Chapter 3: Newton's Laws of Motion

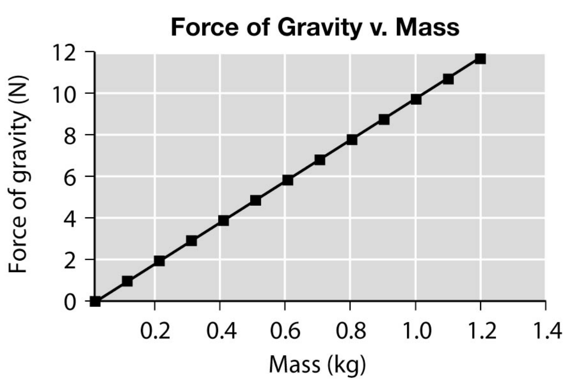
Mini Investigation: Predicting Forces, page 113

Answers may vary. Sample answers:
A. I predicted the reading in question 3 would be the sum of the readings from questions 1 and 2, and that the reading in question 4 would be half the reading from question 2. My predictions were accurate.
To make the results more accurate, the experiment should be performed in a vacuum. The object should be suspended above a table by the same distance for both the spring sensor and my arm. Ideally, my arm should be held up by a sling or other device so that the force I use to hold up the spring will be pretty much the same each time I suspend the object.
B. Forces such as gravity act upon all objects in the same way. Each force exerted on an object should have an equal but opposite force exerted on an object. For example, if I use 1 N of force to hold up an object, then there should be 1 N of gravitational force pulling the object down.

Section 3.1 Types of Forces

Mini Investigation: Measuring the Force of Gravity, page 116

Answers may vary. Sample answers:
A.



B. The slope of the line of best fit is 0.98. The slope represents the rate of change of gravity on objects of different masses. The heavier the objects are, the stronger the force of gravity is.

C. i. F_g = (0.30 kg)(9.8 m/s)

= 2.9 N

The force of gravity is 2.9 N.

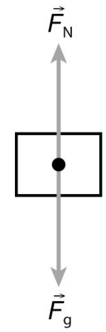
ii. F_g = (0.50 kg)(9.8 m/s)

= 4.7 N

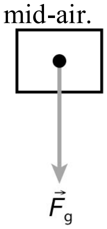
The force of gravity is 4.7 N.
D. To find the force of gravity on an object, multiply the mass of the object, in kilograms, by 9.8 m/s^2.

Tutorial 1 Practice, page 119

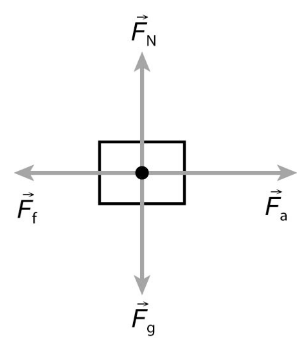
1. (a) System diagrams may vary. Students should draw a book on a flat surface.



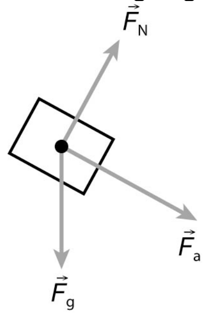
(b) System diagrams may vary. Students should draw a basketball in mid-air.



(c) System diagrams may vary. Students should draw a large trunk being pushed directly east along a floor.



2. The normal force is exerted by the surface of the ramp that is in contact with the sliding block. So, the arrow representing F_N should be perpendicular to the base of the block and going up to the right.

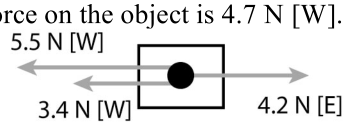


Tutorial 2 Practice, page 120

1. (a) Choose east as positive. So, west is negative.

$$\begin{aligned} F_{net} &= -5.5\text{ N} + (-3.4\text{ N}) + 4.2\text{ N} \\ &= -4.7\text{ N} \end{aligned}$$

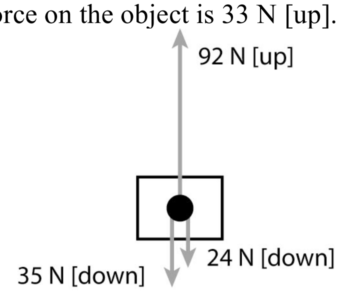
The net force on the object is 4.7 N [W].



