

Objective 5 Momentum Acceleration & Speed

Calculate speed, momentum, acceleration, work, and power in systems such as in the human body, moving toys, and machines

Speed, Distance, and Time Problem Help and Examples

Speed is the distance traveled per unit of time. A unit means one, such as 1 hour, 1 minute, or 1 second. To calculate the rate of speed you must divide the number of distance units traveled by the number of time units it took to travel that distance. Your answer is the number of distance units you traveled in one time unit.

Speed Formula:

Speed = Distance divided by Time, or $S = D / T$

The following are units of distance, time, and speed. Use them to label the numbers in your problems.

Distance -- miles, kilometers (km), meters (m), feet, yards

Time -- hours (hr), minutes (min), seconds (sec)

Speed -- a combination of a distance unit over a time unit such as miles / hour, kilometers / hr, meters / second, feet / second, miles / minutes, etc.

The slash (/) means divided by and is pronounced "per" when you read a unit. (miles / hr is pronounced miles per hour).

The speed formula can be rearranged to solve for distance or time.

Distance = Speed x Time or $D = S \times T$

Time = Distance / Speed or $T = D / S$

The triangle can help you rearrange the formula. Cover up one of the three letters that you

want to solve for. If the other two are side by side you multiply them to get the third. If one

letter is above the other, divide the letter above by the letter below.

Use the wording of the question to decide which formula to use.

If the problem asks, *What is your speed?* or *How fast did you go?* then use the formula $S = D / T$.

If the problem asks, *How far would you go?* then use the formula $D = S \times T$ because it is asking for distance.

If the problem asks, *How long would it take?* then use the formula $T = D / S$, because it is asking for time.

Show your work on all problems as in the following examples. Use the units to identify the numbers given in the problem. Write down each number and unit and what letter in the formulas it is equal to. Decide what the question is asking for and write the correct formula. Then substitute the right numbers for the parts of the formula and multiply or divide the two numbers to get the answer. Put the correct unit after the answer.

Example 1. What is your speed if you went 300 miles in 5 hours?

$D = 300$ miles

$T = 5$ hours

$S = D / T$

$S = 300 \text{ miles} / 5 \text{ hours} = 60 \text{ miles} / \text{hour}$



Example 2. How far would you travel at 80 km / hr for 5 hours?

$$S = 80 \text{ km / hr}$$

$$T = 5 \text{ hours}$$

$$D = S \times T$$

$$D = 80 \text{ km / hr} \times 5 \text{ hrs} = 400 \text{ km (The hours cancel out)}$$

Example 3. How long would it take to go 250 miles at a speed of 50 miles / hour?

$$D = 250 \text{ miles}$$

$$S = 50 \text{ miles / hour}$$

$$T = D / S$$

$$T = 250 \text{ miles} / 50 \text{ miles / hr} = 5 \text{ hours (The miles cancel out)}$$

Converting Time Units

Formulas: hours = minutes / 60 minutes / hour

$$\text{minutes} = \text{hours} \times 60 \text{ minutes / hour}$$

If you are given speed in miles / hour and the time in minutes, the minutes must be converted to hours before you can calculate the distance traveled.

Example 4. If you go 50 miles / hour for 45 minutes, how far will you go?

$$S = 50 \text{ miles / hour}$$

$$T = 45 \text{ minutes}$$

$$D = S \times T$$

The time units are not the same so you must convert the minutes to hours. Time in hours = time in minutes divided by 60 minutes in an hour.

$$T = 45 \text{ minutes} / 60 \text{ minutes / hour} = 0.75 \text{ hours (The minutes cancel out)}$$

$$D = 50 \text{ miles / hour} \times 0.75 \text{ hours} = 37.5 \text{ miles (Now the hours cancel out)}$$

If you are given the time in a combination of hours and minutes you must convert the minutes to hours and add them to the hours before you can solve the problem.

Example 5. How fast did you go if you traveled 50 miles in 2 hours and 15 minutes?

$$D = 50 \text{ miles}$$

$$T = 2 \text{ hrs and } 45 \text{ min}$$

$$S = D / T$$

You cannot divide 50 miles by 2 hrs and 45 minutes. You must convert the minutes to hours by dividing 45 minutes by 60 minutes in an hour and adding what you get to the hours.

$$T = 2 \text{ hours} + 45 \text{ minutes} / 60 \text{ minutes / hr} = 2 \text{ hours} + 0.75 \text{ hours} = 2.75 \text{ hours}$$

Then you can find the speed.

$$S = 50 \text{ miles} / 2.75 \text{ hrs} = 18.2 \text{ miles / hr}$$

Acceleration Problem Help and Examples

Acceleration is the change in velocity divided by the time. If the velocity increases then the acceleration is positive. If the velocity decreases, then the acceleration is negative.

Acceleration Formulas

Acceleration = Final velocity - Original velocity divided by Time, or

$$1. a = V_f - V_o / t \quad (\text{Subtract } V_o \text{ from } V_f \text{ first and then divide your answer by the } t)$$

The following are units of velocity, time, and acceleration. Use them to label the numbers in your problems.

