Work Problems

1. Find the work done in pushing a cart 20 ft along a level road if 90 lb of constant force is being applied.

2. How much work is required to lift a 15 kg object vertically 4 m?

3. Find the work done in stretching a spring from 8 in to 10 in if

   (a) 18 lb of force is required to stretch the spring from its natural length of 5 in to a length of 9 in.

   (b) 36 in·lb of work is required to stretch the spring from its natural length of 5 in to a length of 9 in.

4. According to Newton's universal law of gravitation, the gravitational force of attraction between two masses m_1 and m_2 that are separated by a distance r is given by

$$F = \frac{Gm_1m_2}{r^2},$$

where $G = 6.673 \times 10^{-11}$ N · m^2/kg^2 is the gravitational constant. Find the work done in propelling a 34 g Twinkie ($m_1 = 0.034$ kg) a distance of 2,670 km ($h = 2.67 \times 10^6$ m) above the surface of the Earth. The mass of the Earth is $m_2 = 5.98 \times 10^{24}$ kg and its radius is $R = 6.38 \times 10^6$ m.

5. Suppose a right circular cylindrical tank has diameter 4 m across the top and height 6 m.

   (a) Find the work done in emptying water from the tank if it is initially filled to a height of 3 m and the water is pumped out over the top edge of the tank.

   (b) Find the work done in filling the tank with water to a height of 3 m if it is initially empty by pumping water in through a hole in the bottom of the tank.

   (c) Repeat parts (a) and (b) if the tank were a cone with the same dimensions.

   Note: The (mass) density of water is $\rho = 1{,}000$ kg/m^3 and its weight density is $\rho g = (1{,}000$ kg/m$^3)(9.80$ m/s$^2) = 9{,}800$ N/m^3, or equivalently 62.4 lb/ft^3.

6. Each end of a 5 ft long storage tank is in the shape of the region bounded by the curves $y = 1/x$, $y = -1/x$, $y = 1$, and $y = 2$, as illustrated, where x and y are measured in feet and where the bottom of the tank is 1 ft above the ground. How much work is done in completely filling the tank with gasoline, which has a weight density of 42 lb/ft^3, by pumping the gasoline from the ground up into the tank through an opening in its bottom?