(b) Choose up as positive. So, down is negative.

$$\begin{aligned} F_{net} &= +92\text{ N} + (-35\text{ N}) + (-24\text{ N}) \\ &= +33\text{ N} \end{aligned}$$

The net force on the object is 33 N [up].



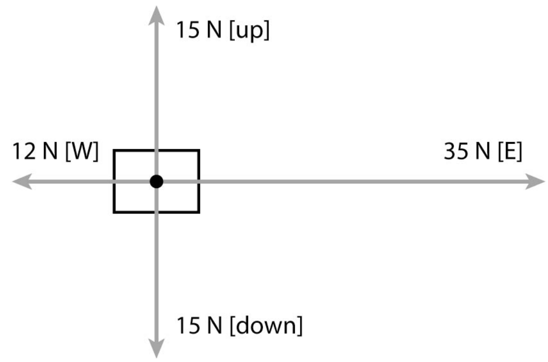
(c) Choose up and east as positive. So, down and west are negative. Define east and west forces as being along the x-axis. So, up and down forces are along the y-axis.

$$\begin{aligned} (F_{net})_x &= +35\text{ N} + (-12\text{ N}) \\ &= +23\text{ N} \end{aligned}$$

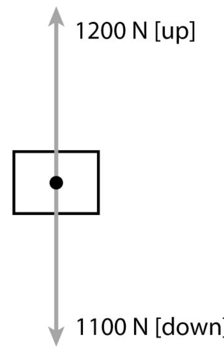
The net force on the x-axis is 23 N.

$$\begin{aligned} (F_{net})_y &= +15\text{ N} + (-15\text{ N}) \\ &= 0\text{ N} \end{aligned}$$

The net force on the y-axis is 0 N.
Therefore, the net force on the object is 23 N [E].



2.

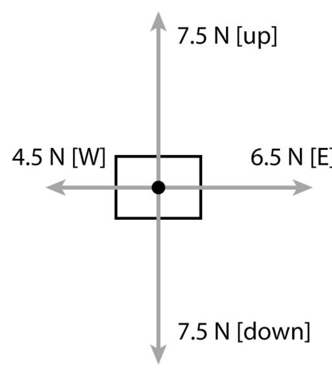


Choose up as positive. So, down is negative.

$$\begin{aligned} F_{net} &= +1200\text{ N} + (-1100\text{ N}) \\ &= +100\text{ N} \end{aligned}$$

The net force on the beam is 100 N [up].

3.



Choose up and east as positive. So, down and west are negative. Define east and west forces as being along the x-axis. So, up and down forces are along the y-axis.

$$\begin{aligned} (F_{net})_x &= +6.5\text{ N} + (-4.5\text{ N}) \\ &= +2.0\text{ N} \end{aligned}$$

The net force on the x-axis is 2.0 N.

$$\begin{aligned} (F_{net})_y &= +7.5\text{ N} + (-7.5\text{ N}) \\ &= 0\text{ N} \end{aligned}$$

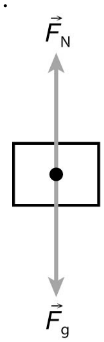
The net force on the y-axis is 0 N.
Therefore, the net force on the book is 2.0 N [E].

