



Computing the Net Force

Review: One way to start a class dialog on “force” is to ask students to give examples from their own experience of a “force”. Responses might include a “hit” or some sort of forceful contact; others might be more group-oriented, like the “Air Force”; another possibility is “The Force” from the Star Wars movies. There are very few wrong answers to this question, and some reflection on their own experiences often helps students when they try to grasp the slightly more formal definition below.

A force is defined in its simplest sense as a “push” or a “pull”. These definitions do not imply a direction. Students can “pull” in any direction as they can “push” in any direction! The terms are frequently used because students can readily identify with the actions of pushing and pulling, and the fact that these actions usually have an effect on what they are pushing or pulling.

Review with students that there are two parts to the definition of a force. In fact, when a force is defined it must have both parts - one is not enough! The two parts are: magnitude (a quantity that can be measured) and direction. The direction of a force is self-explanatory, and again, has nothing to do with the terms “push” or “pull”.

The magnitude of a force can be described as “how hard the force is”, or “how much power the force has”. For example, a force of magnitude 10 can be described as a “stronger” force than one of magnitude 2, which can be described as a “weaker” force.

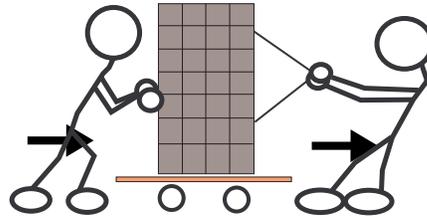
Special note: When working with this lesson, it is very important that students learn to draw accurate pictures of the events described!

Background: When two forces act in parallel, in either the same or opposite direction, measuring them is simply a matter of adding or subtracting their magnitudes. When two forces are acting in parallel and in the same direction, measure them by adding the magnitudes together.



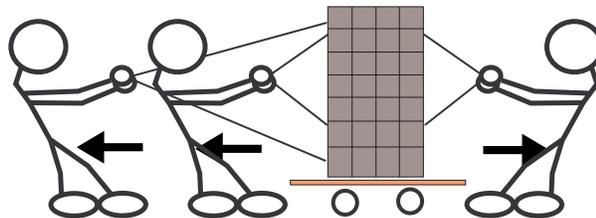
In the example below, a “push” of magnitude 1 added to a “pull” of magnitude 1 equals a net force of magnitude 2. The cart will then move in the direction of the greatest magnitude - in this case to the right.

Push 1 + Pull 1 = Net Force 2 to the right



When two forces act in parallel in the opposite direction, measure them by subtracting the magnitudes. In the example below, a pull of magnitude 1 is acting opposite to a pull of magnitude 2. The cart will move in whichever direction has the greatest magnitude. In this case the cart will move to the left.

Push 2 - Pull 1 = Net Force 1 to the left



You may want to walk the students through a similar process using ropes or string and students of equal size to demonstrate the concept.

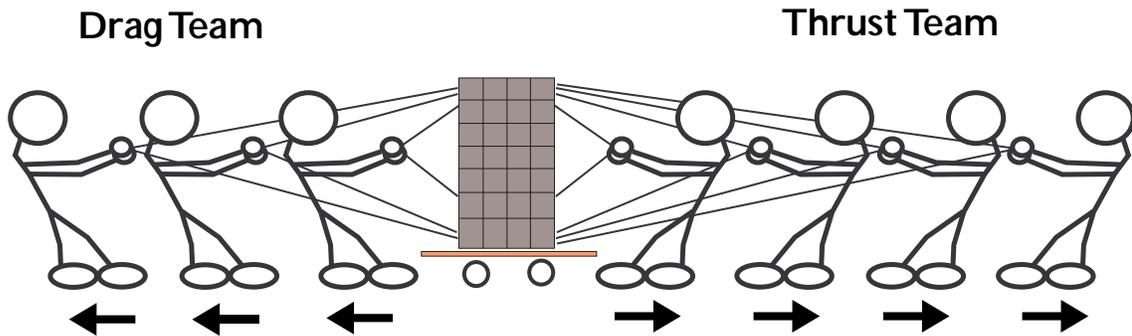
Forces that act in opposite directions are called “oppositional” forces. Four of the forces in aeronautics (lift, drag, weight, and thrust) can be thought of as “oppositional” pairs.

thrust acts in a direction opposite to drag

lift acts in a direction opposite to weight



The oppositional forces can be introduced as a game of tug-of-war. Teams can be named as the four forces. For example, a tug-of-war can be set up between a “thrust” team and a “drag” team.



In the above graphic, the “Thrust Team” has a magnitude of 4 and the “Drag Team” has a magnitude of 3. The net force will be

$$\text{Thrust } 4 - \text{Drag } 3 = \text{Net Force } 1 \text{ to the right}$$

Since the “Thrust Team” has the greater magnitude, the cart will move in the direction that the “Thrust Team” is pulling, in this case to the right.



Worksheet

Question 1: Define the word "force".

Question 2: Complete the sentences below by filling in the blanks.

A force can move in different _____.

A force has "strength" or _____ that can be _____.

Parallel forces can be added or _____.

Question 3: An F-14 is flying west. Its engines are creating a thrust force of magnitude 4,000. A strong headwind is blowing to the east creating a drag force on the F-14 of magnitude 1,000.

What is the net force on the F-14? _____

In what direction will the F-14 fly? _____

Draw a picture of this event. Make sure you include the F-14, the wind, arrows to represent the magnitudes, and the equation that gives the net force. Draw one arrow for each 1,000 units of magnitude.

Question 4: After the Space Shuttle is launched, its huge rocket engines lift it upward with incredible force. As it blasts through the top of the atmosphere into outer space, the engines are creating a force pushing up into space with a magnitude of 6 times the force of gravity. We write this as "6g".

The gravity force is pulling the Shuttle back down in the direction of the earth with a magnitude of 1 times the force of gravity. We write this as "1g".

What is the net force on the Space Shuttle? _____

Draw a picture of this event to help you answer the question. Be sure



to include the Shuttle, the Earth, arrows to represent which direction the engines and the earth are pulling, and the equation that gives the net force. Draw one arrow for each g.

Question 5: Four people are pulling on ropes attached to a cart. Each person is pulling with a magnitude of 1. Two people are pulling to the right and two people are pulling to the left.

What is the magnitude of the net force? _____

In which direction will the cart move? _____

Draw a picture of this event to help you answer the questions. Be sure to include the cart, the people, arrows to represent the directions that the people are pulling, and the equation that gives the net force. Draw one arrow for each unit of magnitude.



Worksheet Key

Question 1: *A force is a "push" or a "pull". It has two parts: magnitude and direction.*

Question 2: *directions
magnitude, measured
subtracted*

Question 3: *3,000
West
thrust 4,000 - drag 1,000 = net force 3,000 in the direction of thrust*

Question 4: *5g
up 6g - down 1g = net force 5g in up direction or
lift 6g - weight 1g = net force 5g in direction of lift*

Question 5: *0
neither
pull 1 - pull 1 = net force 0*