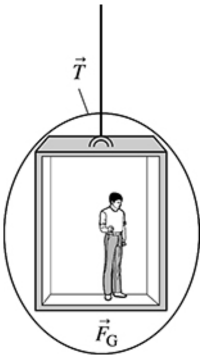
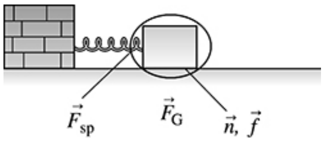
Chapter 5, Conceptual Questions

5.1.



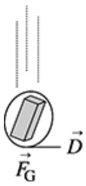
Two forces are present, tension $\vec{T}$ in the cable and gravitational force $\vec{F}_G$ as seen in the figure.

5.2.



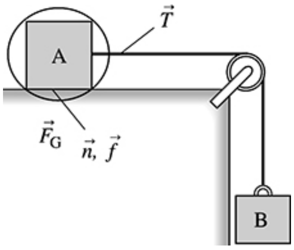
Four forces act on the block: the push of the spring $\vec{F}_{sp}$, gravitational force $\vec{F}_G$, a normal force from the table top $\vec{n}$, and a frictional force due to the rough table surface $\vec{f}$.

5.3.



Two forces act on the brick. Air resistance, or drag $\vec{D}$, may be present, and the noncontact force due to gravity $\vec{F}_G$.

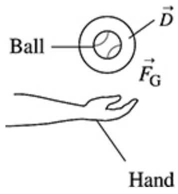
5.4. Four forces act on the block: the string tension $\vec{T}$, normal force $\vec{n}$ and friction $\vec{f}$ with the surface, and gravitational force $\vec{F}_G$.



5.5. **(a)** Two forces act on the ball after it leaves your hand: the long-range gravitational force $\vec{F}_G$ and the contact force of drag $\vec{D}$.

(b) $\vec{F}_G$ is due to an interaction between the ball and earth, so earth is the agent. Drag $\vec{D}$ is due to an interaction between the ball and the air, so the air is the agent.

Some students are tempted to list a force due to the hand acting on the ball. As can be seen in the figure, the hand is not touching the ball, and therefore it no longer applies a force to the ball.



5.6. **(a)** The object with the largest mass accelerates the slowest, since $a = \frac{F}{m}$. Thus B has the largest mass.

(b) The object with the smallest mass accelerates the fastest, so C has the smallest mass.
(c) Since the same force is applied to both blocks,

$$F_A = F_B \Rightarrow m_A a_A = m_B a_B \Rightarrow \frac{m_A}{m_B} = \frac{a_B}{a_A} = \frac{3}{5}$$

5.7. A force *F* causes an object of mass *m* to accelerate at $a = \frac{F}{m} = 10\ \text{m/s}^2$. Let a' be the new acceleration.

(a) If the force is doubled, $(2F) = ma' \Rightarrow a' = 2\left(\frac{F}{m}\right) = 2a = 20\ \text{m/s}^2$.

(b) Doubling the mass means that $F = (2m)a' \Rightarrow a' = \frac{1}{2}\left(\frac{F}{m}\right) = 5\ \text{m/s}^2$.

(c) If the force and mass are both doubled, then $(2F) = (2m)a' \Rightarrow a' = \frac{F}{m} = 10\ \text{m/s}^2$.

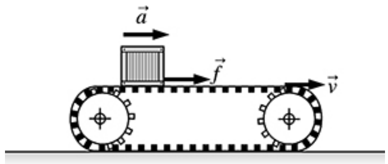
5.9. No. If an object is at rest its acceleration is zero, so you can only conclude that the net force is zero. Thus there may be several forces acting on the object.

5.10. Yes, as long as any other applied forces add to cancel the first force, so that the *net* force is zero.

5.11. False. An object will *accelerate* in the direction of the net force. Its initial velocity may be in any direction.

5.12. No. Newton's second law relates the applied net force $\vec{F}_{net}$ to the resulting change in motion $\vec{a}$. So the quantity $m\vec{a}$ is better understood as related to a change in motion. Note, however, that $m\vec{a}$ has units that are the same as force.

5.13.

