PHYSICS IN MOTION
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Unit 4H
Conservation of Energy
Practice Problems TEACHER

Work each of the following problems. SHOW ALL WORK.

1. A very thoughtful physics student takes her younger sibling to the arcade to play skeeball. She estimates the mass of the skee ball to be about 0.5 kg and the height of the fifty-point ring to be about 1 m above the position from which the ball is released.

   a. How much gravitational potential energy will the ball have if it hits the fifty-point ring at the highest point?

$$PE_G = mgh$$
$$PE_G = (0.5\,kg)(9.8\,m/s^2)(1\,m)$$
$$PE_G = 4.9\,J$$

   b. How much kinetic energy does the ball need at its release to reach the highest point?

$$ME_i = ME_f$$
$$KE_i = PE_{G_f}$$
$$KE_i = 4.9\,J$$

   c. At what velocity must the ball be released to reach the highest point?

$$KE = \frac{1}{2}mv^2$$
$$4.9\,J = \frac{1}{2}(0.5\,kg)v^2$$
$$19.6\,m^2/s^2 = v^2$$
$$v = 4.43\,m/s$$

   d. The student's sibling uses a radar gun to determine how fast she releases the ball, and it is exactly the speed she calculated to reach the 1 m height. However, the ball lands in the thirty-point ring, which is 0.8 m above the release point. How much energy is lost to friction if the ball only reaches 0.8 m instead of 1 m?

The ball starts with 4.9 J of kinetic energy. If the ball reaches only 0.8 m, it has 3.92 J of gravitational potential energy at the highest point:

$$PE_G = mgh$$
$$PE_G = (0.5\,kg)(9.8\,m/s^2)(0.8\,m)$$
$$PE_G = 3.92\,J$$

If the ball starts with 4.9 J and ends with only 3.92 J, some energy is lost to friction:

$$ME_i = ME_f + E_{friction}$$
$$KE_i = PE_{G_f} + E_{friction}$$
$$4.9\,J = 3.92\,J + E_{friction}$$
$$E_{friction} = 0.98\,J$$

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Work each of the following problems. SHOW ALL WORK.

2. The platform height for Olympic divers is 10 m. A 60 kg diver steps off the platform to begin his dive.

a. How much gravitational potential energy does the diver have?

$$PE_G = mgh$$
$$PE_G = (60\ kg)(9.8\ ^m/_{s^2})(10\ m)$$
$$PE_G = 5880\ J$$

b. How much kinetic energy does the diver have as he strikes the water?

$$ME = ME_f$$
$$PE_G = KE_f$$
$$5880\ J = KE_f$$

c. How much work does the water do on the diver to stop his momentum?

$$W = \triangle KE$$
$$W = KE_f - KE_i$$
$$W = 0 - 5880\ J$$
$$W = -5880\ J$$

d. If the diver stops in 2.5 m after entering the water, what net force is applied to the diver?

$$W = Fd$$
$$-5880\ J = F(2.5\ m)$$
$$F = -2350\ N$$

3. A 0.75 kg wood block is pushed 0.2 m into a horizontal spring with a spring constant of 50 N/m and released.

a. How much spring potential energy is in the system before the wood block begins to move?

$$PE_s = \frac{1}{2}kx^2$$
$$PE_s = \frac{1}{2}(50\ ^N/_m)(0.2\ m)^2$$
$$PE_s = 1\ J$$

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Work each of the following problems. SHOW ALL WORK.

b. If the surface is frictionless, what is the kinetic energy of the block as it leaves the spring?

$$ME_i = ME_f$$
$$PE_{s_i} = KE_f$$
$$1\,J = KE_f$$

c. If the surface is frictionless, what is the velocity of the block as it leaves the spring?

$$KE_f = \frac{1}{2}mv^2$$
$$1\,J = \frac{1}{2}(0.75\,kg)v^2$$
$$\sqrt{2.67\,m^2/s^2} = \sqrt{v^2}$$
$$v = 1.63\,m/s$$

d. Assuming the surface is not frictionless, and the wood block leaves the spring at a velocity of 1.32 m/s. How much energy is lost due to friction?

$$ME_i = ME_f + E_{friction}$$
$$PE_{s_i} = KE_f + E_{friction}$$
$$1\,J = \frac{1}{2}(0.75\,kg)(1.32\,m/s)^2 + E_{friction}$$
$$1\,J = 0.65\,J + E_{friction}$$
$$E_{friction} = 0.35\,J$$

4. A 4 kg bowling ball begins rolling down a lane at the bowling alley at 6 m/s. When it strikes the pins, it is estimated to be moving at 5 m/s. How much energy is lost due to friction?

$$ME_i = ME_f + E_{friction}$$
$$KE_i = KE_f + E_{friction}$$
$$\frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2 + E_{friction}$$
$$\frac{1}{2}(4\,kg)(6\,m/s)^2 = \frac{1}{2}(4\,kg)(5\,m/s)^2 + E_{friction}$$
$$72\,J = 50\,J + E_{friction}$$
$$E_{friction} = 22\,J$$

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Work each of the following problems. SHOW ALL WORK.

5. A 250 g car at rest rolls down a frictionless incline from a starting height of 0.75 m. What is the final velocity of the car?

$$ME_i = ME_f$$
$$PE_{G_i} = KE_f$$
$$mgh_i = \frac{1}{2}mv_f^2$$
$$(0.25\,kg)(9.8\,{}^{m}/{}_{s^2})(0.75\,m) = \frac{1}{2}(0.25\,kg)v_f^2$$
$$1.84\,J = \frac{1}{2}(0.25\,kg)v_f^2$$
$$\sqrt{14.72\,{}^{m^2}/{}_{s^2}} = \sqrt{v_f^2}$$
$$v_f = 3.84\,{}^{m}/{}_{s}$$

6. Assuming the surface is not frictionless, and the final velocity of the car in the previous question is only 3 m/s, how much energy is lost due to friction?

$$ME_i = ME_f + E_{friction}$$
$$PE_{G_i} = KE_f + E_{friction}$$
$$mgh_i = \frac{1}{2}mv_f^2 + E_{friction}$$
$$(0.25\,kg)(9.8\,{}^{m}/{}_{s^2})(0.75\,m) = \frac{1}{2}(0.25\,kg)(3\,{}^{m}/{}_{s})^2 + E_{friction}$$
$$1.84\,J = 1.13\,J + E_{friction}$$
$$E_{friction} = 0.71\,J$$