Work and Energy

Additional Practice B

Givens	*Solutions*
1. $m = 7.5 \times 10^7$ kg $v = 57$ km/h	$KE = \frac{1}{2}mv^2 = \frac{1}{2}(7.5 \times 10^7 \text{ kg})\,[(57 \text{ km/h})(10^3 \text{ m/km})(1\text{h}/3600 \text{ s})]^2$ $KE = \boxed{9.4 \times 10^9 \text{ J}}$
2. $v = 15.8$ km/s $m = 0.20$ g	$KE = \frac{1}{2}mv^2 = \frac{1}{2}(0.20 \times 10^{-3} \text{ kg})(15.8 \times 10^3 \text{ m/s})^2$ $KE = \boxed{2.5 \times 10^4 \text{ J}}$
3. $v = 35.0$ km/h $m = 9.00 \times 10^2$ kg	$KE = \frac{1}{2}mv^2 = \frac{1}{2}(9.00 \times 10^2 \text{ kg})\,[(35.0 \text{ km/h})(10^3 \text{ m/km})(1 \text{ h}/3600 \text{ s})]^2$ $KE = \boxed{4.25 \times 10^4 \text{ J}}$
4. $v_1 = 220.0$ km/h $m_1 = 8.84 \times 10^5$ kg $v_2 = 320.0$ km/h $m_2 = 4.80 \times 10^5$ kg	$KE_1 = \frac{1}{2}m_1 v_1^2 = \frac{1}{2}(8.84 \times 10^5 \text{ kg})[(220.0 \text{ km/h})(10^3 \text{ m/km})(1 \text{ h}/3600 \text{ s})]^2$ $KE_1 = \boxed{1.65 \times 10^9 \text{ J}}$ $KE_2 = \frac{1}{2}m_2 v_2^2 = \frac{1}{2}(4.80 \times 10^5 \text{ kg})[(320.0 \text{ km/h})(10^3 \text{ m/km})(1\text{h}/3600 \text{ s})]^2$ $KE_2 = \boxed{1.90 \times 10^9 \text{ J}}$
5. $KE = 2.78 \times 10^9$ J $v = 275$ km/h	$m = \frac{2KE}{v^2} = \frac{(2)(2.78 \times 10^9 \text{ J})}{[(275 \text{ km/h})(10^3 \text{ m/km})(1\text{h}/3600 \text{ s})]^2}$ $m = \boxed{9.53 \times 10^5 \text{ kg}}$
6. $v = 850$ km/h $KE = 9.76 \times 10^9$ J	$m = \frac{2\,KE}{v^2} = \frac{(2)(9.76 \times 10^9 \text{ J})}{[(850 \text{ km/h})(10^3 \text{ m/km})(1 \text{ h}/3600 \text{ s})]^2}$ $m = \boxed{3.50 \times 10^5 \text{ kg}}$
7. $v = 9.78$ m/s $KE = 6.08 \times 10^4$ J	$m = \frac{2\,KE}{v^2} = \frac{(2)(6.08 \times 10^4 \text{ J})}{(9.78 \text{ m/s})^2} = \boxed{1.27 \times 10^3 \text{ kg}}$

Givens | *Solutions*

8. $KE = 7.81 \times 10^4$ J

$m = 55.0$ kg

$$v = \sqrt{\frac{2\,KE}{m}} = \sqrt{\frac{(2)(7.81 \times 10^4 \text{ J})}{55.0 \text{ kg}}} = \boxed{53.3 \text{ m/s}}$$

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9. $KE = 1433$ J

$m = 47.0$ g

$$v = \sqrt{\frac{2\,KE}{m}} = \sqrt{\frac{(2)(1433 \text{ J})}{47.0 \times 10^{-3} \text{ kg}}} = \boxed{247 \text{ m/s}}$$

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10. $KE_{A,i} = \frac{1}{2}KE_B$

$v_{A,f} = v_{A,i} + 1.3$ m/s

$KE_{A,f} = KE_B$

$m_A = 2.0\ m_B$

$KE_{A,i} = \frac{1}{2}KE_B$

$\frac{1}{2}m_A v_{A,i}{}^2 = \frac{1}{2}\left(\frac{1}{2}\,m_B v_B{}^2\right)$

$\frac{1}{2}(2m_B)v_{A,i}{}^2 = \frac{1}{4}\,m_B v_B{}^2$

$v_{A,i}{}^2 = \frac{1}{4}\,v_B{}^2$, *or* $v_B{}^2 = 4v_{A,i}{}^2$

$v_{A,i} = \frac{1}{2}\,v_B$

$KE_{A,f} = KE_B$

$\frac{1}{2}\,m_A v_{A,f}{}^2 = \frac{1}{2}\,m_B v_B{}^2$

$\frac{1}{2}\,(2m_B)(v_{A,i} + 1.3 \text{ m/s})^2 = \frac{1}{2}\,m_B v_B{}^{2.}$

$(v_{A,i} + 1.3 \text{ m/s})^2 = \frac{1}{2}\,v_B{}^2 = \frac{1}{2}\,(4v_{A,i}{}^2) = 2v_{A,i}{}^2$

