Lesson 9: d-t & v-t Graphs

Graphing the motion of objects gives us a way to interpret the motion that would otherwise be difficult.

- Graphs will also allow you to show a large amount of information in a compact way.

Essentially you need to be able to sketch and interpret two main kinds of graphs in kinematics:

1. Displacement – Time Graphs
   - Sometimes called d-t graphs, or position – time graphs.
2. Velocity – Time Graphs
   - Sometimes called v-t graphs.

Displacement - Time (d-t) Graphs

This type of graph is based on the most basic things we need to know about the motion of an object (position and time).

- Typically you will be given a table of values that show the displacement of the object over a particular period of time.
- If the graph shows complex motion (such as Illustration 1 below), you do not just draw a single best fit line. Instead, you need to look at each section of motion and determine what kind of line best fits the data.
  - Don't worry too much about sketching these complex situations... it is much more likely that you will draw an object moving in one way only.
- For the example graph shown below, imagine that you are running in a marathon, and we have decided to graph your movement.

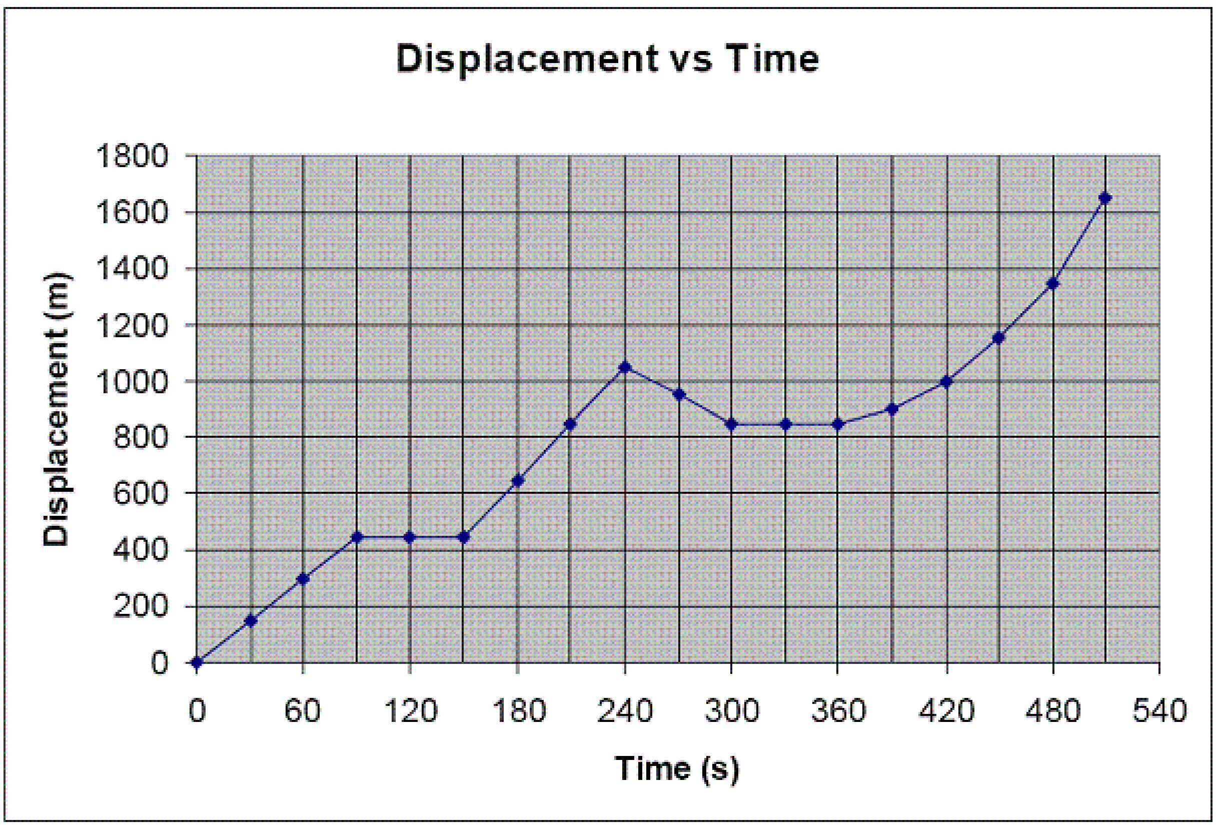

Illustration 1: d-t graph of a person running a marathon.

