

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.

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

3. What are two different units that represent work?

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.

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

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

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

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

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?

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.

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?

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?

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.

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?

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

a. How high did you lift the backpack?

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

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.)

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?

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?

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?

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

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?

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?

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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