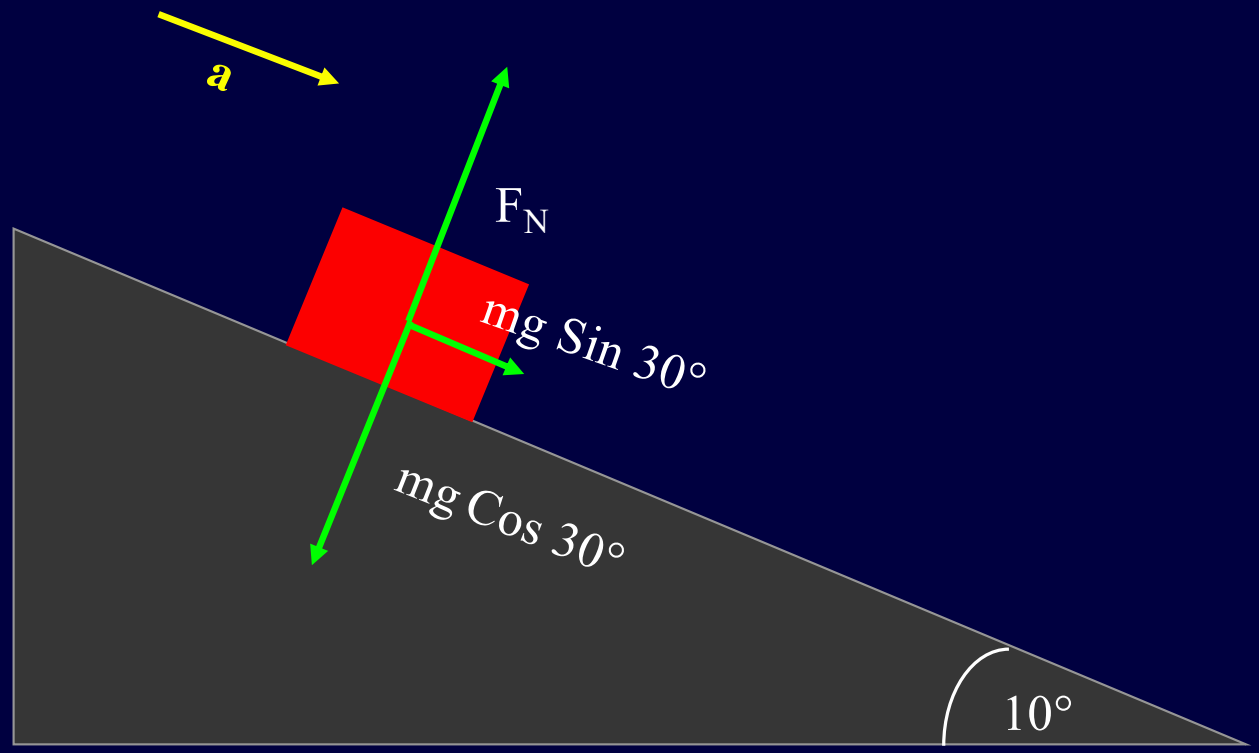


Newton's Third Law

- Whenever an object exerts a force on a second object, the second object exerts a force on the first that is equal in magnitude and opposite in direction. (Action-Reaction)

- Sometimes this law is misunderstood

- 'Action-reaction' pairs are ***always*** equal and opposite

Clicker Question 2:

A bug hits the windshield of a truck on the highway. Which is a true statement about the magnitude of the force the windshield feels due to the bug, $F_{w,b}$, and the magnitude of the force the bug feels due to the windshield, $F_{b,w}$.

