WORKSHEET

15 Math Skills

Acceleration

Sample Problem

In 1970, Don "Big Daddy" Garlits set what was then the world record for drag racing. He started at rest and accelerated at 16.5 m/s^2 (about 1.68 times free-fall acceleration) for 6.5 s. What was Garlits's final speed?

1. List the given and unknown values.

Given: acceleration, $a = 16.5$ m/s^2
time, $t = 6.5$ s
initial speed, *initial* $v = 0$ m/s

Unknown: final speed, *final* $v =$? m/s

2. Rearrange the acceleration equation to solve for final speed.

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time}} \qquad a = \frac{\Delta v}{t} = \frac{\textit{final } v - \textit{initial } v}{t}$$

$$at = \left(\frac{\textit{final } v - \textit{initial } v}{t}\right)t$$

$$at = \textit{final } v - \textit{initial } v$$

$$\textit{final } v = at + \textit{initial } v$$

4. Substitute acceleration, time, and initial speed values into the acceleration equation, and solve.

$$\textit{final } v = (1.65 \text{ m/s}^2 \times 6.5 \text{ s}) + 0 \text{ m/s}$$

$$\textit{final } v = 11 \text{ m/s}$$

Practice

1. A bicyclist accelerates at 0.89 m/s^2 during a 5.0 s interval. What is the change in the speed of the bicyclist and the bicycle?
2. A freight train traveling with a speed of 18.0 m/s begins braking as it approaches a train yard. The train's acceleration while braking is -0.33 m/s^2. What is the train's speed after 23 s?
3. An automobile accelerates 1.77 m/s^2 over 6.00 s to reach freeway speed at the end of an entrance ramp. If the car's final speed is 88.0 km/h, what was its initial speed when it began accelerating? Express your answer in km/h.

Sample Problem

A child sleds down a steep, snow-covered hill with an acceleration of 2.82 m/s^2. If her initial speed is 0.0 m/s and her final speed is 15.5 m/s, how long does it take her to travel from the top of the hill to the bottom?

1. List the given and unknown values.

Given: acceleration, $a = 2.82$ m/s^2
initial speed, *initial* $v = 0.0$ m/s
final speed, *final* $v = 15.5$ m/s

Unknown: time, $t =$? s

2. Rearrange the acceleration equation to solve for time.

$$acceleration = \frac{change\ in\ speed}{time} \qquad a = \frac{\Delta v}{t} = \frac{final\ v - initial\ v}{t}$$

$$a\left(\frac{t}{a}\right) = \left(\frac{final\ v - initial\ v}{t}\right)\left(\frac{t}{a}\right) = \frac{final\ v - initial\ v}{a}$$

$$t = \frac{final\ v - initial\ v}{a}$$

4. Substitute speed and acceleration values into the equation, and solve.

$$t = \frac{15.5\ \text{m/s} - 0.0\ \text{m/s}}{2.82\ \text{m/s}^2} = \frac{15.5}{2.82}\ \text{s}$$

$$t = 5.50\ \text{s}$$

Practice

4. Once the child in the sample problem reaches the bottom of the hill, she continues sliding along flat, snow-covered ground until she comes to a stop. If her acceleration during this time is -0.392 m/s^2, how long does it take her to travel from the bottom of the hill to her stopping point?

5. The "street" automobile with the greatest acceleration is the *Tempest*. It has an acceleration of 6.89 m/s^2. Suppose the car accelerates from rest to a final speed of 96.5 km/h. How long does it take the *Tempest* to reach this speed?

6. The *Impact* is the first commercial electric car to be developed in over 60 years. During tests in 1994, the car reached a top speed of nearly 296 km/h. Suppose the car started at rest and then underwent a constant acceleration of 1.6 m/s^2 until it reached its top speed. How long did it take the *Impact* to reach its top speed?

Sample Problem

An automobile manufacturer claims that its latest model can "go from 0 to 90" in 7.5 s. If the "90" refers to 90.0 km/h, calculate the automobile's acceleration.

