Graphing Motion

<u>Definitions</u>

Frame of Reference:

Position:

Displacement:

Distance:

<u>Examples:</u>

1. What is the position of the cat relative to the tree?

2. What is the position of the person relative to the cat?

3. What is the displacement of the car if it drives into the tree?

4. What is the displacement of the cat if it walks to the person?

5. The person walks to the cat, picks it up, then walks back to the tree.

      a. What distance did the person walk?

      b. What is the person's displacement?

Time interval

Speed

Average speed

Velocity

Average velocity

Acceleration

Examples:

1. A cyclist rides 25 km [E] then 26 km [W] in 2 hours
   a. What is his average speed?

   b. What is his average velocity?

2. A student drives 140 km in 1h15, then takes a 10 minute break. He then continues for 240 km in 2.0 hours. What is the average speed for the student on the trip?

3. A car accelerates uniformly from 12 m/s to 25 m/s in 4.0 seconds. What is the acceleration of the car?

A reminder from grade 10:

Last year you saw that for objects moving at a constant speed

Speed = $\dfrac{\text{distance}}{\text{time}}$

Different velocities...

Instantaneous velocity:

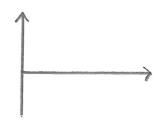   The velocity of an object at a specific time

Average velocity:

      $V_{ave} = \Delta d / \Delta t$

Example: A car starts to run at 1.5 m/s for 5.0 seconds, and then runs in the same direction at a speed of 0.50 m/s for 20 seconds.
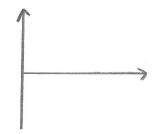
1. What is the instantaneous velocity of the cat 3.0 seconds after it started running?

2. What is the instantaneous velocity of the cat 10 seconds after it started running?
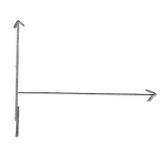
3. What is the average velocity of the cat for 25 seconds?

Position vs Time Graphs (d-t)

Object is not moving

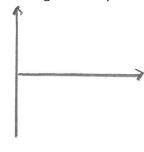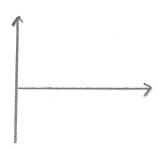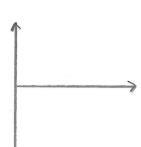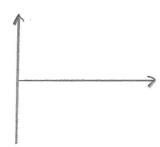Object is moving at a constant velocity (uniform motion)

Object is accelerating uniformly

From d-t graph:

To find displacement: final position – initial position ($\vec{d_f}$ - $\vec{d_i}$)

To find distance: add up the length of the path

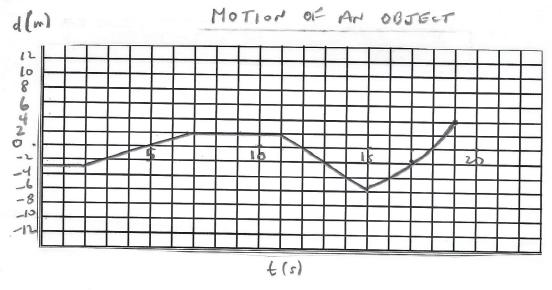To find velocity at one point (instantaneous)

      Find the rate of change of the line the point is on

      Find the rate of change of the tangent line (for a curve)

To find average velocity or average speed, first find the displacement or the distance.

Example:

The graph below shows the motion of an object over a period of 19 seconds

d (m)

MOTION OF AN OBJECT

t (s)

1. What is the displacement of the object from 1 s to 9 s?

2. What is the distance covered from 5 s to 13 s?

3. What is the velocity of the object at 5 s?

4. What is the velocity of the object at 12 s?

5. What is the velocity of the object at 17 s?

6. What is the average speed of the object at 19s?

7. During what time interval is the object moving backwards?

8. During what time is the object accelerating?

9. During what time is the object at rest?

Velocity vs Time graphs (v-t)

Object is not moving

Object is moving at a constant velocity (uniform motion)

Object is accelerating uniformly
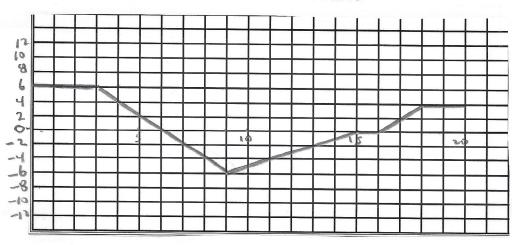
Object has non-uniform acceleration

From a v-t graph

- To find the velocity
- To find the acceleration at one point
- To find the average acceleration
- To find the displacement or distance

Example:

Consider the graph below

v (m/s)   MOTION OF AN OBJECT

t (s)

1. What is the velocity of the object at 5 s?

2. What is the acceleration of the object at 11 s?

3. What is the acceleration of the object at 2 s?

4. What is the average acceleration of the object from 2 s to 13 s?

5. During what time interval(s) is the object at rest?

6. During what time intervals is the object speeding up?

7. During what time intervals is the object slowing down?

8. What is the displacement of the object from 0 to 9 s?

9. What is the average speed from 0 to 15 s?

10. What is the average velocity from 0 s to 15 s?

11. What is the distance covered for the entire 20 s?

12. Assuming the object starts at zero, where would it be after 3 s?

Acceleration vs Time graphs (a-t)

Object is not moving

Object is moving at a constant velocity (uniform motion)

Object is accelerating uniformly
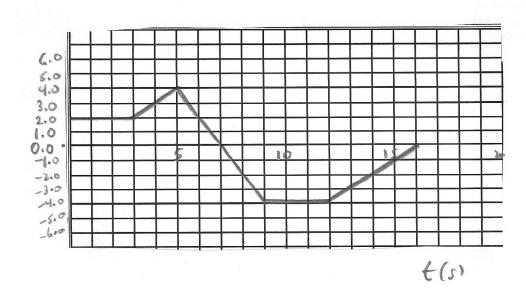
Object has non-uniform acceleration

From an a-t graph

To find acceleration

To find change in velocity

Example

$a(m/s^2)$

Acceleration vs Time

$t(s)$

1. What is the acceleration of the object at 6 s?

2. At 5 s, the velocity of the object was 5.0 m/s. What was the velocity at 7 s?

Going back and forth between the different graphs: