The speed of an object is a measure of how fast it is going.
To know the speed of an object we need to measure distance and time.
Distance (d) is the amount of space between two objects or points.
- it's usually measured in millimeters (mm), centimeters (cm), meters (m), or kilometers (km).
Time (t) is the duration between two events.
- it's usually measured in seconds (s), minutes (min), hours (h), or years (a)

Imagine driving in a car 80 km along a road in one hour.
You would say you travelled 80 km/h.
Were you going the same speed the whole time?
Maybe you speeded up to 100 km/h to pass other vehicles, or stopped for a snack.
Overall, during the entire hour, your **average speed** was 80 km/h.

How do we calculate average speed?
- **average speed** (v_{av}) is calculated by dividing the total distance traveled by the total time taken

$$v_{av} = \frac{\Delta d}{\Delta t} = \frac{d_2 - d_1}{t_2 - t_1} = \frac{d}{t}$$

Δ = "delta"
it means "the change in"

The units for speed are always a distance measurement per time measurement because the formula is

$$v_{av} = \frac{d}{t}$$

For example, km/h, m/s

So, what's the difference between average speed and **instantaneous speed?**

Instantaneous speed of an object is its speed at a particular moment in time.
This guy doesn't care what your speed was a moment ago.
All that matters is your speed at the moment it was measured.

Intro

Solving Problems
Steps:
1. Write down given information.
2. Write down the unknown variable (the one you are solving for).
3. If necessary, rearrange the speed equation for the unknown variable.
4. Plug in the known values, and their units, into the equation and solve for the unknown.

Important reminders
- Only round off at the very end of the calculations.
- Watch significant figures.
- Include the correct units.

Solving Problems

Let's try an example

Julia wants to show off her skating skills so she does a marathon skate around the ice at the QPlex, a distance 4.5 km. She has to slow down a couple of times to skate round Parker who keeps falling down. It takes her 0.62 h. What is Julia's average skating speed?

1. Write down given information.

distance = 4.5 km How many sig dig?

time = 0.62 h

2. Write down the unknown variable (the one you are solving for).

velocity = ?

3. If necessary, rearrange the speed equation for the unknown variable.

$$v_{av} = \frac{d}{t}$$

4. Plug in the known values, and their units, into the equation and solve for the unknown.

$$v_{av} = \frac{4.5 \text{ km}}{0.62 \text{ h}} = 7.3 \text{ km/h}$$

How many sig dig?

Example 1

MacKenzie and Jade take a train trip to Hogwarts. They notice that there are signs marking the distance along the tracks. Never wanting to miss a chance to do a little science, they decide to measure the time between signs. The next two signs read 120 km and 130 km. They record the elapsed time as 390.6 s. Determine the speed of the train between the two signs in kilometers per hour.

1. Write down given information.

d = 10 km
t = 390.6 s

$d_2 = 130$ km
$d_1 = 120$ km

2. Write down the unknown variable (the one you are solving for).

v = ?

3. If necessary, rearrange the speed equation for the unknown variable.

$$v_{av} = \frac{d}{t}$$

How do you feel about those units?

4. Plug in the known values, and their units, into the equation and solve for the unknown.

$$v_{av} = \frac{10 \text{ km}}{390.6 \text{ s}} = 0.0256 \text{ km/s}$$

10.0

- we want km/h

Should we round off first?

How do we convert?

$$\frac{0.0256 \text{ km}}{\text{s}} \left| \frac{60 \text{ s}}{1 \text{ min}} \right| \frac{60 \text{ min}}{1 \text{ h}} = 92 \text{ km/h}$$

How many sig dig?

Example 2

For March break, Aina and Josi decide to visit Spain and Germany One day on the beach they bump into Richard who is building a sand castle. They all decide to get a snack at the hotel restaurant which is 1.9 km away. The restaurant closes in 15 minutes. If they can walk 1.4 m/s, will they make it in time?

1. Write down given information.

d = 1.9 km
v = 1.4 m/s

How do you feel about these units?

- units must be the same
- change the easiest one

$$\frac{1.9 \text{ km}}{} \left| \frac{1000 \text{ m}}{1 \text{ km}} \right. = 1900 \text{ m}$$

2. Write down the unknown variable (the one you are solving for).

t = ?