$v_{A,i}{}^2 + (2.6 \text{ m/s})\ v_{A,i} + 1.7 \text{ m}^2/\text{s}^2 = 2v_{A,i}{}^2$

$v_{A,i}{}^2 - (2.6 \text{ m/s})\ v_{A,i} - 1.7 \text{ m}^2/\text{s}^2 = 0$

Using the quadratic equation,

$$v_{A,i} = \frac{2.6 \text{ m/s} \pm \sqrt{(-2.6 \text{ m/s})^2 - 4(-1.7 \text{ m}^2/\text{s}^2)}}{2} = \frac{2.6 \text{ m/s} \pm \sqrt{6.8 \text{ m}^2/\text{s}^2 + 6.8 \text{ m}^2/\text{s}^2}}{2}$$

$$v_{A,i} = \frac{2.6 \text{ m/s} \pm \sqrt{13.6 \text{ m}^2/\text{s}^2}}{2} = \frac{2.6 \text{ m/s} \pm 3.69 \text{ m/s}}{2} = \frac{6.3 \text{ m/s}}{2} = \boxed{3.2 \text{ m/s}}$$

$v_{A,i} = \frac{1}{2}\,v_B$

$v_B = v_{A,i} = (2)(3.2 \text{ m/s}) = \boxed{6.4 \text{ m/s}}$

Work and Energy

Problem B

KINETIC ENERGY

PROBLEM

A 2.00 g projectile has a speed of 3.00 10^2 m/s. What is its kinetic energy?

SOLUTION

Given: $m = 2.00$ g

$v = 3.00 \times 10^2$ m/s

Unknown: $KE = ?$

Use the kinetic energy equation to solve for KE.

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}(2.00 \times 10^{-3}\ \text{kg})(3.00 \times 10^2\ \text{m/s})^2$$

$$KE = \boxed{90.0\ \text{J}}$$

ADDITIONAL PRACTICE

1. The *Queen Mary* was one of the largest ocean liners of the mid-twentieth century, crossing the Atlantic Ocean 1000 times. The ship is now a tourist attraction at Long Beach, California. Given that the mass of the *Queen Mary* is 7.5×10^7 kg and her maximum cruising speed was 57 km/h, what would be the kinetic energy of the ship at maximum speed?
2. The fastest speed achieved on Earth for any object, with the exception of sub-atomic particles in particle accelerators, is 15.8 km/s. A device at Sandia Laboratories in Albuquerque, New Mexico, uses highly compressed air to accelerate a small metal disk to supersonic speeds. Suppose the disk has a mass of 0.20 g. What is the maximum kinetic energy of the disk?
3. Although ungraceful on land, walruses are fine swimmers. They normally swim at 7 km/h, and for short periods of time are capable of reaching speeds of nearly 35 km/h. If a walrus swimming at a speed of 35.0 km/h has a mass of 9.00×10^2 kg, what is its kinetic energy?
4. The Shinkansen, Japan's high-speed trains, have been in service since 1964. Since that time, several train designs have been developed. Most of these trains travel between 240 km/h and 285 km/h. The exceptions are the "0" series, which began service in 1964, and the "500" series, which began service in 1997. Series 0 trains travel up to 220.0 km/h and have a total mass of about 8.84×10^5 kg. The lighter, streamlined series 500 trains travel up to 320.0 km/h, and have an estimated total mass of about 4.80×10^5 kg. What are the maximum kinetic energies that can be achieved by each of these trains?

5. The most massive of the Shinkansen are the series 200 trains, yet they are among the fastest. Series 200 trains can reach speeds of 275 km/h. If a 16-car series 200 train has a maximum kinetic energy of 2.78×10^9 J, what is its mass?
6. 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 850 km/h, at which point its kinetic energy is 9.76×10^9 J. What is its mass?
7. 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 the top leatherback speed. If its kinetic energy was 6.08×10^4 J, what was its mass?
8. At the time a 55.0 kg skydiver jumps from a plane, her speed steadily increases until air resistance provides a force that balances that due to free-fall. How fast is the skydiver falling if her kinetic energy at the moment is 7.81×10^4 J?
9. The kinetic energy of a golf ball is measured to be 1433 J. If the golf ball has a mass of about 47.0 g, what is the ball's speed?
10. A running student has half the kinetic energy that his younger brother has. The student speeds up by 1.3 m/s, at which point he has the same kinetic energy as his brother. If the student's mass is twice as large as his brother's mass, what were the original speeds of both the student and his brother? (See Appendix A of the text for hints on solving quadratic equations.)