

## 4E Work

### Read:

In science, “work” is defined with an equation. Work is the amount of force applied to an object (in the same direction as the motion) over a 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.

The formula for work is:

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

$$W = F \times d$$

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

$$1.0 \text{ joule} = 1.0 \text{ newton} \times 1.0 \text{ meter} = 1.0 \text{ newton} \cdot \text{meter}$$

### Example:

- How much work is done on a 10-N block that is lifted 5 m off the ground by a pulley?

**Solution:** The force applied by the pulley to lift the block is equal to the block’s weight. We can use the formula  $W = F \times d$  to solve the problem:

$$\text{Work} = 10 \text{ newtons} \times 5 \text{ meters} = 50 \text{ newton} \cdot \text{meters}$$

### Practice:

1. In your own words, define *work* as a scientific term.

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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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4. For the following situations, determine whether work was done. Write “work done” or “no work done” for each situation.

- a. An ice skater glides for two meters across ice.

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b. The ice skater's partner lifts her up a distance of 1 m.

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c. The ice skater's partner carries her across the ice a distance of 3 m.

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d. After setting her down, the ice skater's partner pulls her across the ice a distance of 10 m.

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e. After skating practice, the ice skater lifts her 20-N gym bag up 0.5 m.

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5. A woman lifts her 100-N child up one meter and carries her for a distance of 50 m to the child's bedroom. How much work does the woman do?

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6. How much work does a mother do if she lifts each of her twin babies upward 1.0 m? Each baby weighs 90 N.

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7. You pull your sled through the snow a distance of 500 m with a horizontal force of 200 N. How much work did you do?

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8. Because the snow suddenly gets too slushy, you decide to carry your 100-N sled the rest of the way home. How much work do you do when you pick up the sled, lifting it 0.5 m upward? How much work do you do to carry the sled if your house is 800 m away?

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9. An ant sits on the back of a mouse. The mouse carries the ant across the floor for a distance of 10 m. Was there work done by the mouse? Explain.

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10. You decide to add up all the work you did yesterday. If you accomplished 10,000 N · m of work yesterday, how much work did you do in units of joules?

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11. You did 150 J of work lifting a 120-N backpack.

a. How high did you lift the backpack?

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b. How much did the backpack weigh in pounds? (Hint: There are 4.448 N in one pound.)

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12. A crane does 62,500 J of work to lift a boulder a distance of 25.0 m. How much did the boulder weigh? (Hint: The weight of an object is considered to be a force in units of newtons.)

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13. A bulldozer does 30,000 J of work to push another boulder a distance of 20 m. How much force is applied to push the boulder?

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14. You lift a 45-N bag of mulch 1.2 m and carry it a distance of 10 m to the garden. How much work was done?

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15. A 450-N gymnast jumps upward a distance of 0.50 m to reach the uneven parallel bars. How much work did she do before she even began her routine?

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16. It took a 500-N ballerina a force of 250 J to lift herself upward through the air. How high did she jump?

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17. A people-moving conveyor-belt moves a 600-N person a distance of 100 m through the airport.

a. How much work was done?

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b. The same 600-N person lifts his 100-N carry-on bag upward a distance of 1 m. They travel another 10 m by riding on the “people mover.” How much work was done in this situation?

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18. Which person did the most work?

- a. John walks 1,000 m to the store. He buys 4.448 N of candy and then carries it to his friend's house which is 500 m away.
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- b. Sally lifts her 22-N cat a distance of 0.50 m.
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- c. Henry carries groceries from a car to his house. Each bag of groceries weighs 40 N. He has 10 bags. He lifts each bag up 1 m to carry it and then walks 10 m from his car to his house.
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