The weight lifter applies a large force to hold the barbell over his head.

Because the barbell is motionless, no work is done on the barbell.

DOK question:

Construct a visual representation of what is happening here.

What Is Work?

When does a force do work?

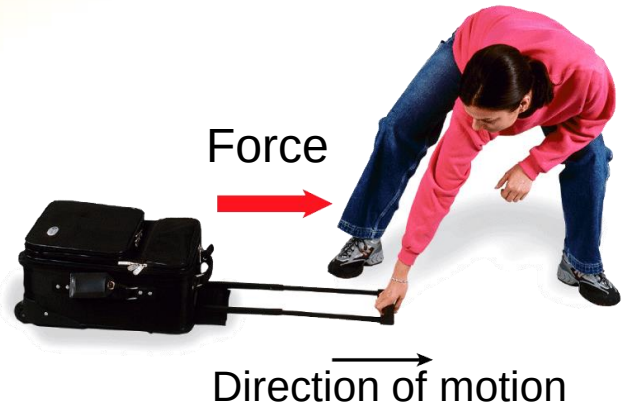
In science, **work** is the product of force and distance.

What Is Work?

- For a force to do work on an object, some of the force must act in the same direction as the object moves. If there is no movement, no work is done.
- Any part of a force that does not act in the direction of motion does no work on an object.

What Is Work?

A. All of the force does work on the suitcase.

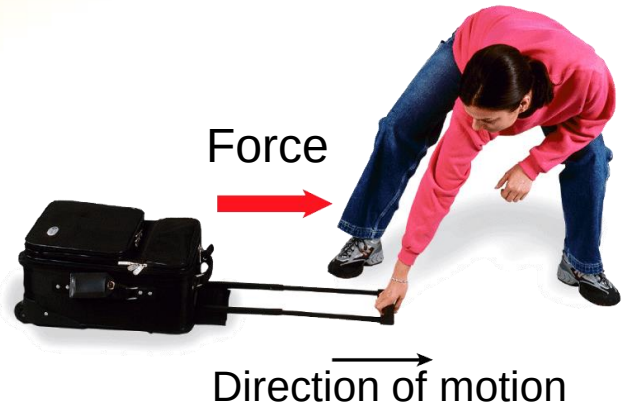


A Force and motion in the same direction

What Is Work?

A. All of the force does work on the suitcase.

B. The horizontal part of the force does work.



A Force and motion in the same direction

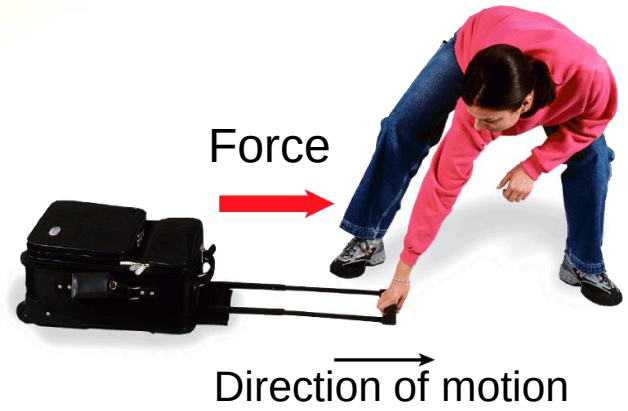
B Part of force in direction of motion

What Is Work?

A. All of the force does work on the suitcase.

B. The horizontal part of the force does work.

C. The force does no work on the suitcase.



A Force and motion in the same direction

B Part of force in direction of motion

C Lifting force not in direction of motion

Calculating Work

Work

$$\text{Work} = \text{Force} \times \text{Distance}$$

Calculating Work

Units of Work

When using SI units in the work formula, the force is in newtons, and distance is in meters.

The **joule** (J) is the SI unit of work. A joule is equal to 1 newton-meter.

DOK question:

Construct another example of combining units utilizing previous units (m, s, or s^2).

Calculating Work

Using the Work Formula

A weight lifter raises a 1600-newton barbell to a height of 2.0 meters.

- Work = Force × Distance
- Work = 1600 N × 2.0 m
- Work = 3200 N·m = 3200 J

What Is Power?

How are work and power related?

Power is the rate of doing work.