Now lets look at a description of the person's movement in each of the major sections.

Zero to 90s

Look at how you are running in those first 90 seconds.

- Every 30 seconds you have moved about another 150m away from the starting point… you must be moving at a constant positive velocity!
- A constant positive velocity is shown on a d-t graph as a straight line that slopes upwards. It is a linear relationship.
    - In fact, if you found the **slope of the line** in this section, it will be the **velocity** that you were running at.

The slope of a d-t graph always equals the velocity of the object at that time.

$$slope = \frac{rise}{run} = \frac{d}{t} = v$$

90s to 150s

Yikes! You ran too fast at the start and now you're out of breath!

- During this time period, your position on the graph has stayed the same…450m.
- This just means that you are standing in the same spot, exactly 450m away from where you started.
- A flat horizontal line means you are stopped.

The slope of the line is the velocity, and the slope of a flat line is zero. So, the velocity is zero.

150s to 240s

You must have started running forward again, since a positively sloped line means a positive velocity.

- Notice that this section of line is a little steeper than the first section. You are now running about 200m every 30s.
- A steeper line (which has a bigger slope) means that you are moving at a faster constant velocity.

240s to 300s

In this section the line slopes down, which means it has a negative slope.

- Since slope is equal to velocity, this must mean that you are running backwards.
- A **negative** slope means a constant **negative** velocity.
    - You must have forgotten to pass a check point, so you ran back to it.

300s to 360s

Again, we have a horizontal line. You must be stopped.

360s to 510s

You know that you have only one chance to still win the race… run as fast as you can!

- During this time period, the line ***curves*** upwards.
- The line becomes steeper and steeper as it continues. This means that the slope of the line is getting bigger and bigger.

- Since slope is related to velocity, your velocity must be increasing. You are accelerating!
- A curved line on a d-t graph means acceleration.

A curved line on a d-t graph means acceleration is happening.

Here’s how you can remember if it was positive or negative acceleration on a d-t graph.

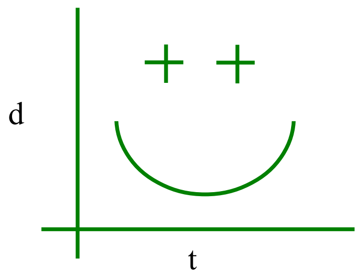

Illustration 2: Happy Clown

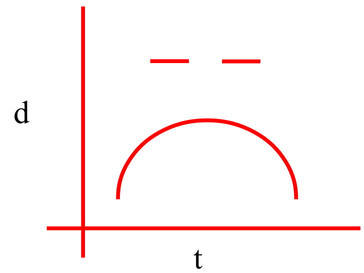

Illustration 3: Unhappy Clown

- **If you see any part of the happy clown's face on a graph, it is positive acceleration.**
- **If you see any part of the sad clown's face, it is negative acceleration.**

Velocity-Time (v-t) Graphs

You need to remember that the rules you learned above for d-t graphs do ***not*** apply to v-t graphs.

- A common mistake by Physics 20 students is when they assume that all types of graphs work the exact same way.
- The graphs can be related to each other, but that doesn’t mean you look at them the same way.
- The following v-t graph is based on the same data as we used for the d-t graph, but we will need to look at what’s different.

