Unit Two - Chapter Three - Forces

Recap

Newton's 1st Law - objects in motion want to stay in motion, objects at rest want to stay at rest (also known as Galileo's Inertia Law)

$F_{Net} = 0$ for objects at REST or moving at a CONSTANT Velocity (both cases have an acceleration of zero)

Newton's 2nd Law - Force equals mass times acceleration (Fnet = m x a)

Learning Goal: By the end of today, I will be able to explain Newton's third law of motion (for every action there is an equal and opposite reaction).

Section 3.4 - Newton's Third Law of Motion

Action and Reaction Forces

When I sit at my desk in the chair with rollers and push on the desk, what happens?

Does the desk push back on me?

Newton's Third Law of Motion

For every action force, there is a simultaneous reaction force that is equal in magnitude, but opposite in direction.

"For every action, there is an equal and opposite reaction"
(but they don't act on the same object)

So if I push on the wall, and the wall is pushing back on me, why don't the forces cancel each other out?

Although the forces are equal in magnitude, the forces are acting on different objects

Interval vs External Forces

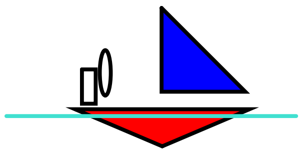
When we discuss situations in physics, we regularly have to talk about systems or reference frames.

For example if you were sitting inside a car and you pushed on the dashboard.

If we viewed the reference frame as being the interior of the car, the dashboard and you are different objects and can affect each other with forces. (external force) Your push on the dashboard will move you and your seat backwards.

If we viewed the system as the entire car, you pushing on the dashboard will not make it move any differently because the forces are within the object (car). (internal force)

A common example of the misunderstanding of internal and external forces can be seen when a fan is placed in the back of a sailboat.



Forces - Success Criteria

1. Draw a FBD, choose your positive directions

2. Write an F_{net} equation based on the DIAGRAM

3. Substitute values and F=ma into the F_{net} equation

Tutorial 2 Using Newton's Third Law in Calculations

In the following Sample Problem, we will clarify Newton's third law and demonstrate how it can be used to explain motion when objects exert forces on each other.

(Pause and Try)

Sample Problem 1: One Skater Pushing on Another

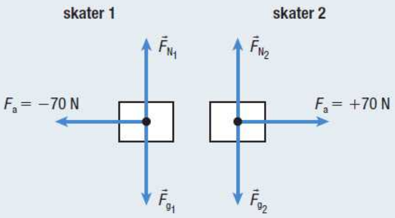
Two skaters are standing on ice facing each other (**Figure 5**). Skater 1 pushes on skater 2 with a force of 70 N [E]. Assume that no friction acts on either skater. The mass of skater 1 is 50 kg and the mass of skater 2 is 70 kg.

(a) State the action and reaction forces.
(b) Draw the FBD of each skater.
(c) Describe what will happen to each skater.
(d) Calculate the acceleration of each skater.

Solution

(a) The action force is skater 1 pushing with 70 N [E] on skater 2. The reaction force is skater 2 pushing with 70 N [W] on skater 1.

(b) Choose east as positive. So west is negative.



(c) Skater 1 will accelerate west and skater 2 will accelerate east.

(d) For each skater, the normal force and the force of gravity cancel. This means that the applied force is equal to the net force. For skater 1,

$$\vec{F}_{net} = \vec{F}_a$$
$$m_1a_1 = -70 \text{ N}$$
$$(50 \text{ kg})a_1 = -70 \text{ N}$$
$$a_1 = -1.4 \text{ m/s}^2$$

1. Draw a FBD, choose your positive directions
2. Write an F_{net} equation based on the DIAGRAM
3. Substitute values and F=ma into the F_{net} equation

The acceleration of skater 1 is 1.4 m/s^2 [W].

Similarly, for skater 2,

$$\vec{F}_{net} = \vec{F}_a$$
$$m_2a_2 = +70 \text{ N}$$
$$(70 \text{ kg})a_2 = 70 \text{ N}$$
$$a_2 = +1.0 \text{ m/s}^2$$

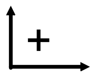
The acceleration of skater 2 is 1.0 m/s^2 [E].

Notice that the two skaters accelerate in opposite directions and with different accelerations. The accelerations do not have the same magnitude because the skaters' masses are different.

Practice

(Pause and Try)

1. Given the action force, describe the reaction force for each situation. K/U C
   (a) You push forward on a book with 5.2 N.
   (b) A boat exerts a force of 450 N [W] on the water.
   (c) A hockey player hits the boards with a force of 180 N [toward the boards].
2. Nobel and Maaham are wearing inline skates. Nobel has a mass of 62 kg and pushes on Maaham, whose mass is 54 kg. Maaham accelerates at 1.2 m/s^2 [left]. Assume that no friction acts on either person. T/I
   (a) Determine the force that Nobel exerts on Maaham.
   (b) Determine Nobel's acceleration.



Maaham
54kg

Nobel
62kg

1. Draw a FBD, choose your positive directions
2. Write an F_{net} equation based on the DIAGRAM
3. Substitute values and F=ma into the F_{net} equation

Section 3.4
#1,4,5,6,7

3.4 Questions

1. Given each action force, state the reaction force.
   (a) A tire pushes on the road with a force of 240 N [backwards].
   (b) You pull on a desk with a force of 25 N [N].
2. Explain each event below in terms of Newton's third law.
   (a) A squid moves through the water by taking in water and expelling it.
   (b) Walking on a wagon is dangerous.
   (c) A helicopter can hover above the ground.
3. During a space walk, an astronaut notices that her tether is not attached and she is drifting away from the space station. Explain each statement below using Newton's third law.
   (a) She can pull herself back to the space station if she can reach the space station and pull on it.
   (b) She cannot push herself back to the station by pulling forward on her space suit.
   (c) She can get back to the space station even if she cannot reach it if she is holding a tool.
4. **Figure 6** shows a photograph of an early naval cannon tied to a ship. Explain why the ropes are necessary.

Figure 6

5. **Figure 7** shows a fan cart.
   (a) Explain why the fan cart cannot accelerate.
   (b) Explain why the fan cart can accelerate if the rigid sail is removed.

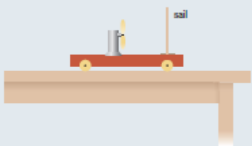


Figure 7

6. A toy car (200 g) moves by shooting a plastic ball (50 g) horizontally out the back. The average acceleration of the car is 1.2 m/s^2 [E] and there is negligible friction acting on each part of the toy.
   (a) Draw an FBD for each object.
   (b) Identify the action and reaction forces on each part of the toy.
7. Two figure skaters are moving east together during a performance. Skater 1 (78 kg) is behind skater 2 (56 kg) when skater 2 pushes on skater 1 with a force of 64 N [W]. Assume that no friction acts on either skater.
   (a) Determine the acceleration of each skater.
   (b) What will happen to the motion of each skater? Explain your reasoning.
8. A milk carton filled with water is hanging from a string (**Figure 8**). What will happen if you punch two holes in opposite sides of the carton at the opposite corners? Explain your reasoning.

Figure 8

9. A male astronaut (82 kg) and a female astronaut (64 kg) are floating side by side in space.
   (a) Determine the acceleration of each astronaut if the woman pushes on the man with a force of 16 N [left].
   (b) How will your answers change if the man pushes with 16 N [right] on the woman instead?
   (c) How will your answers change if they both reach out and push on each other's shoulders with a force of 16 N?