1. List the given and unknown values.

Given: time, $t = 7.5$ s
initial speed, *initial* $v = 0.0$ km/h
final speed, *final* $v = 90.0$ km/h

Unknown: acceleration, $a = ?$ m/s^2

2. Perform any necessary conversions.
To find the final speed in m/s, you must multiply the value for speed by the number of meters in a kilometer and divide by the number of seconds in an hour.

$$\textit{final } v = 90.0 \frac{\text{km}}{\text{h}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ h}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ s}}$$

$$\textit{final } v = 25.0 \text{ m/s}$$

3. Write out the equation for acceleration.

$$\textit{acceleration} = \frac{\textit{change in speed}}{\textit{time}} \qquad a = \frac{\Delta v}{t} = \frac{\textit{final } v - \textit{initial } v}{t}$$

4. Substitute speed and time values into the acceleration equation, and solve.

$$a = \frac{\Delta v}{t} = \frac{\textit{final } v - \textit{initial } v}{t} = \frac{25.0 \text{ m/s} - 0.0 \text{ m/s}}{7.5 \text{ s}} = \frac{25.0 \text{ m/s}}{7.5 \text{ s}}$$

$$a = 3.3 \text{ m/s}^2$$

Practice

7. The gravitational force between Mars and an object near its surface is much lower than the force between an object on Earth's surface and Earth. If a dropped hammer's speed increases from 0.0 m/s to 15.0 m/s in 4.04 s, what is the acceleration due to the gravitational force on the surface of Mars?

8. A fighter jet landing on an aircraft carrier's flight deck that has a length of 300.0 m must reduce its speed from about 153 km/h to exactly 0 km/h in 2.0 s. What is the jet's acceleration?

9. A runner whose initial speed is 29 km/h increases her speed to 31 km/h in order to win a race. If the runner takes 5.0 s to complete this increase in her speed, what is her acceleration?

Mixed Review

10. A certain roller coaster accelerates its cars 6.35 m/s^2 up the first incline. If this acceleration happens during the first 7.0 s of the ride, how much does the speed of the roller coaster cars increase?

11. The solid-fuel rocket boosters used to launch the space shuttle are able to lift the shuttle 45 km above Earth's surface. During that time, the shuttle undergoes a nearly constant total acceleration of 6.25 m/s^2, so that its speed increases from rest to about 750 m/s. How long does it take for the shuttle to reach this speed?

12. Bonnie Blair currently holds the world record for skating 500.0 m in 38.69 s, which she set in 1995. Suppose that after she crossed the finish line she coasted to a stop on the ice. If her initial speed was 13 m/s and her acceleration was -2.9 m/s^2, how long did it take her to stop?

13. The elevators in the Landmark Tower, in Yokohama, Japan, are among the fastest in the world. They accelerate upward at 3.125 m/s^2 for 4.00 s to reach their final speed. If these elevators start at rest, what is their final speed?

14. A ship with a mass of 5.22×10^7 kg has engines capable of an acceleration equal to -0.357 m/s^2. Suppose the ship approaches the dock at a speed of 16.98 m/s. How much time does the ship need to stop?

15. A dog runs with an initial speed of 1.5 m/s on a waxed floor. It slides to a stop with an acceleration of -0.35 m/s^2. How long does it take for the dog to stop?

16. A certain type of rocket sled is used to measure the effects of sudden, extreme deceleration. The sled reaches a top speed of 320 km/h, then comes to a complete stop in 0.18 s. What is the acceleration that takes place in this time?

17. The building with the highest occupiable floor is currently the Sears Tower in Chicago. The top floor of the Sears Tower is 110 stories (436 m) above street level, and the roof of the tower is 442 m above the street. Assume a golf ball is thrown downward from the roof of the Sears Tower. Neglecting air resistance, the golf ball accelerates at 9.8 m/s^2 and lands on the pavement after 9.2 s. If the ball's final speed is 93.0 m/s, what was the speed with which the ball was initially thrown?

18. In the theory of *plate tectonics,* various segments of Earth's crust, called *plates,* move toward and away from each other. In one instance, the plate that consists of the Indian subcontinent drifted from southeastern Africa to its current position in Asia, traveling at a speed of 15 cm/y. This plate collided with Asia, forming the Himalayan mountain range in the process. Most of this formation occurred during the last 1.00×10^7 years, during which time the Indian subcontinent's motion has slowed to about 5 cm/y. What has been the acceleration, in units of cm/y^2, of the Indian subcontinent during this time period?