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## Section 7.4: Work

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**Definition:** If a constant force  $F$  acts on an object, the work  $W$  to move (pull, push) it over a distance  $d$  is

$$W = Fd.$$

where

- $F$  is in Newton ( $N$ ),  $d$  in meter ( $m$ ), and  $W$  in Joule ( $J$ ),
- or,  $F$  in pounds ( $lb$ ),  $d$  in feet ( $ft$ ), and  $W$  in ( $ft\text{-}lb$ ).

**Exercise 1.** Find the work done in lifting a 2 pounds book from the floor to a height of 3 feet.

**Exercise 2.** Find the work done in raising a 20 kg barbell from the floor to a height of 1.5 m.  
Use the fact that the acceleration due to gravity is  $g = 9.8m/s^2$

**Exercise 3.** A particle is moved along the  $x$ -axis by a force that measures  $5x^2 + 1$  pounds at a point  $x$  feet from the origin. Find the work done in moving the particle from the origin to a distance of 3 feet.

**Definition:** If a variable force  $F(x)$  acts on an object moving on the  $x$ -axis, the work  $W$  to move (pull, push) from  $x = a$  to  $x = b$  is

$$W = \int_a^b F(x)dx.$$

where

- $F$  is in Newton ( $N$ ),  $x$  in meter ( $m$ ), and  $W$  in Joule ( $J$ ),
- or,  $F$  in pounds ( $lb$ ),  $x$  in feet ( $ft$ ), and  $W$  in ( $ft\text{-}lb$ ).

**Exercise 4.** A force 12 lb is required to hold a spring stretched 4 in. beyond its natural length. How much work is done in stretching it from its natural length to 6 in.?

**Hooke's Law:** The force  $F$  required to maintain a spring stretched  $x$  units beyond its natural length is proportional to  $x$ :

$$F(x) = kx.$$

**Exercise 5.** (7p448) Suppose that 2 J of work are needed to stretch a spring from its natural length of 30 cm to a length of 42 cm. How much work is needed to stretch it from 35 cm to 40 cm?

**Exercise 6.** (12p448) A uniform cable hanging over the edge of a tall building is 40 ft long and weight 60 lb. How much work is required to pull 10 ft of the cable to the top.

**Exercise 7.** (16p448) A circular swimming pool has a diameter of 24 ft, the sides are 5 ft high, and the depth of the water is 4ft. How much work is required to pump all of the water out over the side? Use the fact that the water weighs  $62.5 \text{ lb/ft}^3$ .

**Exercise 8.** (18p448) A tank is full of water. Find the work required to pump the water out of the outlet.

