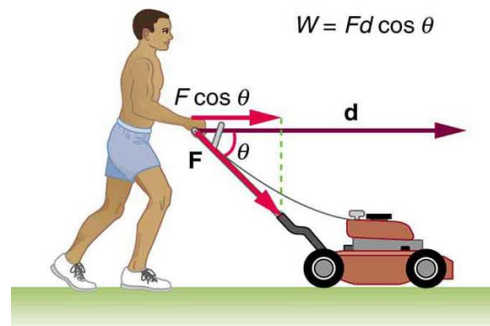## Work

Depends on _____ and the _____ the force moves the object

Want the force in the direction of the _____

$$W = Fd \cos \theta$$

Unit: N m = Joule (J)

_____ (but can be positive and negative)

$W = Fd \cos \theta$

$F \cos \theta$

d

F θ

Marcy pulls a backpack on wheels down the 100-m hall. The 60-N force is applied at an angle of 30° above the horizontal. How much work is done by Marcy?

Mark is carrying books (200 N) down the 100-m hall. How much work is Mark doing on the books?

You carry some books (200 N) while walking down stairs height 2 m and length 3 m. How much work do you do?

A suitcase is hanging straight down from your hand as you ride an escalator. Your hand exerts a force on the suitcase, and this force does work. Which one of the following is correct?

a.   The W is negative when you ride up and positive when you ride down

b.   The W is positive when you ride up and negative when you ride down

c.   The W is positive

d.   The W is negative

$W = Fd$

$F = ma$

So work by a _____ gives an object some _____

Acceleration means the _____ changes

$$W = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2$$

Energy is the _____ to do _____

Kinetic Energy — Energy due to _____

$$KE = \frac{1}{2}mv^2$$

_____

Unit: Joule

Work-Energy Theorem

$$W = KE_f - KE_0$$

A 0.075-kg arrow is fired horizontally. The bowstring exerts a force on the arrow over a distance of 0.90 m. The arrow leaves the bow at 40 m/s. What average force does the bow apply to arrow?

1. A box is being moved with a velocity v by a force P (parallel to v) along a level horizontal floor. The normal force is F_N, the kinetic frictional force is f_k, and the weight of the box is mg. Decide which forces do positive, zero, or negative work. Provide a reason for each of your answers.

2. A sailboat is moving at a constant velocity. (a) Is work being done by a net external force acting on the boat? Explain. (b) Recognizing that the wind propels the boat forward and the water resists the boat's motion, what does your answer in part (a) imply about the work done by the wind's force compared to the work done by the water's resistive force?

3. A slow-moving car may have more kinetic energy than a fast-moving motorcycle. How is this possible?

4. Work done on a system puts energy into it. Work done by a system removes energy from it. Give an example for each statement.

5. The brakes of a truck cause it to slow down by applying a retarding force of 3.0×10^3 N to the truck over a distance of 850 m. What is the work done by this force on the truck? Is the work positive or negative? Why? (Cutnell 6.1) $-\mathbf{2.6 \times 10^6}$ **J**

6. A person pulls a toboggan for a distance of 35.0 m along the snow with a rope directed 25.0° above the snow. The tension in the rope is 94.0 N. (a) How much is done on the toboggan by the tension force? (b) How much work is done if the same tension is directed parallel to the snow? (Cutnell 6.3) **2980 J, 3290 J**

7. A 75.0-kg man is riding an escalator in a shopping mall. The escalator moves the man at a constant velocity from ground level to the floor above, a vertical height of 4.60 m. What is the work done on the man by (a) the gravitational force and (b) the escalator? (Cutnell 6.4) **-3380 J, 3380 J**

8. Suppose in the picture that 1100 J of work are done by the force F = 30.0 N in moving the suitcase a distance of 50.0 m. At what angle θ is the force oriented with respect to the ground? (Cutnell 6.5) **42.8°**

9. A person pushes a 16.0-kg shopping cart at a constant velocity for a distance of 22.0 m. She pushes in a direction 29.0° below the horizontal. A 48.0-N frictional force opposes the motion of the cart. (a) What is the magnitude of the force that the shopper exerts? (review) Determine the work done by (b) the pushing force, (c) the frictional force, and (d) the gravitational force. (Cutnell 6.7) **54.9 N, 1060 J, -1060 J, 0 J**

10. (a) Calculate the work done on a 1500-kg elevator car by its cable to lift it 40.0 m at constant speed, assuming friction averages 100 N. (b) What is the work done on the lift by the gravitational force in this process? (c) What is the total work done on the lift? (OpenStax 7.3) $\mathbf{5.92 \times 10^5}$ **J,** $\mathbf{-5.88 \times 10^5}$ **J, 0 J**

11. How much work is done by the boy pulling his sister 30.0 m in a wagon as shown in Figure 7.36? Assume no friction acts on the wagon. (OpenStax 7.6) $\mathbf{1.30 \times 10^3}$ **J**

12. Compare the kinetic energy of a 20,000-kg truck moving at 110 km/h with that of an 80.0-kg astronaut in orbit moving at 27,500 km/h. (OpenStax 7.9) $\mathbf{9.34 \times 10^6}$ **J,** $\mathbf{2.33 \times 10^9}$ **J**

13. (a) How fast must a 3000-kg elephant move to have the same kinetic energy as a 65.0-kg sprinter running at 10.0 m/s? (b) Discuss how the larger energies needed for the movement of larger animals would relate to metabolic rates. (OpenStax 7.10) **1.47 m/s**

14. A car's bumper is designed to withstand a 4.0-km/h (1.1-m/s) collision with an immovable object without damage to the body of the car. The bumper cushions the shock by absorbing the force over a distance. Calculate the magnitude of the average force on a bumper that collapses 0.200 m while bringing a 900-kg car to rest from an initial speed of 1.1 m/s. (OpenStax 7.13) $-\mathbf{2.8 \times 10^3}$ **N**

15. Two cars, A and B, are traveling with the same speed of 40.0 m/s, each having started from rest. Car A has a mass of 1200 kg, and car B has a mass of 2000 kg. Compared to the work required to bring car A up to speed, how much additional work is required to bring car B up to speed? (Cutnell 6.17) $\mathbf{6.4 \times 10^5}$ **J**

16. A 5.0×10^4-kg space probe is traveling at a speed of 11000 m/s through deep space. Retrorockets are fired along the line of motion to reduce the probe's speed. The retrorockets generate a force of 4.0×10^5 N over a distance of 2500 km. What is the final speed of the probe? (Cutnell 6.18) **9000 m/s**