Physics 101

Prof. Ekey

Chapter 7

Newton's Third Law

(Interaction Pairs, Ropes, Pulleys)

"In this chapter, you will use Newton's III Law to understand how objects interact."

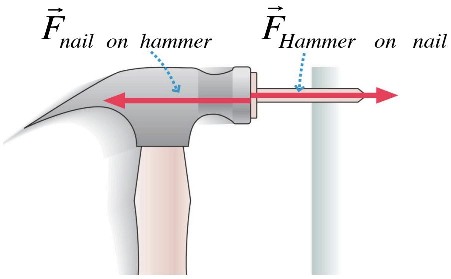
Question

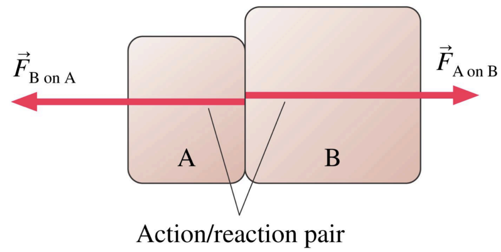
If you push on a friend who is moving away from you, how will the force you exert on your friend compare to the force your friend exerts on you?

(a) You push harder
(b) Your friend pushes harder
(c) The forces are equal in magnitude
(d) I hope my friend realizes that I pushed in the name of science.

Interacting Objects

Interaction – mutual influence of two objects on each other.
Action/Reaction Pair – Force from object A on object B is paired with the force of object B on object A.





You always have an action/reaction pair.
We've just worried about one of the objects so far… not anymore.

System: Objects motion that is to be analyzed - You choose size
Environment: Objects external to the system (gravity, strings… etc)
Requires multiple force-diagrams, and multiple net force equations

Newton's third law: Action/Reaction

"For every action (force) there is an equal and opposite reaction (force)."

"Every force occurs as one member of an action/reaction pair of forces."
- The two members of an action/reaction pair act on two *different* objects
- The two members of an action reaction pair are equal in magnitude, but opposite in direction: $\vec{F}_{A\ on\ B} = -\vec{F}_{B\ on\ A}$ Newton III Law Pairs

Note: A and B do not have to have the same mass/acceleration.

Earth versus rock. A 1.0 kg rock is dropped on earth.

What is the force of gravity on the ball from the earth? Acceleration?

What is the force on the earth from the ball?

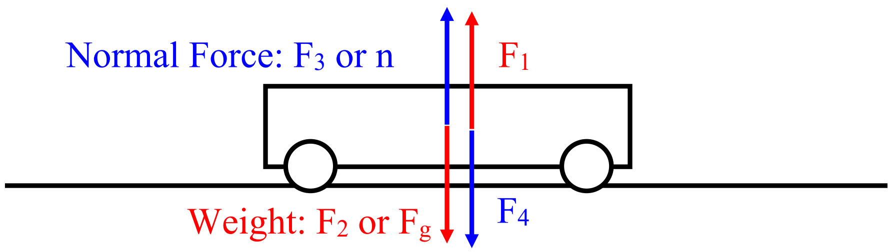
If the mass of the earth is 6.0×10^{24} kg, what is the earth's acceleration?

Horizontal Ramp, again.

Consider a cart on a horizontal ramp and the following four forces:

1. On earth due to gravity from the cart
2. On the cart due to gravity from the earth
3. On the cart due to support from the table
4. On the table due to support from the cart

Third Law Pairs
Forces 1 and 2
Forces 3 and 4
(Equal and opposite)

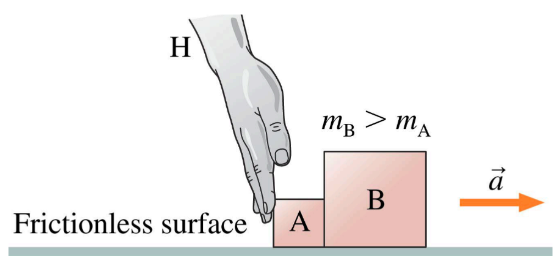


Action-Reaction forces (NIII law pairs) do not act on the same object.
2nd law concerned with forces acting on a particular object.

Forces 2 and 3 are the only force acting on the cart.
They are not a third law pair.
Are the normal force and gravitational force action/reaction pairs?

Two Blocks.

Two blocks with masses m_A=5.0 kg and m_B = 10.0 kg are pushed on a frictionless surface with a force of 15.0 N as shown.



Draw a force diagram for the hand, block A and block B.
What are the third law pairs?

Are the accelerations of the blocks the same?

Write expressions for the net force on A and B.

Determine the net acceleration of the system.

Determine the force (mag & dir) of mass A on mass B

Propulsion with a rock.

Stuck in the middle of a frozen lake with a surface so slippery you (100 kg) cannot walk ($\mu_k=\mu_s=0$). You have a 1.0 kg rock that you can throw with a velocity of 10 m/s in 0.10 seconds.

