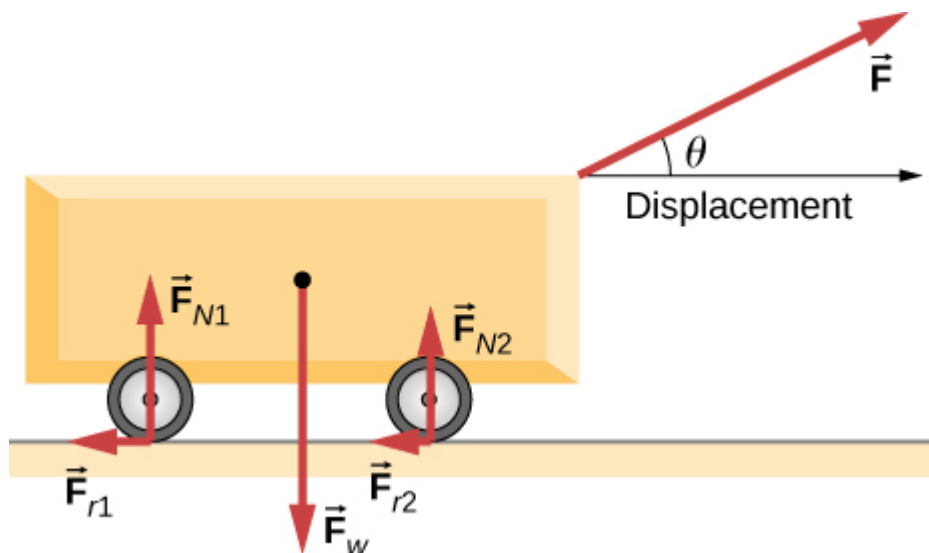


## Additional Problems

**84** . A cart is pulled a distance  $D$  on a flat, horizontal surface by a constant force  $F$  that acts at an angle  $\theta$  with the horizontal direction. The other forces on the object during this time are gravity ( $F_w$ ), normal forces ( $F_{N1}$  and  $F_{N2}$ ), and rolling frictions  $F_{r1}$  and  $F_{r2}$ , as shown below. What is the work done by each force?



**85** . Consider a particle on which several forces act, one of which is known to be constant in time:  $\vec{F}_1 = (3 \text{ N})\hat{i} + (4 \text{ N})\hat{j}$ . As a result, the particle moves along the  $x$ -axis from  $x = 0$  to  $x = 5 \text{ m}$  in some time interval. What is the work done by  $\vec{F}_1$  ?

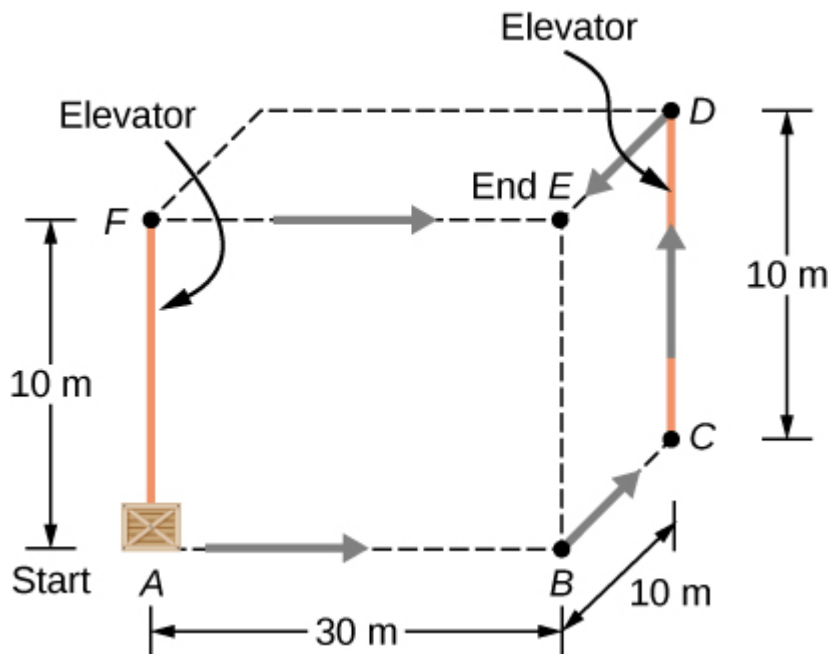
**86** . Consider a particle on which several forces act, one of which is known to be constant in time:  $\vec{F}_1 = (3 \text{ N})\hat{i} + (4 \text{ N})\hat{j}$ . As a result, the particle moves first along the  $x$ -axis from  $x = 0$  to  $x = 5 \text{ m}$  and then parallel to the  $y$ -axis from  $y = 0$  to  $y = 6 \text{ m}$ . What is the work done by  $\vec{F}_1$  ?