3. If necessary, rearrange the speed equation for the unknown variable.

$$v_{av} = \frac{d}{t} \quad t = \frac{d}{v}$$

4. Plug in the known values, and their units, into the equation and solve for the unknown.

$$t = \frac{1900 \text{ m}}{1.4 \text{ m/s}} = 1357.14 \text{ s}$$

What units do we want?
- minutes

$$\frac{1357.14 \text{ s}}{} \left| \frac{1 \text{ min}}{60 \text{ s}} \right. = 23 \text{ min}$$

How many sig dig?

Example 3

Alex gets a summer job herding chickens. He loves science so he decides to record the chickens' movements. He notes that they peck around at an average speed of about 110 m/h for about 7.0 h/d. If he were a really good herder and could get the chickens to travel in a straight line, what distance, in kilometers, could the herd travel in a week?

1. Write down given information.

v = 110 m/h
t = 7.0 h

- units must be the same
- let's convert them at the end

How do you feel about these units?

2. Write down the unknown variable (the one you are solving for).

d = ?

3. If necessary, rearrange the speed equation for the unknown variable.

$$v_{av} = \frac{d}{t} \quad d = vt$$

4. Plug in the known values, and their units, into the equation and solve for the unknown.

d = v t
d = (110 m/h)(7.0 h)
= 770 m
= 7.7×10^2 m

How many sig dig?

$$\frac{7.7 \times 10^2 \text{ m}}{} \left| \frac{1 \text{ km}}{10^3 \text{ m}} \right. = 0.77 \text{ km}$$

$$\frac{0.77 \text{ km}}{1 \text{ d}} \left| \frac{7 \text{ d}}{1 \text{ week}} \right. = 5.39 \text{ km/week} = 5.4 \text{ km/week}$$

Example 4

Distance, Speed and Time Practice

1. Hunter gets his license and decides to show off for Sami so he tears down Hampton Road at 97 km/h. How much time would it take him to travel 6.0 km?

2. Julia and Rachelle decide to try out for the cross country running team. How far would they get if they can run 36 km/h for 5 min before collapsing?

3. Josh M gets a drive to school but the car gets a flat tire on the way. He doesn't want to be late for science class so runs the rest of the way. If he is 5.0 km away and can run 15 km/h, how long will it take him to get there?

4. How much time would it take Dax to walk 2 km to McDonald's for an Angus burger if he walked at a rate of 4.5 km/h?

5. MacKenzie decides to skip science class (actually, she would never do that!) but then sees Ms. Jensen in the hallway so she takes off running. What is her average velocity if she goes 100 m down the hallway in 9.83 s? Give your answer in m/s and km/h.

6. Josh M is staying over at Parker's house and they are coming home late, past their curfew. As they sneak in quietly, trying not to wake up his parents, they slink up the stairs moving 10.7 m in 26.8 s. Find their speed.

7. The night before a big science quiz, Aina, Jose, Bianca and Defne decide to study together but instead end up watching chick flicks all night long. Now they don't want to write the quiz and are dragging themselves to class. If their speed is 0.2 m/s, how far will they move in 28 s?

8. Matt has borrowed his parents' car without permission and is driving without a license. He sees them out walking and realizes that they will be home in about 45 seconds. He is 500 m from home and driving 25 m/s. Will she get to the driveway before they do?

9. Some girls are skating at the QPlex and Richard thinks one of them is cute and decides to impress her by doing some tricks. Unfortunately, he is staring at her and crashes into Kasey – an innocent bystander. He falls, making a fool of himself. Calculate how far he will slide on the ice if he were skating at 12 m/s and slid for 2.5 s.

10. Lochlan is pretty pumped about some new Vans he's getting and can't wait to buy them. He runs across the parking lot to the store at 34 m/s. If it takes him 2.5 s to reach the store, how far away was the car parked?

