Net Forces

Overview: The net force (F_{net}) is when you add up all of the forces on something and see what direction the overall force pushes in. The word "net," in this case, is like net worth or net income. It's a mathematical concept of what is left after everything that applies is added and subtracted.

What to Learn: Today you get to learn how unbalanced forces cause changes in velocity.

Materials

- rope (about 3 feet long)
- friend
- sense of caution (Be careful with this. Don't pull too hard and please don't let go of the rope. This is fun but you can get hurt if you get silly.)

Lab Time

1. Both you and your friend grab either end of the rope. Pull it back just enough to get the rope off the ground. (scenario 1)
2. Have your friend pull harder than you are. (scenario 2)
3. You pull harder than your friend is. (scenario 3)
4. Both of you pull the rope, and try to pull with the same force. (scenario 4)
5. For scenario 1, draw a free body diagram below (the rope is your object, you are on the left, and your friend is on the right)

Reading

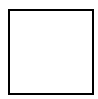
It is not very common for only one force to be acting on an object at one given time. In fact, at almost all times, there are two forces acting on you! We know that gravity is always acting on us, pulling us down towards the center of the Earth (the reason we don't fly off into space). But if gravity was the only force acting on us, we would be constantly falling towards the center of the Earth.

If we aren't always falling towards the center of the Earth, what is stopping us? Of course, it is the chair you are sitting on, or the ground you are standing on. The reason we know there is a force is, simply put: We are NOT falling towards the center of the Earth (I know, seems a little simple, right?). There is also a way to figure out exactly how much force the chair or ground exerts on us. We already know how to calculate to force of gravity ($F_G = mg$), If we are sitting or standing still, then we know the force the chair/ground exerts has to be the exact same amount as the gravity acting on us. The only difference is that gravity pulls us towards the center of the earth, while the force of the chair/ground pushes us away from the center of the earth.

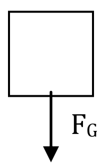
This is how we know Newton's Third Law of Motion. For every action, there is an ***equal*** and ***opposite*** reaction. In this case, for the force of gravity pulling us down there is an ***equal*** force pushing us in the ***opposite*** direction. This force is called a normal force, because it is the normal reaction to gravity.

What this leads us to is what is known as net force. Net is a term commonly used in mathematics and finance as a smart way to say "total." It is the total force acting on an object at any given point in time. Typically, you can draw the object and draw the forces pulling on the object at any given time. Don't worry, you don't have to be a great artist. In fact, to keep things simple and consistent, we always draw the object as a simple box. And we draw the forces acting on the box as an arrow, coming out from the object NOT into the object. If any forces push/pull the object down, we draw it coming out of the bottom of the box, anything pulling the object up coming out from the top of the box. The size of the arrow makes a difference, too. The bigger the force, the bigger the arrow. Let's look at how we would draw our example of you standing on the floor below.

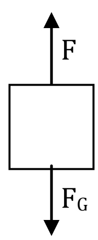
First, draw your object (remember, just a simple box)



Next, draw the first force (usually gravity, because it's always there!) Don't forget to label the force. When you get to 4 or 5 forces, labels help you remember what is what!



Now draw the second force (In this case our normal force). The magnitude of the force is the same, so the arrow should be the same size, but the direction is the opposite of the force of gravity



Our drawing makes it easy to see that there are 2 forces acting on the object, they are equal in magnitude and opposite in direction, so there is a net force of zero acting on our object. We know right away that our object is either not moving, or moving, but at a constant speed, so not accelerating.

We could add numbers to our diagram as well to mathematically calculate to Net Force acting on our object. To calculate the Net Force, we simply add up all of the forces (only add y-axis forces, or x-axis forces together, not an x force and a y force) or:

$F_{NET} = F_1 + F_2 + F_3....$

Let's say the force of gravity acting on our object is 100 N, and the normal force is also 100 N. If we add up our force to get our net force, we would get 200 N.

$F_{NET} = F_G + F_N$
$F_{NET} = 100\ N + 100\ N$
$F_{NET} = 200\ N$

That doesn't seem right, because we know the net force is 0 N. Because the forces are vectors, we have to consider direction. When they move in opposite directions, one of them has to be negative. Typically, the downward and leftward forces are negative, and the upward and rightward forces are positive. This isn't a rule, but an easy way to keep it consistent. So now if we add up the forces:

$F_{NET} = F_G + F_N$
$F_{NET} = -100\text{ N} + 100\text{ N}$
$F_{NET} = 0\text{ N}$

We get zero for the net force, just like we already knew it should be.

Exercises:

1. For scenario 1, in which direction did you both move? Draw the free body diagram below

2. For scenario 2, in which direction did you both move? Draw the free body diagram below

3. For scenario 3, in which direction did you both move? Draw the free body diagram below

4. For scenario 4, in which direction did the rope move? Draw the free body diagram below

5. What was the same about question 1 and question 4? What was different?

6. Even though the forces were less in question 1 than question 4, what was the net force for both?

7. There were always at least 3 forces acting on the rope, what were they? Did you include the third force in your free body diagram?

8. If the rope wasn't moving, but you had only one force moving down, what does that tell you about the force you and your friend exerted?

Net Forces Data Table

Calculations: Assume the light force (when you picked up the rope, or pulled less than your friend was 10 N. Assume the Stronger Force (when your friend pulled harder, or your pulled harder or you both pulled hard) was 75 N. If we ignore amount that counteracted gravity and assume they were both in the x-axis direction, fill in the table below. Don't forget to consider direction.

Scenario	**Your Force**	**Your friend's Force**	**Net Force**
1	*-10 N*	*10 N*	
2	*-10 N*	*75 N*	
3	*-75 N*	*10 N*	
4	*-75 N*	*75 N*	

Answers to Exercises: Net Forces

1. For scenario 1, draw a free body diagram below (the rope is your object, you are on the left, and your friend is on the right)
2. For scenario 2, in which direction did you both move? Draw the free body diagram below (Right)
3. For scenario 3, in which direction did you both move? Draw the free body diagram below (left)
4. For scenario 4, in which direction did the rope move? Draw the free body diagram below (Didn't move)
5. What was the same about question 1 and question 4? What was different? (The rope didn't move. Question 1 had small forces, Question 4 had large forces)
6. Even though the forces were less in question 1 than question 4, what was the net force for both? (Net force was zero in both cases.)
7. There were always at least 3 forces acting on the rope, what were they? Did you include the third force in your free body diagram? (2 applied forces and gravity)
8. If the rope wasn't moving, but you had only one force moving down, what does that tell you about the force you and your friend exerted? (They had to have some portion of the force that was pulling up.)