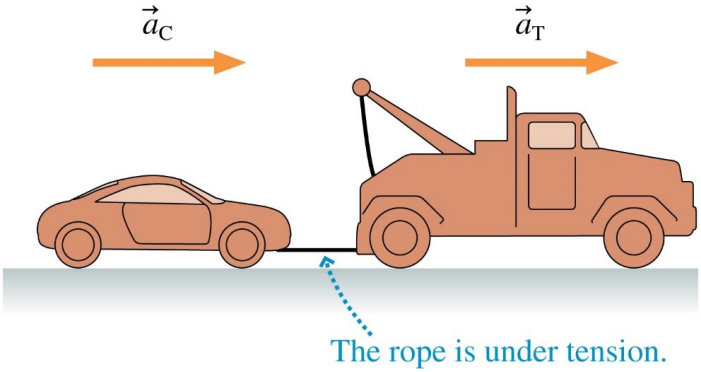
(A) $F_{w,b} > F_{b,w}$

(B) $F_{w,b} = F_{b,w}$

(C) $F_{w,b} < F_{b,w}$

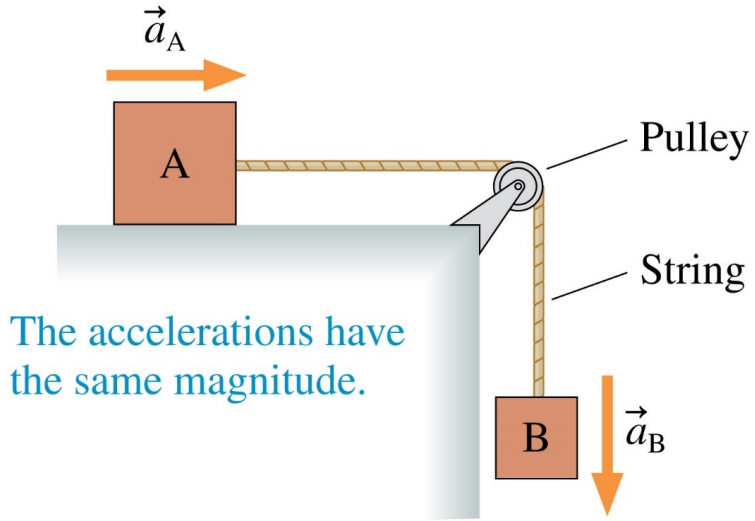
Acceleration Constraints

- If two objects A and B move together, their accelerations are *constrained* to be equal: $a_A = a_B$
- This equation is called an **acceleration constraint**.
- Consider a car being towed by a truck.
- In this case, the acceleration constraint is $a_{Cx} = a_{Tx} = a_x$.
- Because the accelerations of both objects are equal, we can drop the subscripts C and T and call both of them a_x.



Acceleration Constraints

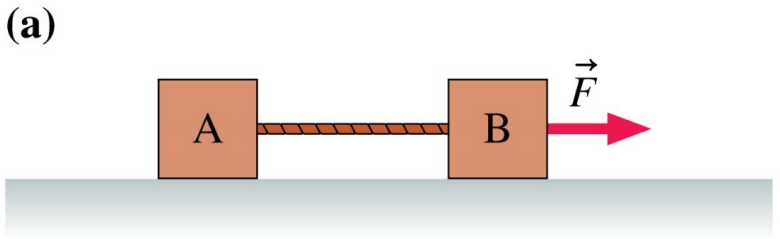
- Sometimes the acceleration of A and B may have different signs.
- Consider the blocks A and B in the figure.
- The string constrains the two objects to accelerate together.



- But, as A moves to the right in the $+x$ direction, B moves down in the $-y$ direction.
- In this case, the acceleration constraint is $a_{Ax} = -a_{By}$.

The Massless String Approximation

- Often in problems the mass of the string or rope is much less than the masses of the objects that it connects.
- In such cases, we can adopt the following **massless string approximation**:



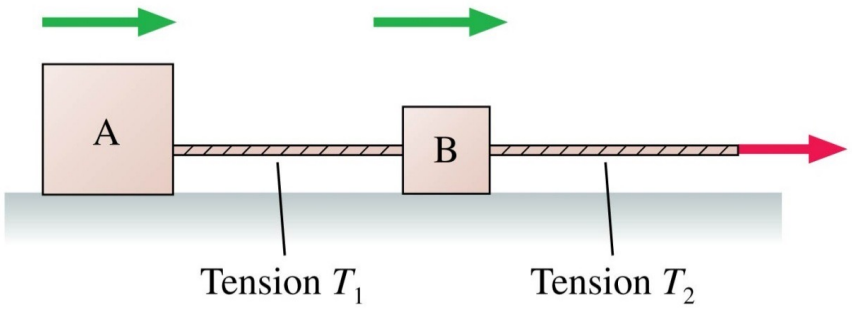
$$T_{\text{B on S}} = T_{\text{A on S}} \qquad \text{(massless string approximation)}$$

Student: For problem 2, if the mass of the blocks differ in mass will the tension remain the same between all the blocks? I think it will but I wanted to be sure.

Clicker Question 3:

Boxes A and B are being pulled to the right on a frictionless surface. Box A has a larger mass than B. How do the two tension forces compare?