Practice

Distance, Speed and Time Practice

1. Hunter gets his license and decides to show off for Sami so he tears down Hampton Road at 97 km/h. How much time would it take him to travel 6.0 km? (t = 0.062 h)

2. Julia and Rachelle decide to try out for the cross country running team. How far would they get if they can run 36 km/h for 5 min before collapsing? (d = 3 km)

3. Josh M gets a drive to school but the car gets a flat tire on the way. He doesn't want to be late for science class so runs the rest of the way. If he is 5.0 km away and can run 15 km/h, how long will it take him to get there? (d = 20 min)

4. How much time would it take Dax to walk 2 km to McDonald's for an Angus burger if he walked at a rate of 4.5 km/h? (t = 0.44 h)

5. MacKenzie decides to skip science class (actually, she would never do that!) but then sees Ms. Jensen in the hallway so she takes off running. What is her average velocity if she goes 100 m down the hallway in 9.83 s? Give your answer in m/s and km/h. (10.2 m/s; 36.6 km/h)

6. Josh M is staying over at Parker's house and they are coming home late, past their curfew. As they sneak in quietly, trying not to wake up his parents, they slink up the stairs moving 10.7 m in 26.8 s. Find their speed. (0.399 m/s)

7. The night before a big science quiz, Aina, Jose, Bianca and Defne decide to study together but instead end up watching chick flicks all night long. Now they don't want to write the quiz and are dragging themselves to class. If their speed is 0.2 m/s, how far will they move in 28 s? (5.6 m)

8. Matt has borrowed his parents' car without permission and is driving without a license. He sees them out walking and realizes that they will be home in about 45 seconds. He is 500 m from home and driving 25 m/s. Will she get to the driveway before they do? (20 s, yes)

9. Some girls are skating at the QPlex and Richard thinks one of them is cute and decides to impress her by doing some tricks. Unfortunately, he is staring at her and crashes into Kasey – an innocent bystander. He falls, making a fool of himself. Calculate how far he will slide on the ice if he were skating at 12 m/s and slid for 2.5 s. (30 m)

10. Lochlan is pretty pumped about some new Vans he's getting and can't wait to buy them. He runs across the parking lot to the store at 34 m/s. If it takes him 2.5 s to reach the store, how far away was the car parked? (85 m)

Answers

Distance, Speed and Time Quiz

Quiz

What's a graph?

Graphs are used to visually communicate quantitative information.

A graph is easier to interpret than a table or written paragraph.

The **independent variable** is plotted on the **x-axis**.

- this is the variable we change or naturally changes on its own

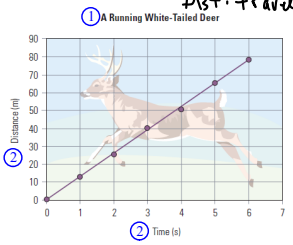
The **dependent variable** is plotted on the **y-axis**.

- this is the one we measure

All graphs MUST have:

- labels on the x- and y-axes showing units of measurement
- a title at the top indicating the information graphed

Dist. travelled by white-tailed deer over time



1) Title

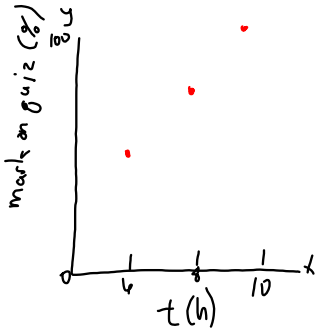
2) Labels on Axes
- quantity
- units
- scale

What's the independent variable? time

What's the dependent variable? distance

Graphing

Quiz result vs. amount of sleep



Nov 28-10:16 AM

1. Complete the table.

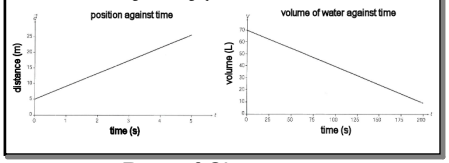
t_i	t_f	Δt	Initial state	Final state	Total change	Average rate of change
3.0 s	17.0 s	17-3=14	10.0 m	28.0 m	28-10=18	18m/14s
0 min	15 min		-10°C	100°C		
1.0 h	9.0 h		1200 kg	350 kg		
35 min	155 min		102 L	12 L		

2. A car is traveling along a straight road. The car is 12.4 km from home at 10:02 a.m. and 74.8 km from home at 11:50 a.m. How fast is the distance changing?