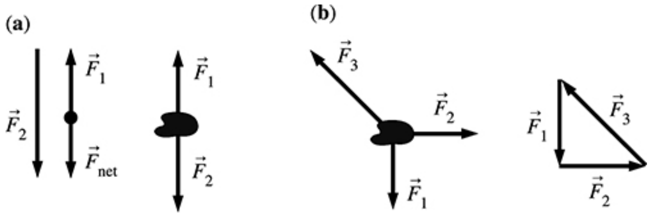


Yes, it is possible for the friction force on an object to be in the same direction as the object's motion. Consider the case shown in the figure, in which a box is dropped onto a moving conveyer belt. The box is pushed horizontally in the same direction as its motion. While an observer standing next to the conveyer belt sees the box move to the right and eventually reach a constant speed (same as the conveyer belt), an observer standing on the conveyer belt would see the box slide to the left and eventually come to a stop. The direction of the kinetic friction force is opposite to the relative direction of motion between the two adjacent surfaces. In the example above, the box is moving to the left in the reference frame of the conveyer belt, and as expected the kinetic friction force is to the right.

5.14. The friction force between two surfaces is parallel to the surfaces. Since the wall is vertical, the friction force is also vertical. To determine whether the static friction force is up or down, imagine that friction slowly disappears. You can imagine the book beginning to slide downwards as no vertical forces are left to counteract the gravitational force (the normal force is perpendicular to the surface, so is horizontal in this problem.) Thus static friction must be up to balance the gravitational force downward.

5.15. The ball follows path C as it emerges from the tube. The centripetal force keeping it moving in a circle within the tube is the normal force exerted by the tube wall on the ball. When that force is removed, the ball moves in a straight line in accordance with Newton's first law with the last velocity it had, which was tangential to the circle.

5.16.



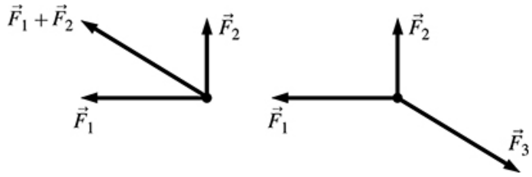
(a) Basketball A is not in equilibrium because $|\vec{F}_2| > |\vec{F}_1|$ and there is a net downward force on A.

(b) Basketball B is in equilibrium because the vector sum of the three forces $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$.

5.17. Only A and B are inertial reference frames because the car is at constant velocity in only those two cases.

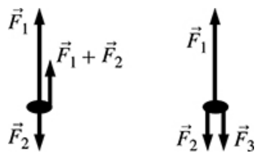
Chapter 5, Exercises and Problems

5.18. **Visualize:**



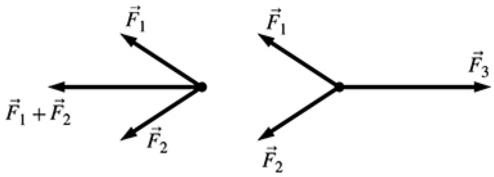
Solve: The object will be in equilibrium if $\vec{F}_3$ has the same magnitude as $\vec{F}_1 + \vec{F}_2$ but is in the opposite direction so that the sum of all the three forces is zero.

5.19. **Visualize:**



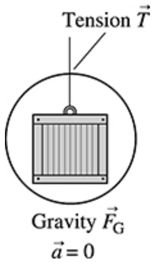
Solve: The object will be in equilibrium if $\vec{F}_3$ has the same magnitude as $\vec{F}_1 + \vec{F}_2$ but is in the opposite direction so that the sum of all three forces is zero.

5.20. **Visualize:**



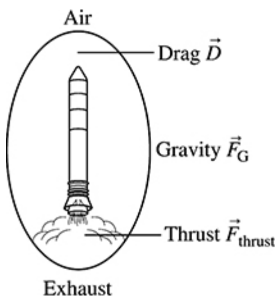
Solve: The object will be in equilibrium if $\vec{F}_3$ has the same magnitude as $\vec{F}_1 + \vec{F}_2$ but is in the opposite direction so that the sum of all the three forces is zero.

5.21. **Visualize:**



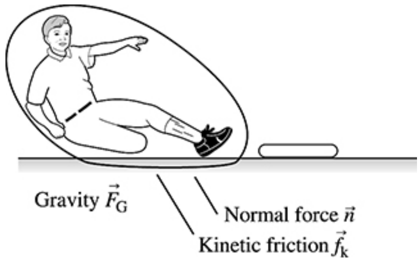
Solve: The free-body diagram shows two equal and opposite forces such that the net force is zero. The force directed down is labeled as a gravitational force, and the force directed up is labeled as a tension. With zero net force the acceleration is zero. So, a possible description is: "An object hangs from a rope and is at rest." Or, "An object hanging from a rope is moving up or down with a constant speed."