A. $T_1 > T_2$
B. $T_1 = T_2$
C. $T_1 < T_2$
D. Not enough information to tell.

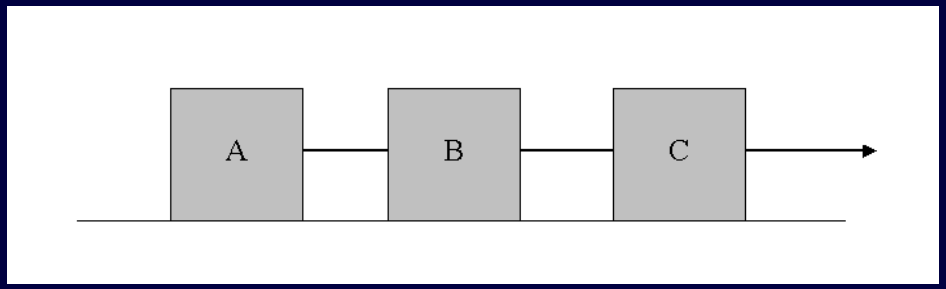


Clicker Question 4:

Three blocks each have a mass of 3 kg and are being pulled over a frictionless surface by a force of 20 N.

What acceleration does block A have?

a) Zero m/s^2
b) 2.22 m/s^2
c) 6.67 m/s^2
d) 60 m/s^2
e) 180 m/s^2



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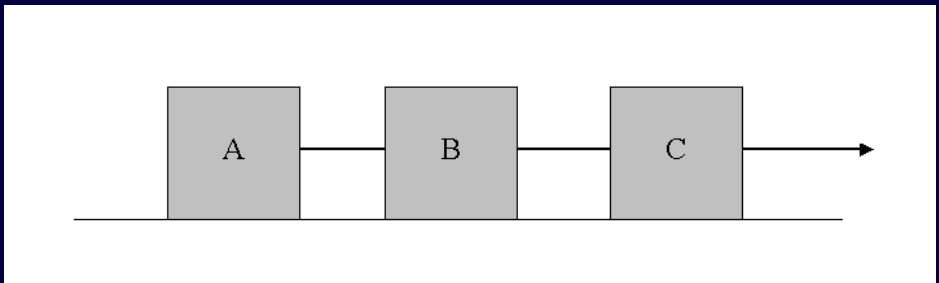
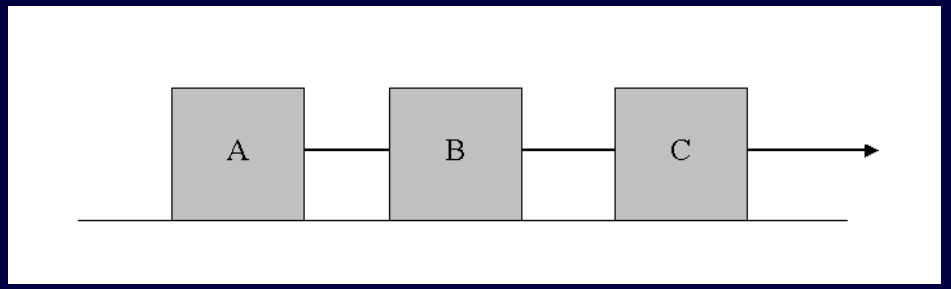


Conceptual Problem 5:

Three blocks each have a mass of 3 kg and are being pulled over a frictionless surface by a force of 20 N.

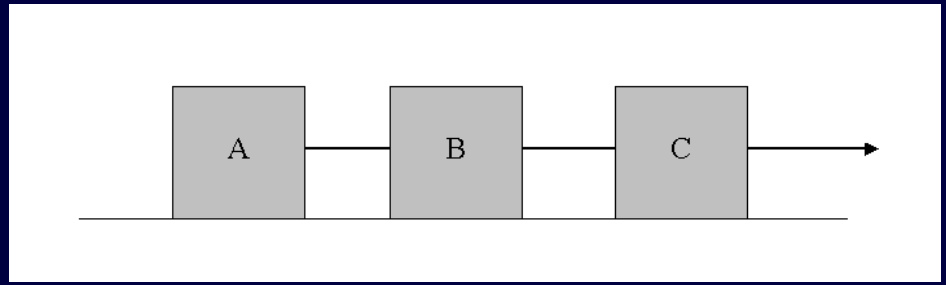
What is the tension between blocks B and C, T_{BC}?

a) 3.32 N
b) 6.67 N
c) 13.34 N
d) 20 N
e) 26.7 N



Three blocks each have a mass of 3 kg and are being pulled over a frictionless surface by a force of 20 N.