Velocity -- miles/hr, meters/sec, yards/sec, Kilometers/hr

Time -- hours (hr), minutes (min), seconds (sec)

Acceleration -- miles / hour / sec, meters / sec / sec, yards / sec / sec, meters/sec²

Example 1. If your speed was 30 miles/hr and you sped up to 50 miles/hr in 20 seconds, what was your acceleration?

$$V_o = 30 \text{ miles/hr}$$

$$V_f = 50 \text{ miles/hr}$$

$$t = 20 \text{ seconds}$$

$$a = V_f - V_o / t$$

$$a = 50 \text{ miles/hr} - 30 \text{ miles/hr} / 20 \text{ seconds}$$

$$a = 20 \text{ miles/hr} / 20 \text{ seconds} = \underline{1 \text{ mile/hr/sec}}$$

Example 2. If you go from 40 miles/hr to 10 miles/hr in 5 seconds, what is your acceleration?

$$V_o = 40 \text{ miles/hr}$$

$$V_f = 10 \text{ miles/hr}$$

$$t = 5 \text{ seconds}$$

$$a = V_f - V_o / t$$

$$a = 10 \text{ miles/hr} - 40 \text{ miles/hr} / 5 \text{ seconds}$$

$$a = -30 \text{ miles/hr} / 5 \text{ seconds} = \underline{-6 \text{ miles/hr/sec}}$$

(the answer is negative because you are slowing down, so final velocity is less than original velocity)

The formula can be rearranged to find other things such as time and final velocity.

2. $t = V_f - V_o / a$ (Subtract V_o from V_f first and then divide your answer by a)

3. $V_f = (a \times t) + V_o$ (Multiply a times t first, and then add V_o)

Example 3. How long would it take a car to accelerate from 15 miles/hr to 75 miles/hr if its acceleration is 10 miles/hr/sec?

$$V_o = 15 \text{ miles/hr}$$

$$V_f = 75 \text{ miles/hr}$$

$$a = 10 \text{ miles/hr/sec}$$

$$t = V_f - V_o / a$$

$$t = 75 \text{ miles/hr} - 15 \text{ miles/hr} / 10 \text{ miles/hr/sec}$$

$$t = 60 \text{ miles/hr} / 10 \text{ miles/hr/sec} = \underline{6 \text{ sec}}$$
 (the miles/hr cancel out)

Example 4. What is the final speed of a car that starts at 60 miles/hr and decelerates at a rate of 10 miles/hr/sec for 3 seconds?

$$V_o = 60 \text{ miles/hr}$$

$$a = -10 \text{ miles/hr/sec}$$
 (a is negative since you are decelerating)

$$t = 3 \text{ seconds}$$

$$V_f = (a \times t) + V_o$$

$$V_f = (-10 \text{ miles/hr/sec} \times 3 \text{ sec}) + 60 \text{ miles/hr}$$

$$V_f = -30 \text{ miles/hr} + 60 \text{ miles/hr} = \underline{30 \text{ miles/hr}} \text{ (seconds cancel out)}$$

Example 5. What is the final speed of a car that starts at 10 miles/hr and accelerates at a rate of 5 miles/hr/sec for 4 seconds?

$$V_o = 10 \text{ miles/hr}$$

$$a = 5 \text{ miles/hr/sec} \text{ (a is positive since you are accelerating)}$$

$$t = 4 \text{ seconds}$$

$$V_f = (a \times t) + V_o$$

$$V_f = (5 \text{ miles/hr/sec} \times 4 \text{ sec}) + 10 \text{ miles/hr}$$

$$V_f = 20 \text{ miles/hr} + 10 \text{ miles/hr} = \underline{30 \text{ miles/hr}}$$

Momentum = mass x velocity or $P = m \times v$

Units:

Momentum (kg x m / sec) = mass (kg) x velocity (m/sec)

If two objects collide (hit), the one with more momentum will push the other one back.

A train has a large momentum because of its large mass.

A bullet has a large momentum because of its high velocity.

The stopping distance of an object like a car is related to its momentum.

When two objects collide they transfer their momentums to each other.

Law of Conservation of Momentum – the total momentum of a group of objects remains the same unless outside forces (like friction) act on the objects. The momentum lost by one object is gained by another when they collide.

The faster things move the more energy they must use.

Moving objects have momentum (mass x velocity). Momentum must be conserved because energy must be conserved.

A force is required to change motion of an object.

Work is done when motion is changed. Forces change the energy of an object when they change its motion.

Power is the rate at which work is done, thus power is the rate at which energy is consumed

Work Problem Help and Examples

Work is defined as a force acting through a distance. Work is done only when a force moves an object.

Work Formula

Work = force times distance, or $W = fd$ or $W = f \times d$

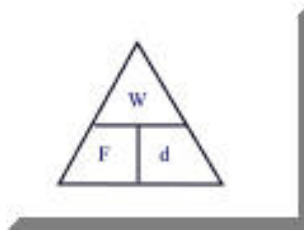
The following are units of work, force, and distance. Use them to label the numbers in your problems.

