

Problem 5A

WORK AND ENERGY

PROBLEM

The largest palace in the world is the Imperial Palace in Beijing, China. Suppose you were to push a lawn mower around the perimeter of a rectangular area identical to that of the palace, applying a constant horizontal force of 60.0 N. If you did 2.05×10^5 J of work, how far would you have pushed the lawn mower? If the Imperial Palace is 9.60×10^2 m long, how wide is it?

SOLUTION

Given:

$$F = 60.0 \text{ N}$$

$$W = 2.05 \times 10^5 \text{ J}$$

$$x = 9.60 \times 10^2 \text{ m}$$

Unknown:

$$d = ?$$

$$y = ?$$

Use the equation for net work done by a constant force.

$$W = Fd(\cos \theta)$$

To calculate the width, y , recall that the perimeter of an area equals the sum of twice its width and twice its length.

$$d = 2x + 2y$$

Rearrange the equations to solve for d and y . Note that the force is applied in the direction of the displacement, so $\theta = 0^\circ$.

$$d = \frac{W}{F(\cos \theta)} = \frac{2.05 \times 10^5 \text{ J}}{(60.0 \text{ N})(\cos 0^\circ)}$$

$$d = \boxed{3.42 \times 10^3 \text{ m}}$$

$$y = \frac{d - 2x}{2} = \frac{3.42 \times 10^3 \text{ m} - (2)(9.60 \times 10^2 \text{ m})}{2}$$

$$y = \frac{3.42 \times 10^3 \text{ m} - 1.92 \times 10^3 \text{ m}}{2} = \frac{1.50 \times 10^3 \text{ m}}{2}$$

$$y = \boxed{7.50 \times 10^2 \text{ m}}$$

ADDITIONAL PRACTICE

1. Lake Point Tower in Chicago is the tallest apartment building in the United States (although not the tallest building in which there are apartments). Suppose you take the elevator from street level to the roof of the building. The elevator moves almost the entire distance at constant speed, so that it does 1.15×10^5 J of work on you as it lifts the en-

tire distance. If your mass is 60.0 kg, how tall is the building?
Ignore the effects of friction.

2. In 1985 in San Antonio, Texas, an entire hotel building was moved several blocks on 36 dollies. The mass of the building was about 1.45×10^6 kg. If 1.00×10^2 MJ of work was done to overcome the force of resistance that was just 2.00 percent of the building's weight, how far was the building moved?
3. A hummingbird has a mass of about 1.7 g. Suppose a hummingbird does 0.15 J of work against gravity, so that it ascends straight up with a net acceleration of 1.2 m/s^2 . How far up does it move?
4. In 1453, during the siege of Constantinople, the Turks used a cannon capable of launching a stone cannonball with a mass of 5.40×10^2 kg. Suppose a soldier dropped a cannonball with this mass while trying to load it into the cannon. The cannonball rolled down a hill that made an angle of 30.0° with the horizontal. If 5.30×10^4 J of work was done by gravity on the cannonball as it rolled down a hill, how far did it roll?
5. The largest turtle ever caught in the United States had a mass of over 800 kg. Suppose this turtle were raised 5.45 m onto the deck of a research ship. If it takes 4.60×10^4 J of work to lift the turtle this distance at a constant velocity, what is the turtle's weight?
6. During World War II, 16 huge wooden hangers were built for United States Navy airships. The hangars were over 300 m long and had a maximum height of 52.0 m. Imagine a 40.0 kg block being lifted by a winch from the ground to the top of the hangar's ceiling. If the winch does 2.08×10^4 J of work in lifting the block, what force is exerted on the block?
7. The *Warszawa Radio* mast in Warsaw, Poland, is 646 m tall, making it the tallest human-built structure. Suppose a worker raises some tools to the top of the tower by means of a small elevator. If 2.15×10^5 J of work is done in lifting the tools, what is the force exerted on them?
8. The largest mincemeat pie ever created had a mass of 1.02×10^3 kg. Suppose that a pie with this mass slides down a ramp that is 18.0 m long and is inclined to the ground by 10.0° . If the coefficient of kinetic friction is 0.13, what is the net work done on the pie during its descent?
9. The longest shish kebab ever made was 881.0 m long. Suppose the meat and vegetables need to be delivered in a cart from one end of this shish kebab's skewer to the other end. A cook pulls the cart by applying a force of 40.00 N at an angle of 45.00° above the horizontal. If the force of friction acting on the cart is 28.00 N, what is the net work done on the cart and its contents during the delivery?
10. The world's largest chandelier was created by a company in South Korea and hangs in one of the department stores in Seoul, South Korea. The chandelier's mass is about 9.7×10^3 kg. Consider a situation in which this chandelier is placed in a wooden crate whose mass is negligible. The chandelier is then pulled along a smooth horizontal surface

by two forces that are parallel to the smooth surface, are at right angles to each other, and are applied 45° to either side of the direction in which the chandelier is moving. If each of these forces is 1.2×10^3 N, how much work must be done on the chandelier to pull it 12 m?

- 11.** The world's largest flag, which was manufactured in Pennsylvania, has a length of 154 m and a width of 78 m. The flag's mass is 1.24×10^3 kg, which may explain why the flag has never been flown from a flagpole. Suppose this flag is being pulled by two forces: a force of 8.00×10^3 N to the east and a force of 5.00×10^3 N that is directed 30.0° south of east. How much work is done in moving the flag 20.0 m directly south?