What is the tension between blocks B and C, T_{BC}?

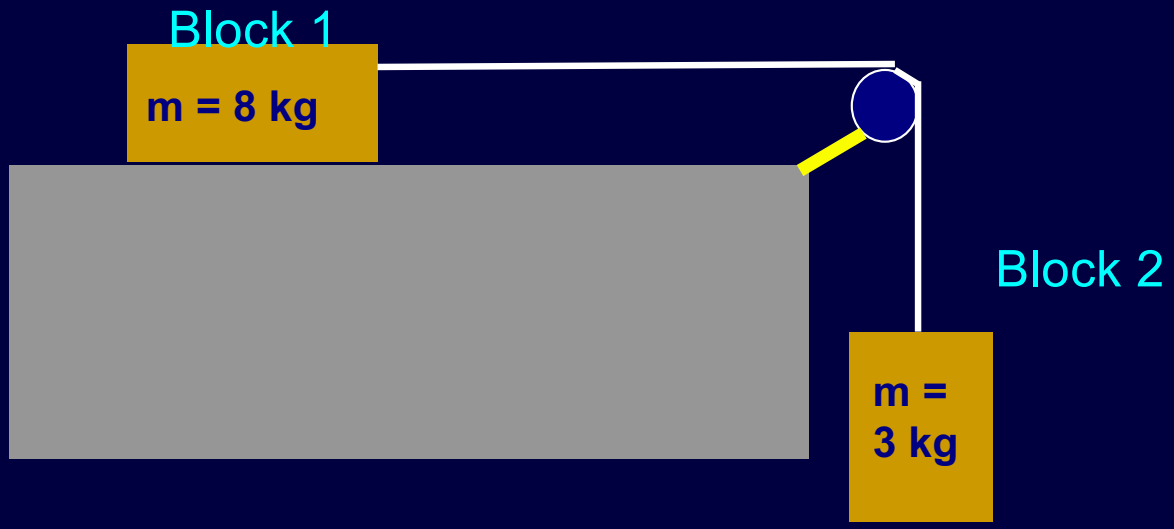


Example

- Assume two blocks are set up as below. There is no friction between the top block and the table. What is the acceleration of the blocks?

Example

- Step 1: Select the objects of interest.
- The two blocks, must work with both of them.



Example

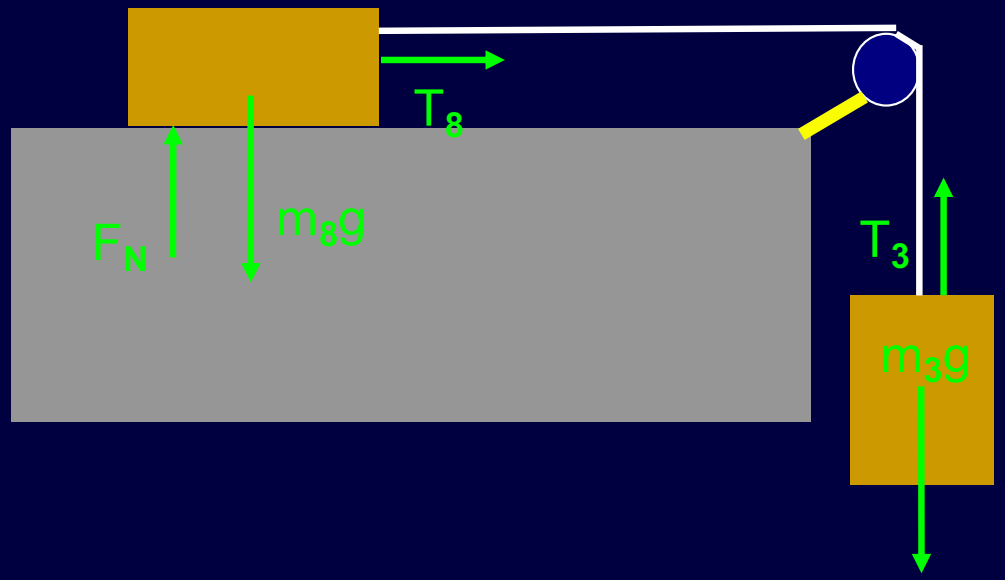
- Step 2: Draw a Free Body Diagram

What Forces act on the blocks?