3. A water tank has a volume of 800 L. It develops a leak 23 s after being filled. Later, 327 s after being filled, the volume of water in the tank is 613 L. How fast is the volume of water changing?

4. A can of pop is taken out of a refrigerator and placed on a counter. After 30.0 min, the rate of change of temperature for the pop was found to be 0.7 °C/min. If the pop had a temperature of 5oC in the refrigerator, find its final temperature.

5. Find the rate of change in each graph.



Rate of Change

Changing Student Performance - Part 1

A teacher, Mr. Ganong decides to perform an experiment in which he throws candy at students to try to improve their performance. The results are shown below:

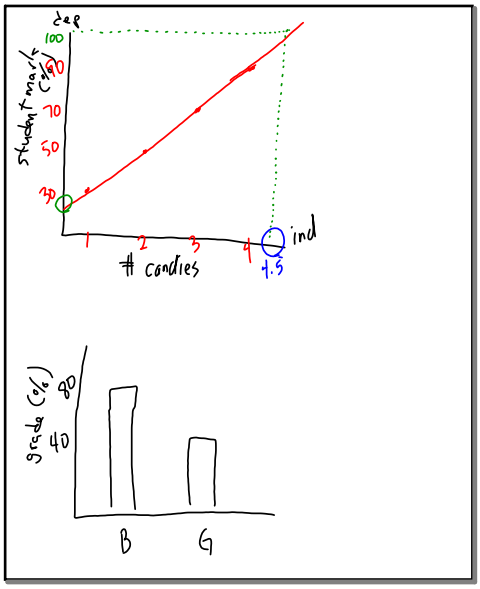
Jimbo got 90% in math and received 4 candies
Betty-Sue got 2 candies and her math mark was 50%
Betty-Ann got 30% in math and received 1 candy.
Bubba got 3 candies and ended up with 70% in math.

1. Organize the data into a chart.
2. Graph the data. Call this graph 1.
3. Construct a bar graph to compare the boys to the girls. Call this graph 2.
4. Describe a situation in which a line graph is the best type of graph while in others a bar graph is best.
5. Use Graph 1 to determine the rate of change.
6. Use Graph 1 to predict the number of candies that would result in a student grade of 100%.
7. Predict the grade you would expect from a student who received no candies.

Line graphs are for cause and effect.

Bar graphs are for comparisons.

Changing student performance



Changing Student Performance - Part 2

Another teacher, inspired by Mr. Ganong's results, decided to try an experiment of his own. Mr. Meene thought he could improve student performance by dishing out insults when students made mistakes. His results are shown below:

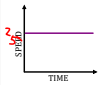
Shadynasty got 70% in math and received 4 insults.
K-Ci got only 1 insult and got 80% in math.
La-A ended up with 50% in math and received 10 insults.
Cviiilyn received 7 insults and got 60% in math.

ABCDE

1. Organize the data into a chart.
2. Graph the data.
3. Use the graph to determine the rate of change.
4. Use the graph to predict the number of insults that would result in a student grade of 100%.
5. Predict the grade you would expect from a student who received no insults.
6. Compare the results of Mr. Ganong and Mr. Meene. If a student received the same number of candies as insults, predict the effect on the student's performance.

Changing student performance part 2

Uniform motion means something is traveling at a **constant speed.**
- speed remains the same over a period of time – no speeding up or slowing down



What's the independent variable? time

What's the dependent variable? speed

What does this graph show us?
- speed is the same at every time

What's the independent variable? time

What's the dependent variable? distance

What does this graph show us?
- the change in distance is the same for all times

How could this happen?
Driving with cruise control keeps your car moving at the same speed.

Non-uniform motion occurs when speed is NOT constant.
- speed changes – speeding up or slowing down.

What's the independent variable? time

What's the dependent variable? speed

What does this graph show us?
- the change in speed is the same for all times

What's the independent variable? time

What's the dependent variable? distance

What does this graph show us?
- the change in distance is NOT the same for all times

How could this happen?
Stepping on the gas or the brake causes your speed to change

Uniform and non-uniform motion

Monitoring Traffic

Monitoring Traffic

Slope in Distance-Time Graphs

Imagine the distance covered by a running white-tailed deer is measured.

