B5

Force saves you from the monotony of everything moving at the same speed and direction forever. Force can act on objects, changing their direction and/or speed. The relationship between force, mass, and acceleration is primary in physics classes, so this section (and even broader, this chapter) helps you become a pro at solving problems involving these quantities.

To start, you need to know Newton's Second Law of Motion, which is a big one in physics: "When a net force ΣF acts on an object of mass m, the acceleration of that mass can be calculated by $\Sigma F = ma$." The translation version is that the force equals mass times acceleration, or $\Sigma F = ma$. The Σ stands for "sum," so $\Sigma F = ma$ can be read as "the sum of all forces on an object (the net force) equals mass times acceleration." This equation is often just abbreviated as $F = ma$.

Force, like displacement, velocity, and acceleration, is a vector quantity, which is why Newton's Second Law is written as $\Sigma \mathbf{F} = m \cdot \mathbf{a}$. Put into words, it says that the vector sum of the forces acting on an object is equal to its mass (a scalar) multiplied by its acceleration (a vector).

11. Add two forces: **A** is 8.0 N at 53°, and **B** is 9.0 N at 19°.

Solve It

12. Add two forces: **A** is 16.0 N at 39°, and **B** is 5.0 N at 125°.

Solve It

15. Assume that the two forces acting on a 0.10 kg hockey puck are as follows: **A** is 16.0 N at 53°, and **B** is 21.0 N at 19°. What is the acceleration of the hockey puck?

Solve It

16. Two forces act on a 1000 kg car. **A** is 220 N at 64°, and **B** is 90 N at 80°. Neglecting friction, what is the car's acceleration?

Solve It

17. Suppose that two forces act on a 100 kg boat. **A** is 100 N at 10°, and **B** is 190 N at 210°. What is the boat's acceleration?

Solve It

18. A marble with a mass of 1.0 g is hit by two other marbles that each apply a force for 0.3 seconds. If force **A** is 0.010 N at 63° and **B** is 0.050 N at 135°, what is the acceleration of the original marble?

Solve It

Q. You're trying to lift a suitcase with a mass of 20 kg. How much force must you supply at a minimum to lift the suitcase?

A. The correct answer is 196 N.

To be able to lift the suitcase, you have to overcome the force due to gravity. Calculate it as follows: $F = mg = (20)(9.8) = 196$ N.

19. You're holding a basketball in your hands. If it has a mass of 0.8 kg, how much force must you provide to keep it where it is?

Solve It

20. A ball drops off a cliff. How fast is it going 1.0 seconds later (neglecting wind resistance)?

Solve It

21. A ball drops off a cliff. How far has it gone in 2.0 seconds (neglecting wind resistance)?

Solve It

22. A skydiver jumps out of a plane. How far has he gone 4.0 seconds later (neglecting wind resistance)?

Solve It

23. You throw a baseball straight up into the air at 60 m/sec. How fast is it going 1.0 seconds later?

Solve It

24. You throw a physics book straight up into the air at 30 m/sec. How fast is it going 4.0 seconds later?

Solve It

25. Holding a ball over the edge of a cliff, you throw it up at 10 m/sec. What is its position 5.0 seconds later?

Solve It

26. Holding a ball over the edge of a cliff, you throw it up at 20 m/sec. What is its positio[n] 7.0 seconds later?

Solve It

Newton's Third Law of Motion is a famous one: "Whenever one body exerts a force on a second body, the second body exerts an oppositely directed force of equal magnitude on the first body." If that doesn't ring a bell, try this on for size: "For every action, there is an equal and opposite reaction."

Put simply, this law of motion says that, if your car pushes against the Earth, the Earth pushes back against your car with the same amount of force. This force causes your car to accelerate. What about the Earth? Doesn't it accelerate in response to the force your car exerts on it? Believe it or not, it does, but because the Earth has a mass about 6,000,000,000,000,000,000,000 times that of your car, the effect of your car on the Earth isn't very noticeable!

Newton's Third Law is particularly useful when it comes to problems of *equilibrium*, in which all the forces balance out. When you have equilibrium, you know that all forces sum to zero.

Q. In Figure 4-3, you see three connected ropes. If rope A has a tension of 10 N at 135°, and rope B has a tension of 10 N at 45°, what must the tension in rope C be to keep things in equilibrium?

A. The correct answer is 14 N downward.

1. Convert tension **A** into vector component notation. Use the equation $A_x = A \cos \theta$ to find the x coordinate of the tension: $10.0 \cos 135° = -7.07$.
2. Use the equation $A_y = A \sin \theta$ to find the y coordinate of the tension: $10.0 \sin 135°$, or 7.07. That makes the tension **A** (–7.07, 7.07) in coordinate form.
3. Convert the tension **B** into components. Use the equation $B_x = B \cos \theta$ to find the x coordinate of the tension: $10.0 \cos 45° = 7.07$.
4. Use the equation $B_y = B \sin \theta$ to find the y coordinate of the second tension: $10.0 \sin 45°$, or 7.07. That makes the tension B (7.07, 7.07) in coordinate form.
5. Perform vector addition to find the net tension: (–7.07, 7.07) + (7.07, 7.07) = (0, 14.1).
6. To counteract the net tension, the tension in rope C must be 14.1 N downward (that is, –14.1 N).

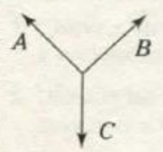

Figure 4-3: Three forces balancing out.

27. You have three ropes tied together in equilibrium. The tension in rope A is 15 N at 135°, and the tension in rope B is 15 N at 45°. What must the tension in rope C be?

Solve It

28. You have three ropes tied together in equilibrium. The tension in rope A is 17.0 N at 115°, and the tension in rope B is 18.0 N at 25°. What must the tension in rope C be?

Solve It