Doing work at a faster rate requires more power. To increase power, you can increase the amount of work done in a given time, or you can do a given amount of work in less time.

Calculating Power

Power

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

Calculating Power

When using SI units in the power formula, work is measured in joules (J), and time is measured in seconds (s).

The SI unit of power is the **watt** (W), which is equal to one joule per second.

DOK question:

Construct another example of combining units utilizing previous units (m, s, or s^2).

Calculating Power

Math Practice

1. Your family is moving to a new apartment. While lifting a box 1.5 m straight up to put it on a truck, you exert an upward force of 200 N for 1.0 s. How much power is required to do this?

Calculating Power

Math Practice

1. Your family is moving to a new apartment. While lifting a box 1.5 m straight up to put it on a truck, you exert an upward force of 200 N for 1.0 s. How much power is required to do this?

Answer: Work = Force × Distance =

200 N × 1.5 m = 300 J

Power = Work/Time = 300 J/1.0 s = 300 W

Calculating Power

Math Practice

2. You lift a book from the floor to a bookshelf 1.0 m above the ground. How much power is used if the upward force is 15.0 N and you do the work in 2.0 s?

Calculating Power

Math Practice

2. You lift a book from the floor to a bookshelf 1.0 m above the ground. How much power is used if the upward force is 15.0 N and you do the work in 2.0 s?

Answer: Work = Force × Distance =

15 N × 1.0 m = 15 J

Power = Work/Time = 15 J/2.0 s = 7.5 W

Calculating Power

Math Practice

3. You apply a horizontal force of 10.0 N to pull a wheeled suitcase at a constant speed of 0.5 m/s across flat ground. How much power is used? (*Hint:* The suitcase moves 0.5 m/s. Consider how much work the force does each second and how work is related to power.)

Calculating Power

Math Practice

3. You apply a horizontal force of 10.0 N to pull a wheeled suitcase at a constant speed of 0.5 m/s across flat ground. How much power is used? (*Hint:* The suitcase moves 0.5 m/s. Consider how much work the force does each second and how work is related to power.)

Answer:

Work = Force × Distance =

10.0 N × 0.5 m = 5 J

Power = Work/Time = 5 J/1.0 s = 5 W

James Watt and Horsepower

Another common unit of power is the horsepower. One **horsepower** (hp) is equal to about 746 watts.

James Watt (1736-1819) was looking for a way to compare the power outputs of steam engines he had designed. Horses were a logical choice for comparison as they were the most commonly used source of power in the 1700s.

Assessment Questions

1. In which of the following cases is work being done on an object?
   a. pushing against a locked door
   b. suspending a heavy weight with a strong chain
   c. pulling a trailer up a hill
   d. carrying a box down a corridor

Assessment Questions

1. In which of the following cases is work being done on an object?
   a. pushing against a locked door
   b. suspending a heavy weight with a strong chain
   c. pulling a trailer up a hill
   d. carrying a box down a corridor

   ANS: C

Assessment Questions

2. A tractor exerts a force of 20,000 newtons to move a trailer 8 meters. How much work was done on the trailer?
   a. 2,500 J
   b. 4,000 J
   c. 20,000 J
   d. 160,000 J

Assessment Questions

2. A tractor exerts a force of 20,000 newtons to move a trailer 8 meters. How much work was done on the trailer?

   a. 2,500 J
   b. 4,000 J
   c. 20,000 J
   d. 160,000 J

   ANS: D

Assessment Questions

3. A car exerts a force of 500 newtons to pull a boat 100 meters in 10 seconds. How much power does the car use?
   a. 5000 W
   b. 6000 W
   c. 50 W
   d. 1000 W

Assessment Questions

3. A car exerts a force of 500 newtons to pull a boat 100 meters in 10 seconds. How much power does the car use?
   a. 5000 W
   b. 6000 W
   c. 50 W
   d. 1000 W

   ANS: A

Assessment Questions

4. One horsepower is a unit of power equal to
   a. 0.746 W.
   b. 1.0 W.
   c. 746 W.
   d. 2,000 W.

Assessment Questions

4. One horsepower is a unit of power equal to
   a. 0.746 W.
   b. 1.0 W.
   c. 746 W.
   d. 2,000 W.

   ANS: C