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.

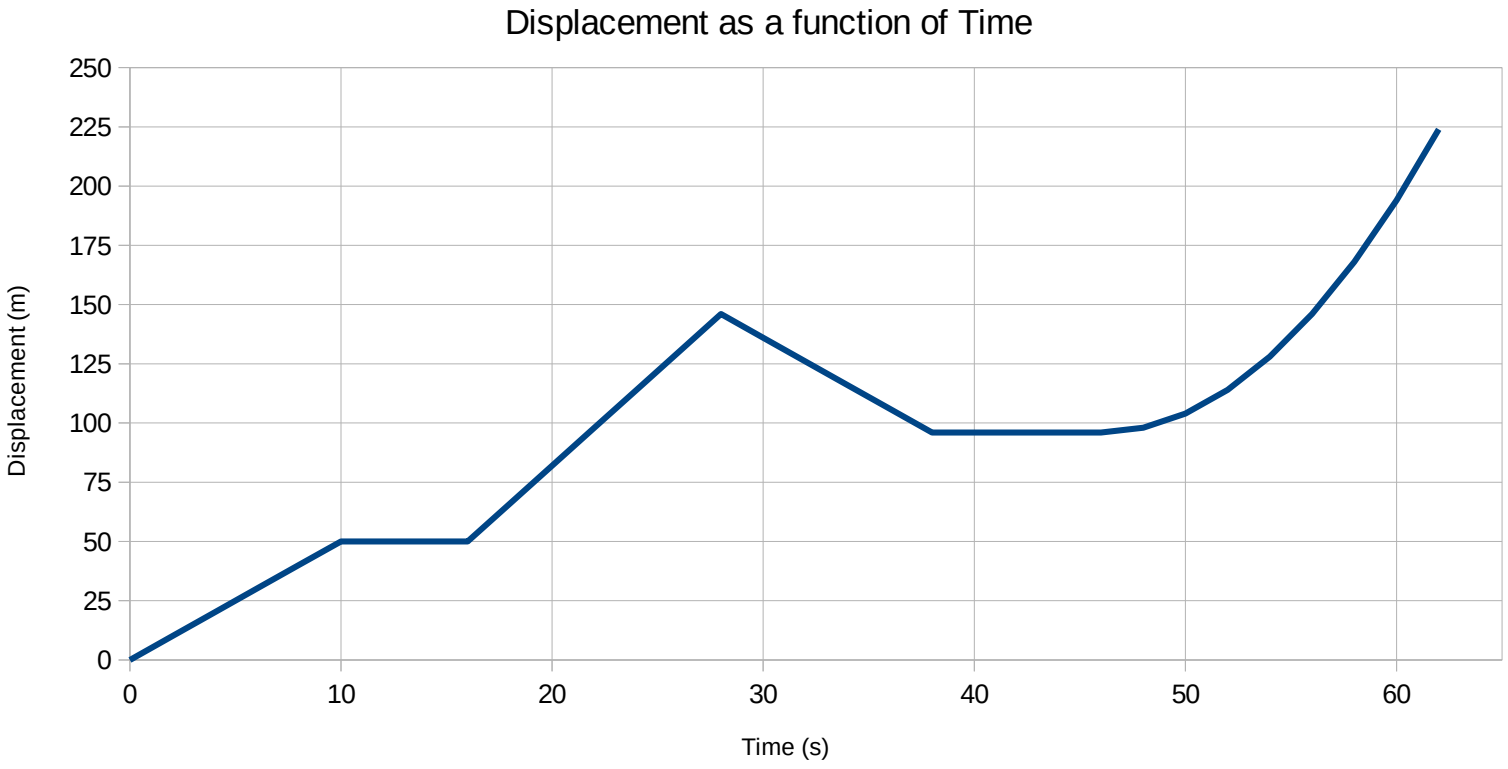
Essentially you need to be able to sketch and interpret two main kinds of graphs in kinematics:

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

Displacement as a function of Time 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, imagine that you are walking in a hallway at school after physics

class is done, and we have decided to graph your movement. Lets look at a description of the person's movement in each of the major sections.

Zero to 10 s

Look at how you are moving in those first 10 seconds as you move away from the physics classroom (your reference point of zero metres).

- With every passing second you are moving steadily further away from the classroom… 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**, it will be the **velocity** that you were moving at.

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

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

10 s to 16 s

You see a friend at their locker and stop to talk to them for a few seconds.

- During this time period, your position on the graph has stayed the same…50m.
- This just means that you are standing in the same spot, exactly 50m 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.

16 s to 28 s

You started walking 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 moving faster than you were before, still forwards.
- A steeper line (which has a bigger slope) means that you are moving at a faster constant velocity.

28 s to 38 s

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 moving backwards. You think you forgot your phone in my classroom, so you start moving back towards my room.
- A **negative** slope means a constant **negative** velocity.

38 s to 48 s

You realize that you probably just put your phone in your backpack, so you stop in the middle of the hall to look in your bag.

- Again, we have a horizontal line. You are stopped and the slope of the line is zero.

48s to 62 s

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

You realize you're going to be late for your next class so you start to run!

- 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.