What is the acceleration of the rock? Force on the rock?

What happens to you after the throw? Explain.

What is your acceleration and final velocity?

Question

A mosquito hits the windshield of a truck, while the truck is traveling at 50 mph. Needless to say, the bug gets squashed. From this condition we can say that

(a) the magnitude of the force of the mosquito on the truck is equal to force of the truck on the mosquito.

(b) the magnitude of the force of the mosquito on the truck is larger than the force of the truck on the mosquito.

(c) the magnitude of the force of the mosquito on the truck is smaller than the force of the truck on the mosquito.

(d) not enough information given.

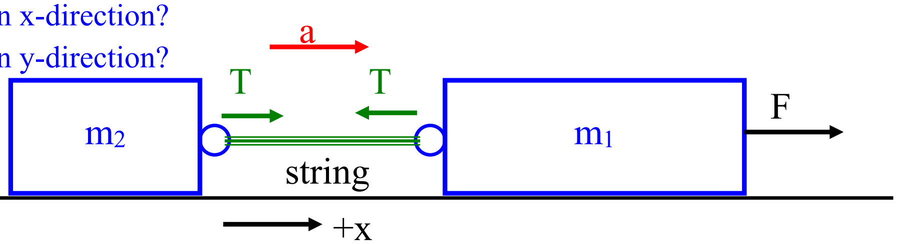
Differences between mosquito and truck?

Strings and Tension

Two blocks with masses m_1=10 kg and m_2 = 5.0 kg are pulled on a frictionless surface with a force of 15.0 N.

Net force in x-direction?

Net force in y-direction?



What is the magnitude of the acceleration in the system?

Tension in a negligible mass string is the same throughout. (equally stretched)

Tension points in opposite directions on either end of the string.

What is magnitude of the tension force (T) in the string?

Look at net force on m_2 or on m_1

Blocks, Strings and Pulleys

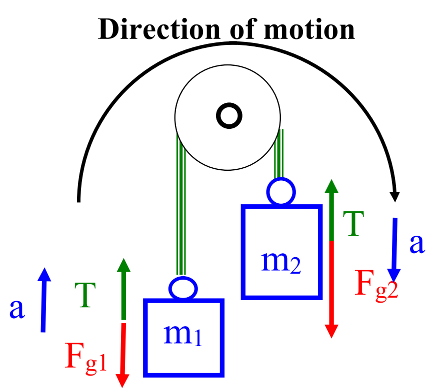
Atwood's machine

Pulleys and strings can change the direction of forces via the tension in the string. Axis (+/-) direction follows the direction of motion.

Two masse, m_1 = 2.0 kg and m_2 = 3.0 kg are connected by a string, which is hung over a pulley, as shown. If you let go of the system, what is the net acceleration of the system and tension in the string?

The motion of m_1 and m_2 are coupled to one another by the tension in the string

Net force on m_1



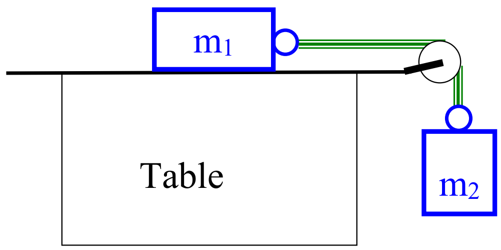
Net force on m_2

Add both equations together to get rid of T then solve for a.

Use your result for a to find T

Block, string, pulley, table

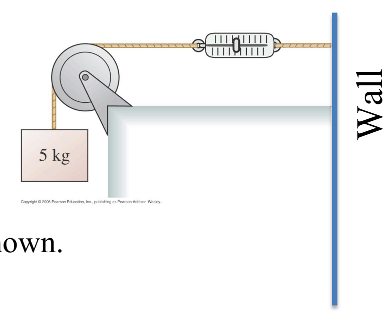
A mass (m_1 = 10 kg) sits on a slippery tabletop and is connected by a string over a pulley to another mass (m_2 = 20 kg). If the mass is released, what is the net acceleration of the system?



Draw in the forces acting on the system
Two ways to do this:
Method I: Find net force on system
Method II: Find net force on both masses

How do you find Tension? What if this was on an incline? What if there was friction?

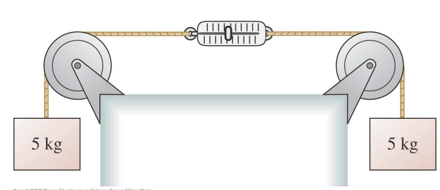
Questions



One end of a spring scale is connected to a wall with a massless string, and with another massless string over a frictionless pulley to a 5 kg mass as shown. What is the reading on the scale?

(a) 10 kg
(b) 5 kg
(c) 0 kg
(d) Disco

Two masses are at rest connected with a massless string over frictionless pulleys, as shown. What is the reading on the spring scale?



(a) 10 kg
(b) 5 kg
(c) 0 kg
(d) Drums