Section 3.1 Questions, page 122

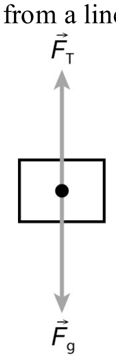
1. (a) The applied force is in the north direction.
(b) The applied force is in the south direction.
2. (a) The force of gravity causes the ball to fall toward the ground.
(b) The force of gravity pulls the person down toward the elevator floor. The tension in the rope of the elevator pulls the elevator up with a force greater than the force of gravity.
(c) The driver applies a force on the brakes. The brakes cause the car to slow down. The road exerts a force of friction on the wheels to stop the car.
3. If the force sensor is not set to zero before performing an investigation (when there is no force acting), the readings for the force changes will not be accurate. For example, when the net force is zero, the sensor will show a non-zero reading.
4. Answers may vary. Sample answer:

Force	Direction
force of gravity	downward
normal force	perpendicular from surface of contact
applied force	same direction as push or pull
friction	opposite to motion
tension	pulls object toward rope or string

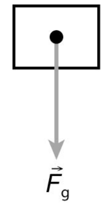
5. (a) System diagrams may vary. Students should draw a stationary car.



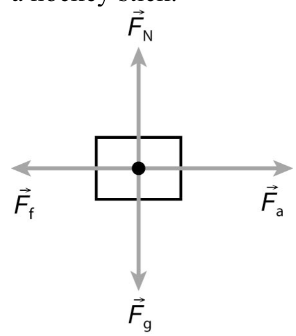
(b) System diagrams may vary. Students should draw a fish hanging from a line.



(c) System diagrams may vary. Students should draw a football in mid-air.



(d) System diagrams may vary. Students should draw a puck being pushed along an ice surface by a hockey stick.



6. Answers may vary. Students' posters could use charts or concept maps and should include at least two system diagrams and the corresponding FBDs. Posters can focus on one common everyday force or all five (applied force, tension, normal force, friction, and gravity), with an example of each. For example, holding a book shows the two vertical forces. Two children pushing and pulling a wagon (Figure 4 on page 115) shows how all five forces act on the same object.

7. (a) Given: m = 2.0 kg; $\vec{g}$ = 9.8 m/s^2 [down]

Required: $\vec{F}_g$

Analysis: $\vec{F}_g = m\vec{g}$

Solution:

$$\begin{aligned}\vec{F}_g &= m\vec{g} \\ &= 2.0\text{ kg} \times 9.8\text{ m/s}^2\text{ [down]} \\ \vec{F}_g &= 20\text{ N [down]}\end{aligned}$$

Statement: The force of gravity acting on the object is 2.0 × 10 N [down].

(b) Given: m = 62 kg; $\vec{g}$ = 9.8 m/s^2 [down]

Required: $\vec{F}_g$

Analysis: $\vec{F}_g = m\vec{g}$

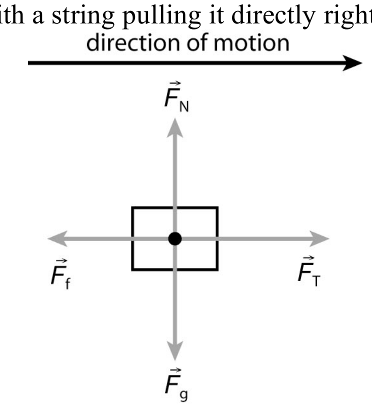
Solution:

$$\begin{aligned}\vec{F}_g &= m\vec{g} \\ &= 62\text{ kg} \times 9.8\text{ m/s}^2\text{ [down]} \\ \vec{F}_g &= 6.1 \times 10^2\text{ N [down]}\end{aligned}$$

Statement: The force of gravity acting on the person is 6.1×10^2 N [down].

8. Answers may vary. Sample answer:
The statement is not valid. A normal force is a perpendicular force exerted by a surface on an object in contact with the surface. This force always points away from the surface. However, an applied force may be exerted by an object or a person in all directions, and the force can point toward the surface that the object or person applying the force is in contact with. For example, when you use your hand to push on a box, the applied force points toward the box surface that is in contact with your hand, and the force may not be perpendicular to the box surface.