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

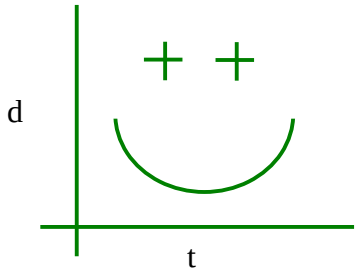


Illustration 1: Happy Clown

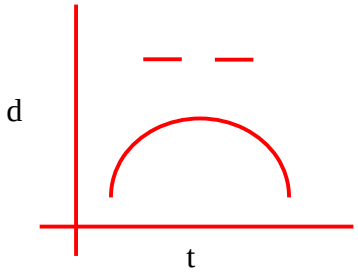


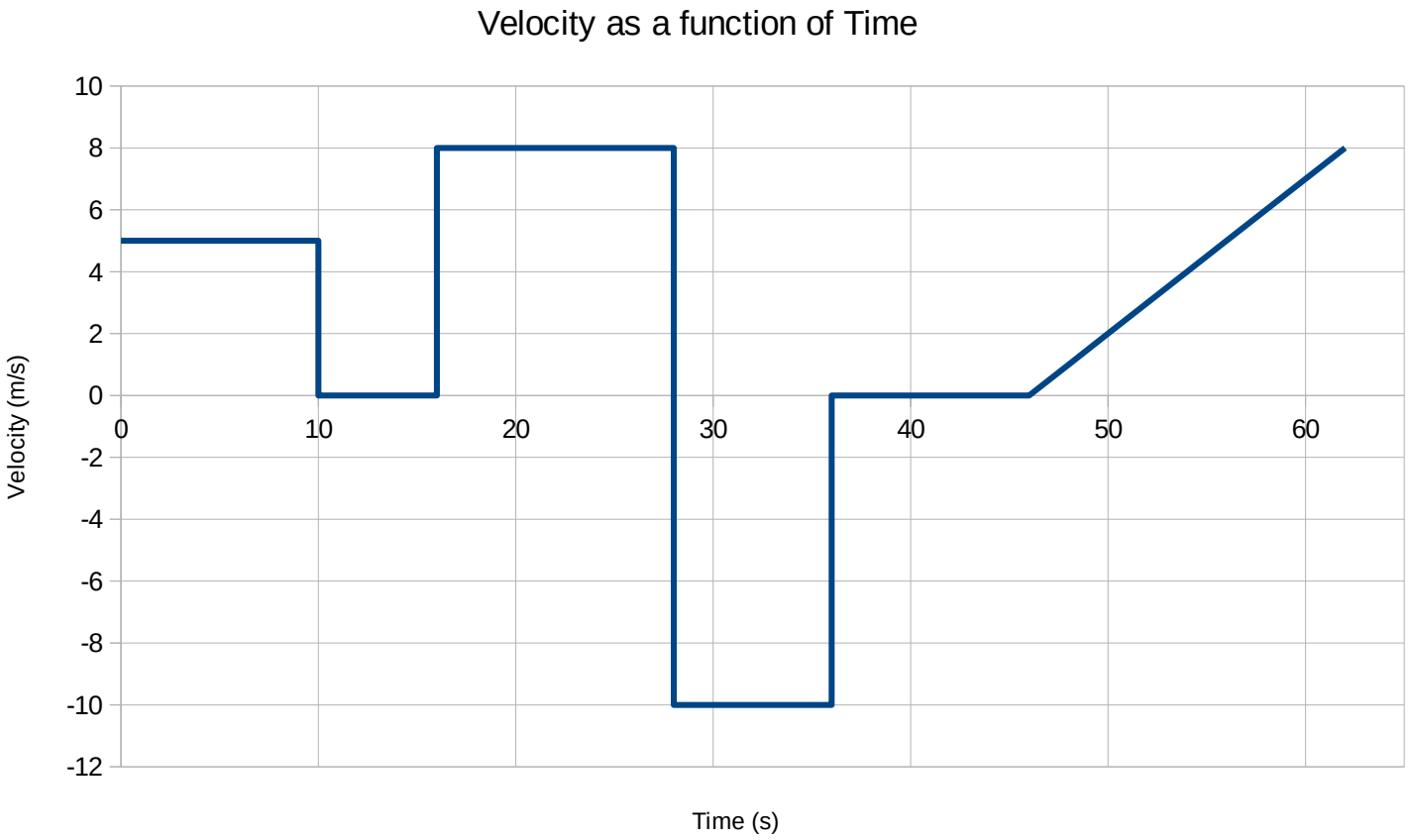
Illustration 2: Unhappy Clown

- **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 as a function of Time 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.



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

Zero to 10 s

Remember that in the first 10 seconds you were walking at a positive constant velocity.

- On this graph we see a horizontal line that corresponds to 5m/s for those same first 10 seconds.
- On a v-t graph a **flat line** means **constant velocity**.

10 s to 16 s

**** Important Note ****

- Between the last section and this section you will see a straight vertical line.
- This is NOT realistic, as it indicates an infinite acceleration. In reality there would be a moment during which a negative acceleration actually happened to get to the new velocity.
- None of the vertical lines that you see on this graph are realistic.

This is the section of time when you stopped because you talked to a friend at their locker.

- 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.

16 s to 28 s

You are moving forwards again.

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

28 s to 38 s

This is when turned around and started back towards the classroom.

- You are running at -10m/s.
- A **negative** velocity is shown as a flat line **in the negative y-axis**.

38 s to 48 s

Again, we have a horizontal line at zero. You are stopped while looking in your bag.

48s to 62 s

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.

$$slope = \frac{\Delta y}{\Delta x} = \frac{\Delta v}{\Delta t} = a$$

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