

## Kinetic Energy

An 725 kg automobile has a kinetic energy of  $3.02 \times 10^5$  J as it travels along a highway. What is the car's speed?

**1. List the given and unknown values.**

Given: mass,  $m = 725$  kg  
 kinetic energy,  $KE = 3.02 \times 10^5$  J

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

**2. Use the kinetic energy equation, and rearrange it to solve for speed.**

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2 \quad KE = \frac{1}{2} mv^2$$

$$KE \times \frac{2}{m} = \frac{1}{2} mv^2 \times \frac{2}{m} = v^2$$

$$v = \sqrt{v^2} = \sqrt{\frac{2KE}{m}}$$

**3. Substitute kinetic energy and mass values into the equation, and solve.**

$$v = \sqrt{\frac{2(3.02 \times 10^5 \text{ J})}{725 \text{ kg}}} = \sqrt{\frac{2(3.02 \times 10^5 \text{ kg} \cdot \text{m}^2/\text{s}^2)}{725 \text{ kg}}}$$

$$v = 28.9 \text{ m/s}$$

### Practice

- When a 65 kg skydiver jumps from a plane, her speed steadily increases until air resistance provides a force that balances the force due to free fall. How fast is the skydiver falling if her kinetic energy at the moment is  $7.04 \times 10^5$  J?
- The kinetic energy of a golf ball is measured to be 143.3 J. If the golf ball has a mass of about 47 g, what is its speed?
- Although there are rumors of new aircraft that can fly at much higher speeds, the current official and unclassified record holder is still the Lockheed SR-71 *Blackbird*, a high-altitude spy plane. Fully loaded, the *Blackbird* has a mass of  $7.7 \times 10^4$  kg, and at top speed it has a kinetic energy of  $3.7 \times 10^{10}$  J. What is the top speed of the SR-71?

**Sample Problem**

The greatest speed that a meteoroid can have and still be pulled down to Earth's surface is 70.0 km/s. If a meteoroid traveling with this speed has a kinetic energy of  $2.56 \times 10^{13}$  J, what is its mass?

**1. List the given and unknown values.**

Given: speed,  $v = 70.0$  km/s =  $7.00 \times 10^4$  m/s

kinetic energy,  $KE = 2.56 \times 10^{13}$  J

Unknown: mass,  $m = ?$  kg

**2. Use the kinetic energy equation, and rearrange it to solve for mass.**

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2 \qquad KE = \frac{1}{2} mv^2$$

$$KE \times \frac{2}{v^2} = \frac{1}{2} mv^2 \times \frac{2}{v^2} = m$$

**3. Substitute kinetic energy and speed values into the equation, and solve.**

$$m = \frac{2 \times (2.56 \times 10^{13} \text{ J})}{(7.00 \times 10^4 \text{ m/s})^2} = \frac{2 \times (2.56 \times 10^{13} \text{ kg} \cdot \text{m}^2/\text{s}^2)}{(7.00 \times 10^4 \text{ m/s})^2}$$

$$m = 1.04 \times 10^4 \text{ kg}$$

## Practice

4. The most massive Shinkansen bullet trains are the series-200 trains. This type of train also has one of the highest operating speeds: 76.4 m/s. If a series-200 train has a maximum kinetic energy of  $2.78 \times 10^9$  J, what is its mass?
5. The largest airplane built that has flown more than once is the Ukrainian-built Antonov-225 *Mriya*. With a length of 85 m and a wingspan of 88 m, the *Mriya (Dream)* was designed to carry the space shuttle of the Soviet Union's space program. Unloaded, the top speed of *Mriya* is 236 m/s, at which its kinetic energy is  $9.76 \times 10^9$  J. What is its mass?
6. The vehicle land-speed record has long been held by rocket cars. These vehicles resemble the high-speed rocket planes that were used in the early days of the space program, but they have heavy metal wheels. On September 5, 1997, the world land-speed record was set by the British-built Thrust SSC rocket car, which had a top recorded speed of 341 m/s. The kinetic energy of the car at this speed is  $5.289 \times 10^8$  J. What is the car's mass?

**Sample Problem**

A baseball is pitched with a speed of 35 m/s. If the baseball has a mass of 0.146 kg, what is its kinetic energy?

**1. List the given and unknown values.**

Given: mass,  $m = 0.146$  kg  
 speed,  $v = 35$  m/s

Unknown: kinetic energy,  $KE = ?$  J

**2. Use the kinetic energy equation.**

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2 \quad KE = \frac{1}{2} mv^2$$

**3. Substitute mass and speed values into the kinetic energy equation, and solve.**

$$KE = \frac{1}{2} (0.146 \text{ kg}) \times (35 \text{ m/s})^2 = 89 \text{ kg} \cdot \text{m}^2/\text{s}^2$$

$$KE = 89 \text{ J}$$

## Practice

7. A cheetah can run briefly with a speed of 31 m/s. Suppose a cheetah with a mass of 47 kg runs at this speed. What is the cheetah's kinetic energy?
8. A table tennis (ping-pong) ball has a mass of about 2.45 g. Suppose the ball is hit across the table with a speed of about 4.0 m/s. What is its kinetic energy?

**Mixed Review**

9. The largest land predator is the male polar bear, which typically has a mass of around  $5.00 \times 10^2$  kg. If the maximum kinetic energy for a polar bear with this mass is  $6.05 \times 10^4$  J, what is its top speed?
10. Though slow on land, the leatherback turtle holds the record for the fastest water speed of any reptile: 9.78 m/s. It is also among the largest of reptiles. Suppose the largest leatherback yet discovered were to swim at a speed of 9.78 m/s. If its kinetic energy was  $6.08 \times 10^4$  J, what was its mass?
11. Most of the various models of the Shinkansen, Japan's high-speed trains, travel between 240 km/h and 285 km/h. The two exceptions are the Shinkansen "0" series, which began service in 1964, and the new "500" series, which began service in 1997. Series-0 trains travel up to 61.1 m/s and have a total mass of about  $8.84 \times 10^5$  kg. The lightweight, streamlined series-500 trains travel up to 88.9 m/s and have an estimated total mass of about  $4.80 \times 10^5$  kg. What are the maximum kinetic energies of these two trains?