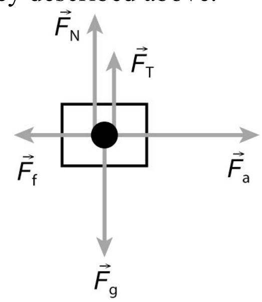
9. When you pull the cart with the string, the tension in the string applies a force that moves the cart forward. Since a string is not rigid, when you push the cart away with a string, it will sag and have no effect on the motion of the cart. As the FBD of the moving cart shows, the applied force, F_T, has to come from a pulled string but not a pushed string.
System diagrams may vary. Students should draw a cart with a string pulling it directly right.



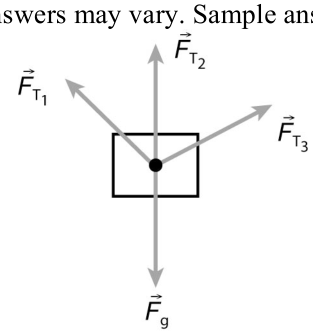
10. Contact forces, such as the normal force and the applied force, require an object to be in contact with another object. Forces that do not require contact, such as the force of gravity and the electromagnetic force, are action-at-a-distance forces. If only action-at-a-distance forces are acting on an object, then the FBD can only show the action-at-a-distance forces.

11. A system diagram tells you all the objects that are involved in a situation. It helps you determine which objects push or pull on other objects. A FBD shows all the forces acting on an object. It helps you determine the net force acting on the object.

12. Answers may vary. Sample answer:
Inflate the balloon. Tape the paperclip to the block of wood and use the elastic band to connect the block of wood to the balloon. Use the magnet to attract the paperclip and draw the wood to the end of the hall.
System diagrams may vary. Students should draw the system they described above.



13. The forces acting on the spider are the tension forces in the spider web strands and the force of gravity. Answers may vary. Sample answer:



14. (a) Answers may vary. Sample answer:
Since muscles are made of small fibres, they are not rigid. Like ropes and strings, they can only pull on an object, not push on an object. Therefore, muscles can only cause tension forces.
(b) Bones are rigid. Like other hard objects, they can push or pull on another object that they are in contact with, whereas muscles cannot push on an object with which they are in contact.

15. (a) Choose up as positive. So, down is negative.

$$F_{net} = +56\text{ N} + (-35\text{ N})$$
$$F_{net} = +21\text{ N}$$

The net force on the object is 21 N [up].
(b) Choose right as positive. So, left is negative.

$$F_{net} = +12.3\text{ N} + 14.4\text{ N} + (-32.7\text{ N})$$
$$F_{net} = -6.0\text{ N}$$

The net force on the object is 6.0 N [left].
(c) Choose up and east as positive. So, down and west are negative. Define east and west forces as being along the *x*-axis. So, up and down forces are along the *y*-axis.

$\left(F_{\text{net}}\right)_y = +45 \text{ N} + (-45 \text{ N})$

$\left(F_{\text{net}}\right)_y = 0 \text{ N}$

The net force on the y-axis is 0 N.

$\left(F_{\text{net}}\right)_x = -21 \text{ N} + 21 \text{ N}$

$\left(F_{\text{net}}\right)_x = 0 \text{ N}$

The net force on the x-axis is 0 N.
Therefore, the net force on the object is 0 N.

16. (a) The four fundamental forces from weakest to strongest are the gravitational force, the weak nuclear force, the electromagnetic force, and the strong nuclear force.

(b) Gravity differs from the other three fundamental forces in that is has the farthest reach but is weakest in actual magnitude. Its effect is insignificant on objects with small masses. This force only attracts objects.

(c) Friction and tension are not fundamental forces because they arise out of other forces.
Friction is not a fundamental force because it originates from the electromagnetic forces and exchange force between atoms. Tension is the result of gravity and electrostatic forces between molecules.