Time (s)	Distance (m)
0	0
1	12
2	26
3	41
4	50
5	65
6	78

What's the independent variable? time

What's the dependent variable? distance

Graph these data.

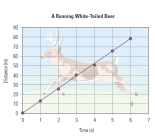
What does the graph show us?
- how the distance (dependent variable) changes with time (independent variable)

What is slope?

- slope is how steep the line is in a graph

$\text{slope} = \frac{\text{rise}}{\text{run}}$

- it shows how much y changes as x changes
- in a distance-time graph y is distance and x is time
- in other words, it shows a change in distance (Δd) as time changes (Δt)



Wait a minute!

- slope of a distance-time graph is y over x which is distance over the time

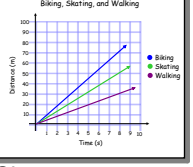
Sound familiar?
- that's speed

$v_{av} = \frac{d}{t}$ How do we calculate speed?

so... the slope of a distance-time graph is velocity

Which one is fastest?
How can you tell?

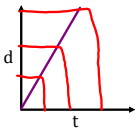
- the greater the slope, the greater the speed (and *vice versa*)



Slope

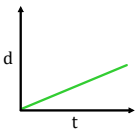
Describe the motion of the object in each graph.

Graph 1



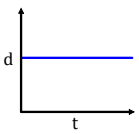
Uniform motion?
- Yes. The change in distance is constant for all times.

Graph 2



Uniform motion?
- Yes. The change in distance is constant for all times.

Graph 3

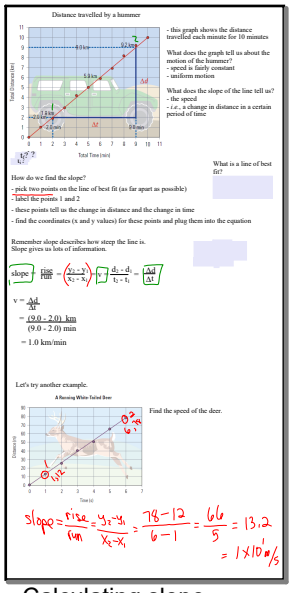


Uniform motion?
- This object is not moving. The distance does not change.

Which object is moving fastest? Graph 1

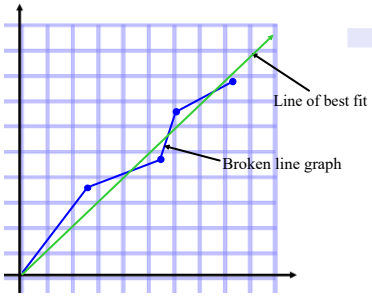
How can you tell? Steeper slope

Describe the graph



Calculating slope

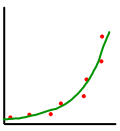
What if the line isn't straight?



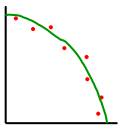
Draw a line of best fit for each graph.

Graph 1

Graph 2



Graph 3



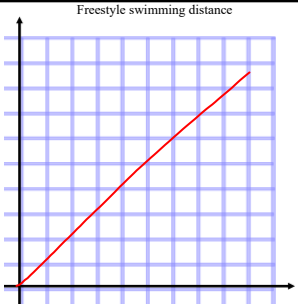
Graphing

What if you don't have the graph?

Time (s)	Freestyle distance (m)
0.0	0.0
5.0	9.5
10.0	18.5
15.0	27.0
20.0	35.5
25.0	45.0

1.8 m/s

Freestyle swimming distance



Draw a graph and find the speed of the swimmer.

$$\text{slope} = \frac{y_2 - y_1}{x_2 - x_1} = v = \frac{d_2 - d_1}{t_2 - t_1} = \frac{\Delta d}{\Delta t}$$

$$= \frac{45.0 - 9.5}{25.0 - 5.0}$$

$$= \frac{35.5}{20.0}$$

= 1.775 How do you feel about the significant digits?

