Chapter 7: Work & Kinetic Energy

Questions and Example Problems

\[ W = \int \mathbf{F} \cdot d\mathbf{s} \quad W = \Delta K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \quad W_s = -\left( \frac{1}{2} m x_f^2 - \frac{1}{2} m x_i^2 \right) \quad P = \frac{dW}{dt} = \mathbf{F} \cdot \mathbf{v} = F v \cos \theta \]

**Questions**

a. A woman swimming upstream in a fast river is not moving with respect to the shore. Is she doing any work? If she stops swimming and merely floats, is work done on her?

b. When you use an automobile jack, you lift a car by exerting a force much smaller in magnitude than the weight of the car. Does this mean that you do less work on the car than if you had lifted the car directly? Explain.

c. Can the normal force on an object ever do work? Explain.

d. When a constant force is applied to a body moving with constant acceleration, is the power of the force constant? If no, how would the force have to vary with speed for the power to be constant?

**Example 7.1**

The figure shows an overhead view of three horizontal forces acting on a box that was initially stationary but that now moves across a frictionless floor. (i) Determine the net work done on the box by the three forces during the first 4.00 m of displacement using two different ways: (i) \( W_{\text{total}} = F_{\text{net}} d \) and (ii) \( W_{\text{total}} = F_{\text{net}} \cdot d \) (the dot product).

**Example 7.2**

A cave rescue team lifts an injured spelunker directly upward and out of a sinkhole by means of a motor-driven cable. The lift is performed in three stages, each requiring a vertical distance of 10.0 m: (1) the initially stationary spelunker is accelerated to a speed of 5.00 m/s; (2) he is then lifted at the constant speed of 5.00 m/s; (3) finally he is decelerated to zero speed. (a) Draw a work-energy diagram of the rescuee. (b) How much work is done on the 80.0 kg rescuee by the force lifting him during each stage?
Example 7.3
An air-track glider of mass 0.100 kg is attached to the end of a horizontal air track by a spring with force constant 20.0 N/m. Initially the spring is unstretched and the glider is moving at 1.50 m/s to the right. Determine the maximum distance d that the glider moves to the right if the air track is (a) turned on ($\mu_k = 0$), and (b) turned off ($\mu_k = 0.47$). (c) For each situation, draw a work-energy diagram of the glider.

Example 7.4
The acceleration of a 2.00 kg particle as an applied force $F_a$ moves it from rest along an x axis from $x = 0$ to $x = 9.0$ m. How much work has the force done on the particle when the particle reaches (a) $x = 4.0$ m, (b) $x = 7.0$ m, and (c) $x = 9.0$ m? What is the particle’s speed and direction of travel when it reaches (d) $x = 4.0$ m, (e) $x = 7.0$ m, and (f) $x = 9.0$ m? (g) For each situation, draw a work-energy diagram of the particle.