Work -- Newton-meter (N-m) or Joule (J)

Force -- a combination of a mass unit times an acceleration unit such as $\text{kg} \times \text{meters/sec}^2$. The Newton (N) is a shorthand way to write the force unit provided that mass is in kilograms and acceleration is in meters/sec^2 .

distance -- meters (m) The work formula can be rearranged to solve for force or distance.

force = work / distance or $F = W / d$
distance = work / force or $d = W / F$



The triangle can help you rearrange the formula. Cover up one of the three letters that you want to solve for. If the other two are side by side you multiply them to get the third. If one letter is above the other, divide the letter above by the letter below.

In the work problem worksheets you have word problems that require you to calculate work, force, or distance. Use the wording of the question to decide which formula to use.

If the problem asks, *How much work is done?* or *What is the work?* use the formula $W = Fd$.

If the problem asks, *What force was needed?* then use the formula $F = W / d$.

If the problem asks, *What distance was moved?* then use the formula $d = W / F$.

Show your work on all problems as in the following examples. Use the units to identify the numbers given in the problem. Write down each number and unit and what letter in the formulas it is equal to. Decide what the question is asking for and write the correct formula. Then substitute the right numbers for the parts of the formula and multiply or divide the two numbers to get the answer. Put the correct unit after the answer.

Example 1. If a force of 20 Newtons moves an object 10 meters, what is the work?

$$F = 20 \text{ N}$$

$$d = 10 \text{ m}$$

$$W = Fd$$

$$W = 20 \text{ N} \times 10 \text{ m} = 200 \text{ Newton-meters or } 200 \text{ Joules}$$

Example 2. If it takes 500 Joules of work to move an object 10 meters, what force was needed?

$$W = 500 \text{ J}$$

$$d = 10 \text{ m}$$

$$F = W / d$$

$$F = 500 \text{ J} / 10 \text{ m} \quad \text{or} \quad F = 500 \text{ N-m} / 10 \text{ m} = 50 \text{ Newtons} \quad (\text{The meters cancel out})$$

Example 3. What distance was an object moved by a force of 40 N if the work was 600 Joules?

$$F = 40 \text{ N}$$

$$W = 600 \text{ J}$$

$$d = W / F$$

$$d = 600 \text{ J} / 40 \text{ N} \quad \text{or} \quad d = 600 \text{ N-m} / 40 \text{ N} = 15 \text{ meters} \quad (\text{The Newtons cancel out})$$

Power Problem Help and Examples

Power is defined as the rate of doing work or the amount of work per unit of time.

Power Formula

$$\text{Power} = \text{work divided by time, or } P = W / t$$

The following are units of power, work, and time. Use them to label the numbers in your problems.

Power -- Newton-meters / sec, or Joules / sec, or Watts (W)

Work -- Newton-meters or Joules (J)

time -- seconds (sec)

The power formula can be rearranged to solve for work or time.

work = power x time or $W = Pt$
time = work / power or $t = W / P$



The triangle can help you rearrange the formula. Cover up one of the three letters that you want to solve for. If the other two are side by side you multiply them to get the third. If one letter is above the other, divide the letter above by the letter below.

In the power problems you have word problems that require you to calculate power, work, or time.

Use the wording of the question to decide which formula to use.

If the problem asks, *How much power is needed?* or *What is the power?* use the formula $P = W / t$.

If the problem asks, *How much work was done?* then use the formula $W = Pt$.

If the problem asks, *How long does it take?* then use the formula $t = W / P$.

Show your work on all problems as in the following examples. Use the units to identify the numbers given in the problem. Write down each number and unit and what letter in the formulas it is equal to. Decide what the question is asking for and write the correct formula. Then substitute the right numbers for the parts of the formula and multiply or divide the two numbers to get the answer. Put the correct unit after the answer.

Example 1. How much power is needed to do 600 Joules of work in 100 seconds?

$$W = 600 \text{ J}$$

$$t = 100 \text{ sec}$$

$$P = W / t$$

$$P = 600 \text{ J} / 100 \text{ sec} = 6 \text{ Joules / sec or } 6 \text{ watts}$$

Example 2. If 500 watts of power are used in 50 seconds, how much work was done?

$$P = 500 \text{ W}$$

$$t = 50 \text{ sec}$$

$$W = P \times t$$

$$W = 500 \text{ W} \times 50 \text{ sec or } 500 \text{ J / sec} \times 50 \text{ sec} = 25000 \text{ Joules (The seconds cancel out)}$$

Example 3. How long does it take to do 400 joules of work with 20 watts of power?

$$W = 400 \text{ J}$$

$$P = 20 \text{ W}$$

$$t = W / P$$

$$t = 400 \text{ J} / 20 \text{ W or } t = 400 \text{ J} / 20 \text{ J / sec} = 20 \text{ seconds (The Joules cancel out)}$$