Name _____ Date _____ Class _____

MATH SKILLS

Kinetic Energy

An 725 kg automobile has a kinetic energy of 3.02×10^5 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 = 3.02×10^5 J

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

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

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

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

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

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

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

v = 28.9 m/s

Your Turn to Think

1. 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 7.04×10^5 J?
2. 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?
3. 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 7.7×10^4 J kg, and at top speed it has a kinetic energy of 3.7×10^{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 2.56×10^{13} J, what is its mass?

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MATH SKILLS

Kinetic Energy *continued*

1. List the given and unknown values.

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

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

   Unknown: *mass*, $m = ? \text{ kg}$

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

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

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

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

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

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

Your Turn to Think

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 2.78×10^9 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 9.76×10^9 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 5.289×10^8 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.

MATH SKILLS

Kinetic Energy *continued*

Given: *mass, m* = 0.146 kg

speed, v = 35 m/s

Unknown: *kinetic energy, KE* = ? J

2. Use the kinetic energy equation.

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

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

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

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

Your Turn to Think

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 5.00×10^2 kg. If the maximum kinetic energy for a polar bear with this mass is 6.05×10^4 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 6.08×10^4 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 8.84×10^5 kg. The lightweight, streamlined series-500 trains travel up to 88.9 m/s and have an estimated total mass of about 4.80×10^5 kg. What are the maximum kinetic energies of these two trains?