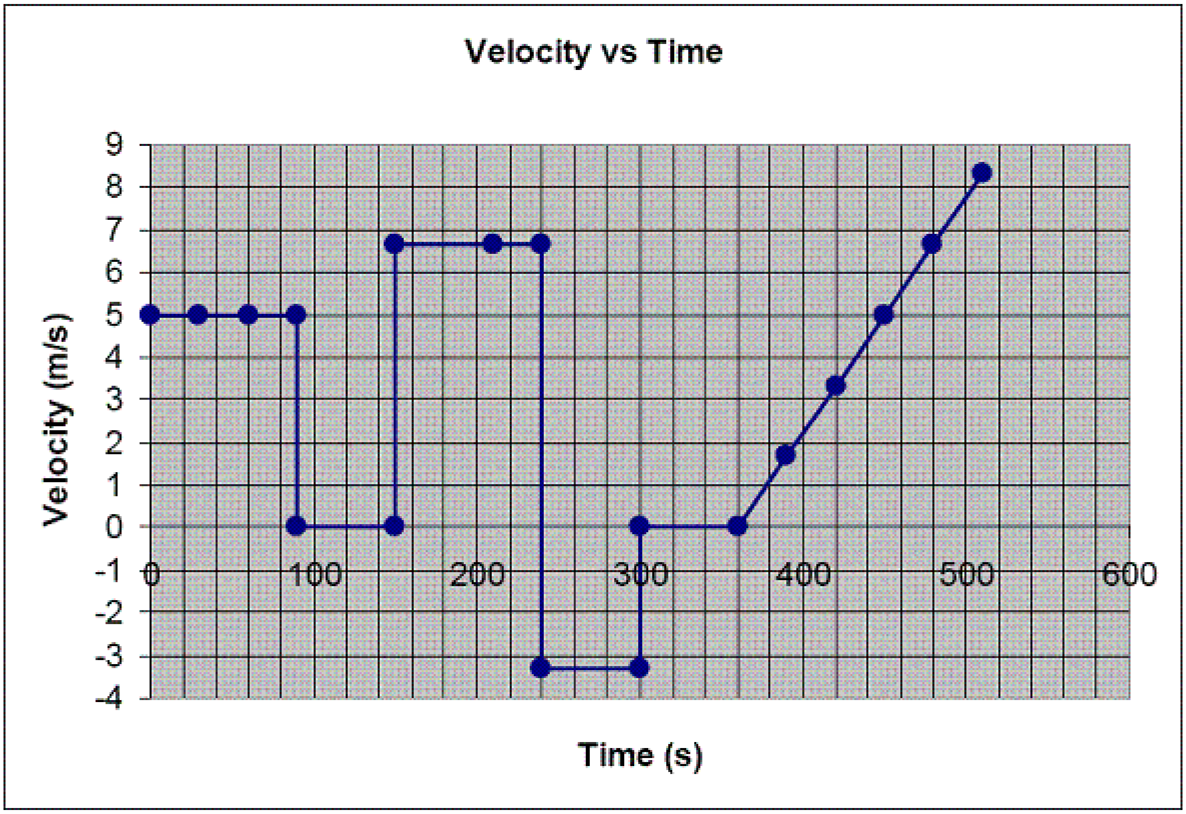

Illustration 4: v-t graph of the same person running.

Zero to 90s

Remember that in the first 90 seconds you were running at a positive constant velocity.

- On this graph we see a horizontal line that reads "5m/s" for those same first 90 seconds.
- On a v-t graph a **flat line** means **constant velocity**.

A flat line on a v-t graph means constant velocity.

90s to 150s

This is the section of time when you stopped because you were out of breath.

- Notice that "stopped" is shown by a horizontal line at exactly 0m/s.
- It's a flat line which means constant velocity. It just so happens that your constant velocity is 0 m/s.

150 to 240 seconds

You are running forward again.

- To show a faster velocity than earlier, we have a flat line that is higher than the previous one.

240 to 300 seconds

This is when you are running back to the check point.

- You are running at -3.3m/s.

- A **negative** velocity is shown as a **negative slope**.

300 to 360 seconds

Again, we have a horizontal line at zero. You must be stopped.

360 to 510 seconds

This is the section in which we already figured out you must be accelerating; you run faster and faster.

On a **d-t** graph the line curves upwards, but not on a **v-t** graph.

- On a v-t graph the line is straight and has a positive slope.
- A straight sloped line on a v-t graph means acceleration.
- The slope of the line is equal to the acceleration; **a positive slope is a positive acceleration**, and **a negative slope is a negative acceleration**.

A slope on a v-t graph means acceleration. The slope of the line is equal to the acceleration.

$$slope = \frac{rise}{run} = \frac{\Delta v}{t} = a$$

There is one other trick you need to know about v-t graphs.

- If you multiply velocity by time, what do you get? According to our formula...

$$v = \frac{d}{t} \quad \text{manipulated to} \quad d = v\,t$$

..displacement!

- So, if I have a v-t graph and I calculate the area under the line (which means I'm calculating velocity multiplied by time), I will know the object's displacement.

The area under the line of a v-t graph is the displacement of the object.

Homework

p.15 #1
p.20 #3, 6, 10
p.27 # 1, 2
p.45 #11,16,17