=

Graph the data

The 200-m Individual Medley

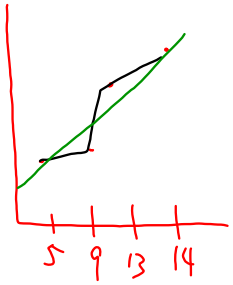
Time (s)	Butterfly distance (m)	Backstroke distance (m)	Breaststroke distance (m)	Freestyle distance (m)
0.0	0.0	0.0	0.0	0.0
5.0	8.2	8.0	7.5	9.5
10.0	16.2	17.0	15.1	18.5
15.0	24.7	24.5	22.7	27.0
20.0	32.8	31.5	30.5	35.5
25.0	42.0	39.0	36.5	45.0

1. From the data in the table, predict which stroke is fastest. Justify your response.
2. Draw a graph for each stroke.
3. From the graph, identify the fastest stroke. Justify your response.
4. Calculate the speed of each stroke.

Graphing Practice

$$v = \frac{d}{t}$$

Measuring Speed Activity $= \frac{30 \text{ tiles}}{36.3 \text{ s}}$

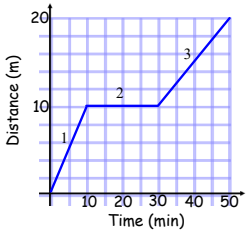


Measuring Speed

For Christmas break you and your family are taking a road trip to Montreal. Never wanting to miss a chance to practice science, you decide to keep track of your speed during the trip. Table 1 shows the data you collected.

Stage of trip	Initial odometer reading (km)	Final odometer reading (km)	Initial time (s)	Final time (s)
1	36252.1	36260.7	8:04	8:14
2	36260.7	36260.7	8:14	8:32
3	36260.7	36542.3	8:32	11:30
4	36542.3	36542.3	11:30	11:52
5	36542.3	36709.6	11:52	13:27

a) During which time periods was the car moving? Calculate the speed during each of these separate time periods.
b) Calculate the average speed for the trip as a whole, from the beginning of Stage 1 to the end of Stage 5.
c) Explain the differences in your answers for (a) and (b).
d) Draw a distance-time graph of the trip.



Find the slope of each section of the graph.

What does the slope in each section tell us about what was happening?

Section 1
- the object is moving fastest (slope = 1 m/min)

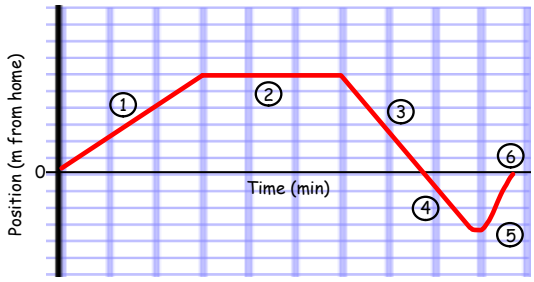
Section 2
- the object is not moving (slope = 0 m/min)

Section 3
- the object is moving slower than in section 1 (slope = 0.5 m/min)

What's happening?

Can you tell the story based on the graph?

Position-time graph of a short walk from home.



Distance-Time Graphing Questions

1. a) How is average speed different from instantaneous speed?
b) When would they be the same?

2. What interpretation can be made about a moving car if the line on a distance–time graph? for the car has the following characteristics?
a) a high or steep slope
b) a low or less steep slope
c) a zero slope

3. A car and a truck travel along the same highway with the car moving faster than the truck.
a) How do their distances travelled compare after the same length of time?
b) How do their times compare after travelling the same distance?

4. A car leaves Borden-Carleton, PEI, on its way across the Confederation Bridge into New Brunswick. The distances and times from the toll booth in PEI are recorded in Table 1. They include a short stretch of road beyond the end of the 12.9 km bridge.
a) Plot a distance–time graph. Draw a line of best fit.
b) Using your graph, find the distance travelled after 5.0 min.
c) Using your graph, find the time required to cross the bridge.
d) Was the speed constant during the car's trip across the Confederation Bridge? How do you know?
e) Calculate the slope of the graph. What does this slope represent?
f) What was the speed of the car in km/h?

Table 1: Travel from toll booth on Confederation Bridge

Time (min)	Distance (km)
0.0	0.0
2.0	2.4
4.0	4.8
6.0	7.2
8.0	9.6
10.0	12.0
12.0	14.4

Questions

Distance, Speed and Time Graphing Quiz

Quiz