1.) Weight due to gravity

2.) Normal Force on block 1

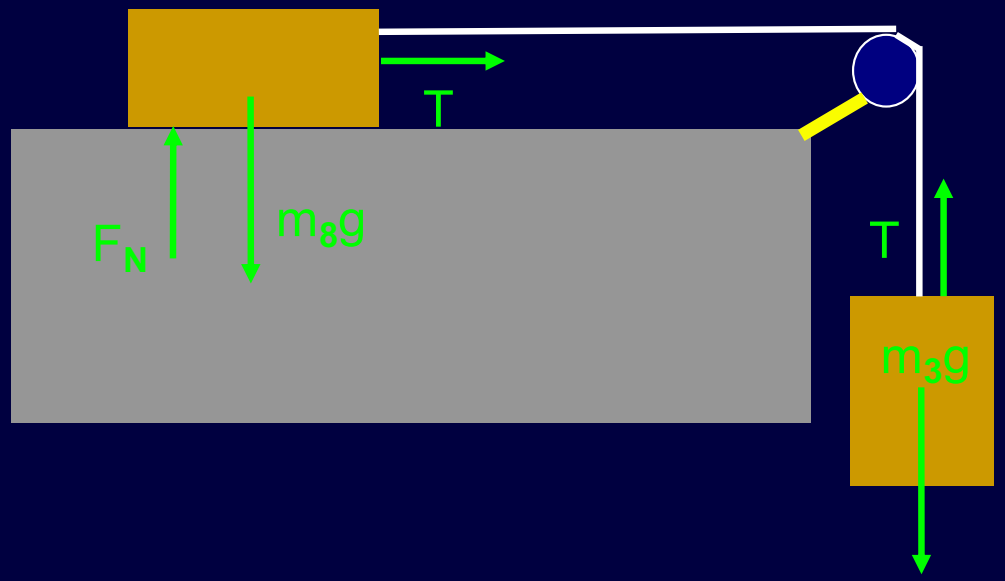
3.) Tensions



Acceleration constraint!

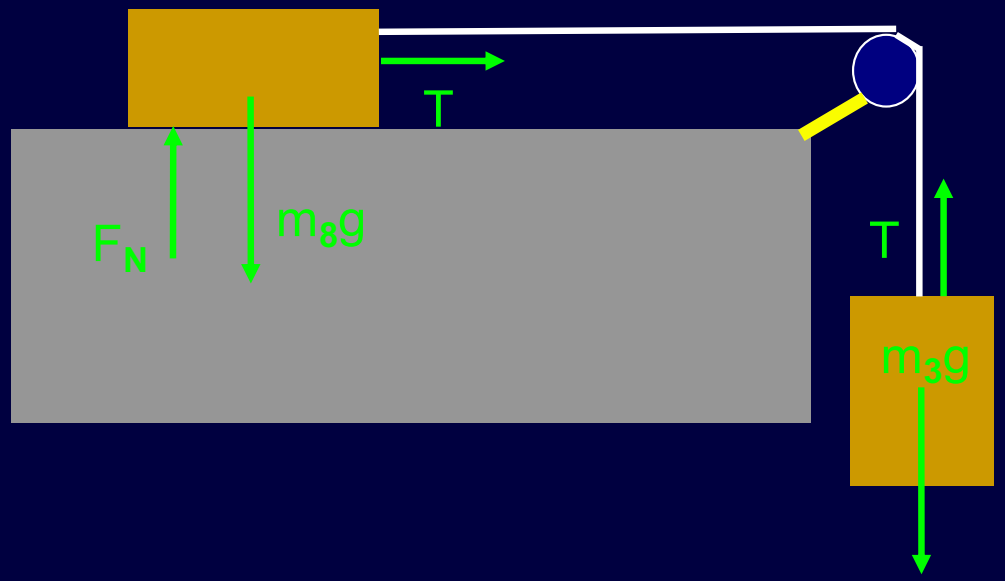
Example

Step 5: Apply Newton's Second law.



Example

Step 5: Apply Newton's Second law.



Clicker Question 6:

Assume two blocks are set up as below. There is no friction between the top block and the table. What is the tension in the rope?

a) 8.0 N
b) 13.4 N
c) 21.4 N
d) 29.37 N
e) 33.33 N