5.22. **Visualize:**



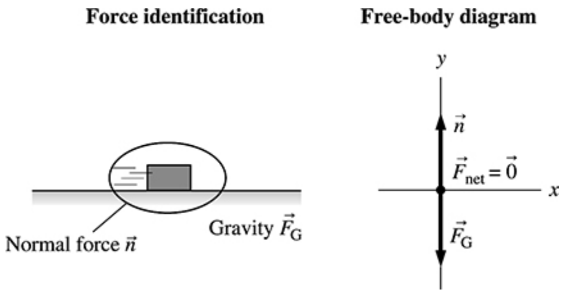
Solve: The free-body diagram shows three forces with a net force (and therefore net acceleration) upward. There is a force labeled $\vec{F}_G$ directed down, a force $\vec{F}_{thrust}$ directed up, and a force $\vec{D}$ directed down. So a possible description is: "A rocket accelerates upward."

5.23. Visualize:



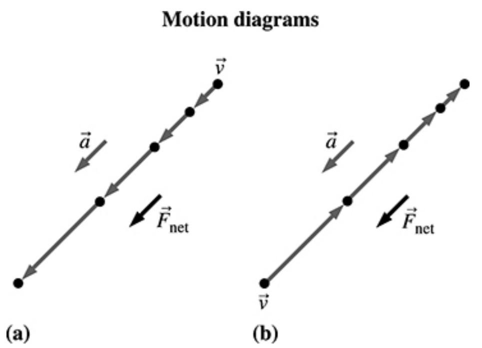
Solve: The free-body diagram shows three forces. There is a gravitational force $\vec{F}_G$, which is down. There is a normal force labeled $\vec{n}$, which is up. The forces $\vec{F}_G$ and $\vec{n}$ are shown with vectors of the same length so they are equal in magnitude and the net vertical force is zero. So we have an object on the ground which is not moving vertically. There is also a force $\vec{f}_k$ to the left. This must be a frictional force and we need to decide whether it is static or kinetic friction. The frictional force is the only horizontal force so the net horizontal force must be $\vec{f}_k$. This means there is a net force to the left producing an acceleration to the left. This all implies motion and therefore the frictional force is kinetic. A possible description is: "A baseball player is sliding into second base."

5.25. Visualize:



Assess: The problem says that there is no friction and it tells you nothing about any drag; so we do not include either of these forces. The only remaining forces are the weight and the normal force.

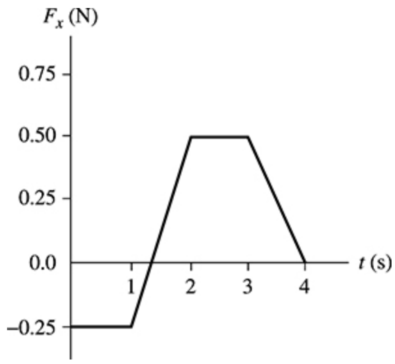
5.29. Visualize:



The velocity vector in figure (a) is shown downward and to the left. So movement is downward and to the left. The velocity vectors get successively longer, which means the speed is increasing. Therefore the acceleration is downward and to the left. By Newton's second law $\vec{F} = m\vec{a}$, the net force must be in the same direction as the acceleration. Thus, the net force is downward and to the left.

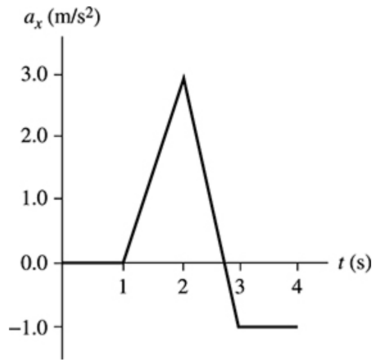
The velocity vector in (b) is shown to be upward and to the right. So movement is upward and to the right. The velocity vector gets successively shorter, which means the speed is decreasing. Therefore the acceleration is downward and to the left. From Newton's second law, the net force must be in the direction of the acceleration and so it is directed downward and to the left.

5.31. Visualize:



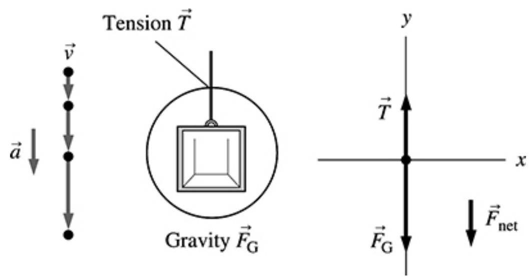
Solve: According to Newton's second law $F = ma$, the force at any time is found simply by multiplying the value of the acceleration by the mass of the object.