**87** . Consider a particle on which several forces act, one of which is known to be constant in time:  $\vec{F}_1 = (3 \text{ N})\hat{i} + (4 \text{ N})\hat{j}$ . As a result, the particle moves along a straight path from a Cartesian coordinate of  $(0 \text{ m}, 0 \text{ m})$  to  $(5 \text{ m}, 6 \text{ m})$ . What is the work done by  $\vec{F}_1$  ?

**88** . Consider a particle on which a force acts that depends on the position of the particle. This force is given by  $\vec{F}_1 = (2y)\hat{i} + (3x)\hat{j}$ . Find the work done by this force when the particle moves from the origin to a point 5 meters to the right on the  $x$ -axis.

**89** . A boy pulls a 5-kg cart with a 20-N force at an angle of  $30^\circ$  above the horizontal for a length of time. Over this time frame, the cart moves a distance of 12 m on the horizontal floor. (a) Find the work done on the cart by the boy. (b) What will be the work done by the boy if he pulled with the same force horizontally instead of at an angle of  $30^\circ$  above the horizontal over the same distance?

**90** . A crate of mass 200 kg is to be brought from a site on the ground floor to a third floor apartment. The workers know that they can either use the elevator first, then slide it along the third floor to the apartment, or first slide the crate to another location marked C below, and then take the elevator to the third floor and slide it on the third floor a shorter distance. The trouble is that the third floor is very rough compared to the ground floor. Given that the coefficient of kinetic friction between the crate and the ground floor is 0.100 and between the crate and the third floor surface is 0.300, find the work needed by the workers for each path shown from A to E. Assume that the force the workers need to do is just enough to slide the crate at constant velocity (zero acceleration). *Note:* The work by the elevator against the force of gravity is not done by the workers.



**91** . A hockey puck of mass 0.17 kg is shot across a rough floor with the roughness different at different places, which can be described by a position-dependent coefficient of kinetic friction. For a puck moving along the  $x$ -axis, the coefficient of kinetic friction is the following function of  $x$ , where  $x$  is in m:  $\mu(x) = 0.1 + 0.05x$ . Find the work done by the kinetic frictional force on the hockey puck when it has moved (a) from  $x = 0$  to  $x = 2$  m, and (b) from  $x = 2$  m to  $x = 4$  m.

**92** . A horizontal force of 20 N is required to keep a 5.0 kg box traveling at a constant speed up a frictionless incline for a vertical height change of 3.0 m. (a) What is the work done by gravity during this change in height? (b) What is the work done by the normal force? (c) What is the work done by the horizontal force?

**93** . A 7.0-kg box slides along a horizontal frictionless floor at 1.7 m/s and collides with a relatively massless spring that compresses 23 cm before the box comes to a stop. (a) How much kinetic energy does the box have before it collides with the spring? (b) Calculate the work done by the spring. (c) Determine the spring constant of the spring.

**94** . You are driving your car on a straight road with a coefficient of friction between the tires and the road of 0.55. A large piece of debris falls in front of your view and you immediately slam on the brakes, leaving a skid mark of 30.5 m (100-feet) long before coming to a stop. A policeman sees your car stopped on the road, looks at the skid mark, and gives you a ticket for traveling over the 13.4 m/s (30 mph) speed limit. Should you fight the speeding ticket in court?

**95** . A crate is being pushed across a rough floor surface. If no force is applied on the crate, the crate will slow down and come to a stop. If the crate of mass 50 kg moving at speed 8 m/s comes to rest in 10 seconds, what is the rate at which the frictional force on the crate takes energy away from the crate?

**96** . Suppose a horizontal force of 20 N is required to maintain a speed of 8 m/s of a 50 kg crate. (a) What is the power of this force? (b) Note that the acceleration of the crate is zero despite the fact that 20 N force acts on the crate horizontally. What happens to the energy given to the crate as a result of the work done by this 20 N force?

**97** . Grains from a hopper falls at a rate of 10 kg/s vertically onto a conveyor belt that is moving horizontally at a constant speed of 2 m/s. (a) What force is needed to keep the conveyor belt moving at the constant velocity? (b) What is the minimum power of the motor driving the conveyor belt?

**98** . A cyclist in a race must climb a  $5^\circ$  hill at a speed of 8 m/s. If the mass of the bike and the biker together is 80 kg, what must be the power output of the biker to achieve the goal?