Section 7.5

Definition of Work Done by a Constant Force: If an object is moved a distance D in the direction of an applied constant force F, then the work W done by the force is defined as $W = FD$.

Units for Work: In the U.S. system, work is measured in foot-pounds, inch-pounds, or foot-tons. In the metric system, work is measure in ergs or joules.

Definition of Work Done by a Variable Force: If an object is moved along a straight line by a continuously varying force $F(x)$, then the work W done by the force as the object is moved from $x = a$ to $x = b$ is

$$W = \lim_{\|\Delta\| \to 0} \sum_{i=1}^{n} \Delta W_i = \int_a^b F(x)\, dx.$$

Hooke's Law: The force F required to compress or stretch a spring (within its elastic limits) is proportional to the distance d that the spring is compressed or stretched from its original length. That is,

$$F = kd$$

where the constant of proportionality k (the spring constant) depends on the specific nature of the spring.

Newton's Law of Universal Gravitation: The force F of attraction between two particles of masses m_1 and m_2 is proportional to the product of the masses and inversely proportional to the square of the distance d between the two particles. That is,

$$F = k\frac{m_1 m_2}{d^2}.$$

If m_1 and m_2 are given in grams and d in centimeters, F will be in dynes for a values of $k = 6.670 \times 10^{-8}$ cubic centimeters per gram-second squared.

Coulomb's Law: The force F between two charges q_1 and q_2 in a vacuum is proportional to the product of the charges and inversely proportional to the square of the distance between the two charges. That is,

$$F = k\frac{q_1 q_2}{d^2}.$$

If q_1 and q_2 are given in electrostatic units and d in centimeters, F will be in dynes for a value of $k = 1$.

1) A force of 30 pounds compresses a spring 5 inches from its natural length of 20 inches.

   a) Find the amount of work required to compress the spring 8 inches.

   b) Find the amount of work required to compress the spring from 8 inches to 10 inches.

2) Assume the radius of Earth is 4000 miles. Determine the work done in propelling a 5 ton satellite to a height of

   a) 100 miles above the surface of Earth.

   b) 300 miles above the surface of Earth.

3) Mercury is held in a circular cylinder with radius 2 feet and height 5 feet. If there are 4 feet of mercury in the container, calculate the work required to remove all of it. The density of mercury is 844 pounds per cubic foot.

4) A 10 foot chain weighing 10 pounds per foot is lying on the ground. How much work is required to raise one end of the chain to a height of 10 feet (so that it is fully extended)?

Homework for 7.5: #1, 5, 9, 11, 12, 17, 19, 24