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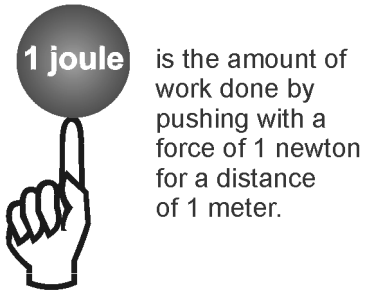
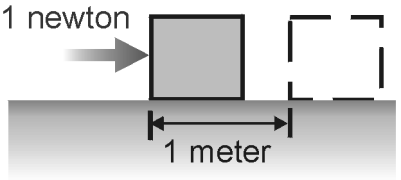
Skill Sheet 5-A Work

In science, "work" is defined with an equation. Work is defined as the amount of force applied over 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 through 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 up, 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 bookshelf, only the lifting is work. Carrying the box is not work because the force on the box is up, and the distance is horizontal. However, you would be doing work if you pushed the box across the floor. Why?





Remember, the only time when 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 that a *joule* of work is actually a *newton-meter*; both units represent the same thing: work! In fact, one joule of work is defined as a force of one newton that is exerted on an object to 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.

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

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3. What are two different units that represent work?

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3. Solving work problems

Solve the following problems using the formula for work. The first problem is done for you.

1. How much work is done on a 10 N 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 child up 1 meter and carries her for a distance of 50 meters to her bedroom. How much work does the woman do?

3. You pull 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 across the floor for a distance of 10 meters. Was there work done by the mouse? Explain.

5. You did 170 joules of work lifting a 140 N backpack. How high did you lift the 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 N bag of mulch 1.2 meters and carry it a distance of 10 meters to the garden. How much work was done?

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9. A 455-N 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?

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10. .It took a 500.0-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?

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

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12. A 600 N person lifts his 100 N carry-on bag upward a distance of 1 meter. They travel 100 meters by riding on the "people mover." How much work was done in this situation?

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Skill Sheet 5-B Power

In science, work is defined as the force needed to move an object a certain distance. Suppose that you and a friend needed to move two 500-newton piles of potting soil to a garden that was 100 meters away. You accomplished this task in 10 minutes while your friend took 30 minutes. Both of you did the same amount of work (force × distance), but you did the work in a shorter amount of time. The amount of work done per unit of time is called power. In the example, you had more power than your friend. This skill sheet will give you practice with how to calculate power.

1. What is power?

Both you and your friend did the same amount of work.

$$W = F \times d$$

$$W = 500\ \text{N} \times 100\ \text{m} = 50{,}000\ \text{joules}$$

However, you had more power than your friend.

$$\text{Power (watts)} = \frac{\text{Work (joules)}}{\text{Time (seconds)}}$$

Let's do the math to see how this is possible.

Step one: Convert minutes to seconds.

$$10\ \text{minutes} \times \frac{60\ \text{seconds}}{\text{minute}} = 600\ \text{seconds (You)}$$

$$30\ \text{minutes} \times \frac{60\ \text{seconds}}{\text{minute}} = 1{,}800\ \text{seconds (Friend)}$$

Step two: Find power.

$$\frac{50{,}000\ \text{joules}}{600\ \text{seconds}} = 83.3\ \text{watts (You)}$$

$$\frac{50{,}000\ \text{joules}}{1{,}800\ \text{seconds}} = 27.7\ \text{watts (Friend)}$$

As you can see, the same amount of work that is done in less time produces more power. You are familiar with the word *watt* from a light bulb. It is now clear to you why a 100-watt bulb is more powerful than a 40-watt bulb. So, now it is time for you to practice solving some problems involving work and power.

2. Solving problems

Solve the following problems using the power and work equations. The first problem is done for you.

1. A motor does 5,000 joules of work in 20 seconds. What is the power of the motor?

$$\text{power} = \frac{\text{work}}{\text{time}} = \frac{5000 \text{ joules}}{20 \text{ sec}} = \frac{250 \text{ joules}}{\text{sec}} = 250 \text{ watts}$$

2. A machine does 1,500 joules of work in 30 seconds. What is the power of this machine?

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3. A sleigh weighs 2,000 N and is pulled by a horse a distance of 1.0 kilometer (that's 1,000 meters) in 45 minutes. What is the power of the horse? (Hint: Convert time to seconds.)

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4. A wagon weighs 1,800 N and is pulled by a horse at a speed of 0.40 meters/second. What is the power of this horse?

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5. Suppose a force of 100 N is used to push an object a distance of 5 meters in 15 seconds. Find the work done and the power for this situation.

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6. A force of 100 N is used to move an object a distance of 15 meters with a power of 25 watts. Find the work done and the time it takes to do the work.

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7. If a small machine does 2,500 joules of work on an object to move it a distance of 100 meters in 10 seconds, what is the force needed to do the work? What is the power of the machine doing the work?

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8. A machine uses a force of 200 N to do 20,000 joules of work in 20 seconds. Find the distance the object moved and the power of the machine. (Hint: A joule is the same as a Newton-meter.)

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9. A machine that uses 200 watts of power moves an object a distance of 15 meters in 25 seconds. Find the force needed and the work done by this machine.

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