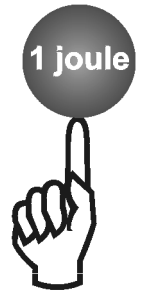
Name: _____

Skill Sheet 10.2 Work

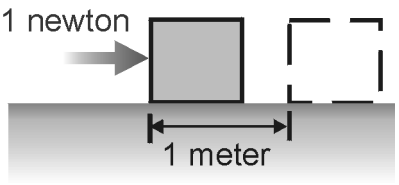
In science, "work" is defined with an equation. Work is defined as force times distance. By measuring how much force you have used to move something over a certain distance, you can calculate how much work you have accomplished. This skill sheet reviews the work equation and provides problems for you to practice using this equation.

1. What is work?

As you recall, in science work is defined as force acting over a distance. That is, a force acts upon an object to move it a certain distance. However, to do work according to this definition, the force must be applied in the same direction as the movement. For example, if you lift a box off a table, the force applied is upward and the distance is also upward. This means that you have done work. However, if you lift the box off the table and then carry it to a shelf, only the lifting is work. Carrying the box is not work because the force on the box is upward but the distance is horizontal. However, you would be doing work if you pushed the box across the floor. Why?



is the amount of work done by pushing with a force of 1 newton for a distance of 1 meter.



Remember, the only time that work is done is when the force and the distance are in the same direction. So, in scientific terms, work is the force that is applied to an object in the same direction as the motion. The formula for work is:

$$\text{Work (joules)} = \text{Force (newtons)} \times \text{distance (meters)}$$

$$W = F \times d$$

You should note and remember that a *joule* of work is a *newton-meter*; both units represent the same thing: WORK. In fact, one joule of work is defined as a force of one newton exerted on an object to move it a distance of one meter.

$$1.0 \text{ joule} = 1.0 \text{ N} \times 1.0 \text{ meter} = 1.0 \text{ newton-meter}$$

2. Applying your knowledge

1. In your own words, define work in scientific terms. Be complete in your definition.

_____

2. How are work, force, and distance related?

_____

3. What are two different units that represent work?

_____

3. Solving work problems

Solve the following problems using the formula for work. The first problem is done for you. Write your answers in joules.

1. How much work is done on a 10-newton block that is lifted 5 meters off the ground by a pulley?

$$\text{work} = F \times d = 10\ \text{N} \times 5\ \text{meters} = 50\ \text{newton-meters} = 50\ \text{joules}$$

2. A woman lifts her 100-newton daughter up 1 meter and carries her a distance of 50 meters to her bedroom. How much work does the woman do?

3. You pulled your sled through the snow a distance of 500 meters with a force of 200 newtons. How much work did you do?

4. An ant sits on the back of a mouse. The mouse carries the ant a distance of 10 meters across the floor. Was there any work done by the mouse? Explain.

5. You did 170 joules of work lifting your140-newton backpack. How high did you lift your backpack?

6. In problem 5, how much did the backpack weigh in pounds? (HINT: There are 4.448 newtons in one pound)

7. A crane does 62,500 joules of work to lift a boulder a distance of 25.0 meters. How much did the boulder weigh? (HINT: The weight of an object is considered to be a force.)

8. You lift a 45-newton bag of mulch 1.2 meters and carry it a distance of 10 meters to your garden. How much work was done?

9. A 455-newton gymnast jumps upward a distance of 1.50 meters to reach the uneven parallel bars. How much work did she do before she even began her routine?

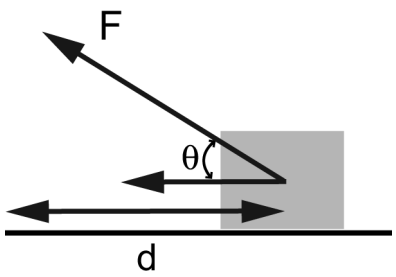
10. It took a 500-newton ballerina a force of 250 joules to lift herself upward through the air. She landed a total of 2.5 meters to the left after completing her jump. How high did she jump?

11. A people-moving conveyor belt moves a 600-newton person a distance of 100 meters through the airport. How much work was done?

12. A 600-newton passenger at the airport lifts his 100-newton carry-on bag upward a distance of 1 meter. They ride for 100 meters on the "people mover." How much work was done in this situation?

4. Solving work problems that involve angles

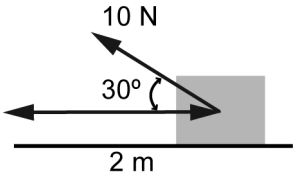
Sometimes work problems involve angles. When the applied force is at an angle to the direction of motion, the only component of the force that contributes to the work is that which is along the direction of motion. As shown on the schematic below, when a force (F) is applied at an angle θ to the direction of motion, the work done by the force (F) as the object moves a distance (d) as indicated is:



$$W = Fd\cos\theta$$

Note that as the angle θ increases, the work done by the force (F) along (d) is decreasing. When θ becomes 90°, the work done by the force (F) along d is zero. Use this information to answer the following questions.

A 10-kilogram box is pulled along the floor by a force of 10 newtons that is at an angle of 30 degrees from horizontal. The box is pulled over a horizontal distance of 2 meters.



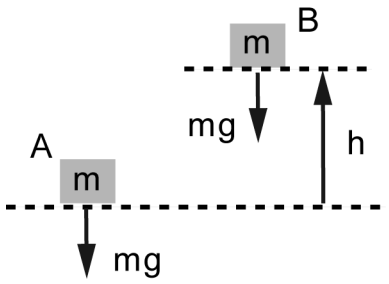
1. How much work is done by the force on the box?

2. What is the work done by the force when the angle increases to 80 degrees?

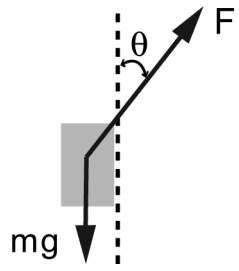
5. Solving work problems using the potential energy equation

When objects of mass (m) are moved vertically, the work done by the force of gravity (mg) is $W = mgh$, where h is the vertical distance in meters that the mass has been moved.

For example, the work done against the force of gravity by moving the mass (m) from position A to position B is $W = mgh$. Note that this work is now stored in the system as energy. If the energy at position A is zero, when the object moves to position B it has potential energy (E) so that $E = mgh$. Use this information to answer the following questions.



An 10-kilogram object is pulled up a vertical wall by a force of 500 newton which acts at an angle 45 degrees.
m = 10 kilograms; θ = 45°; g = 9.8 m/sec^2.



1. What is the work done by the force F on the object as it moves up a distance of 5 meters?

2. What is the work done against the force of gravity as the object is pulled up 5 meters?