5.33. Visualize:



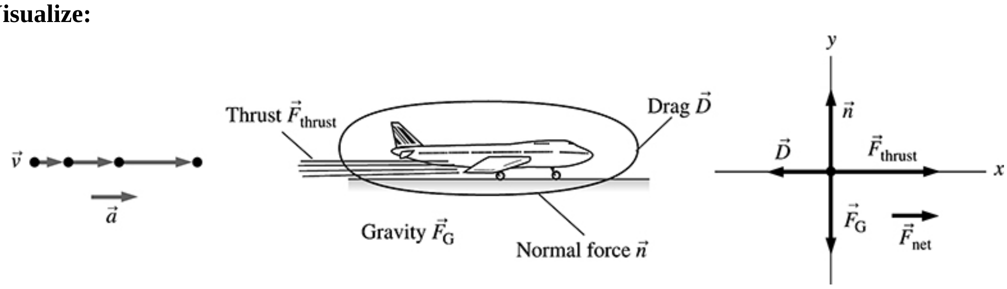
Solve: According to Newton's second law $F = ma$, the acceleration at any time is found simply by dividing the value of the force by the mass of the object.

5.43. Visualize:



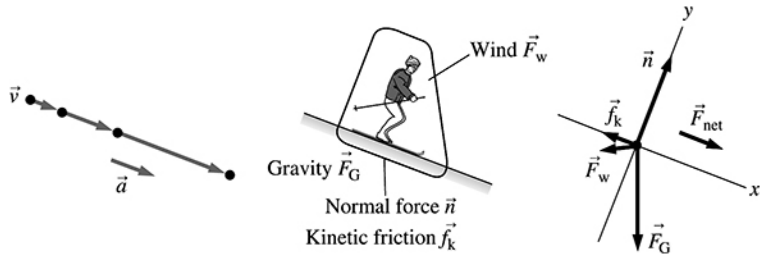
Tension is the only contact force. The downward acceleration implies that $F_G > T$.

5.45. Visualize:



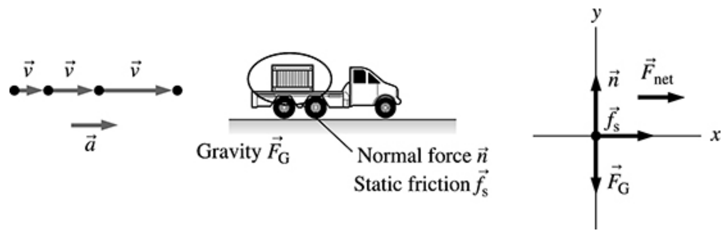
The normal force is perpendicular to the ground. The thrust force is parallel to the ground and in the direction of acceleration. The drag force is opposite to the direction of motion.

5.47. Visualize:



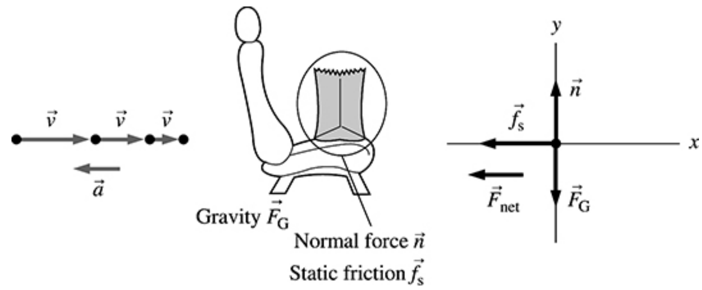
The normal force is perpendicular to the hill. The kinetic frictional force is parallel to the hill and directed upward opposite to the direction of motion. The wind force is given as *horizontal.* Since the skier stays on the slope (that is, there is no acceleration away from the slope) the net force must be parallel to the slope.

5.53. Visualize:



You can see from the motion diagram that the box accelerates to the right along with the truck. According to Newton's second law, $\vec{F} = m\vec{a}$, there must be a force to the *right* acting on the box. This is friction, but not kinetic friction. The box is not sliding against the truck. Instead, it is static friction, the force that prevents slipping. Were it not for static friction, the box would slip off the back of the truck. Static friction acts in the direction needed to prevent slipping. In this case, friction must act in the forward (toward the right) direction.

5.54. Visualize:



You can see from the motion diagram that the bag accelerates to the left along with the car as the car slows down. According to Newton's second law, $\vec{F} = m\vec{a}$, there must be a force to the *left* acting on the bag. This is friction, but not kinetic friction. The bag is not sliding across the seat. Instead, it is static friction, the force that prevents slipping. Were it not for static friction, the bag would slide off the seat as the car stops. Static friction acts in the direction needed to prevent slipping. In this case, friction must act in the backward (toward the left) direction.