Feb. 19

Position-Time Graphs

Graphs are an easy way to communicate quantitative (numerical) information visually. Most people can understand a graph more quickly and easily than they can a table of evidence or paragraphs of text.

There are three advantages to using graphs:

- Patterns in data can be identified more easily (and equations developed)
- They can correct for errors in the observations ("line of best fit") (more accurate than the individual measurements used to produce it)
- The slope of a line graph can give important information (especially in motion graphs), which otherwise would be difficult to calculate.

When studying motion, graphs are a very common way of showing data. Physicists assume that objects change their position and speed smoothly. Therefore, the graph line will always be drawn as a best-fit straight line or as a smooth curve between the data points. Remember, the line will most-likely not go through all the data points, but instead shows the "ideal" experiment with very little error.

How to Construct a Proper Graph:

1. When making a graph use graph paper, it is important to have graph paper with fine enough divisions to give you useful information from your graph. Your graph should fill as much of the page as possible.

2. After selecting a suitable piece of paper, grab a ruler. It is time to draw your axes. You will need a y-axis (up and down) and an x-axis (side to side). These lines will meet or intersect in the lower left corner of your graph paper.

3. Take a look at your data. One set of data probably spans a much larger range than the other. You will want to orient your graph paper so that the larger data set will be plotted on the long side of the paper. Do not be afraid to turn your paper sideways. Don't forget to label each axis with a name and proper units.

4. Now that your axes are drawn, you need to divide them properly.

5. Add your data points to your graph.

6. Now that you have the data, you need to decide on a shape. Most likely you need either a line or a curve. This line or curve does not need to touch every data point on the graph. It should be drawn to be smooth and come close to most of the points.

7. Give your graph a title. No creativity required. A simple Position vs. Time type title will certainly suffice.

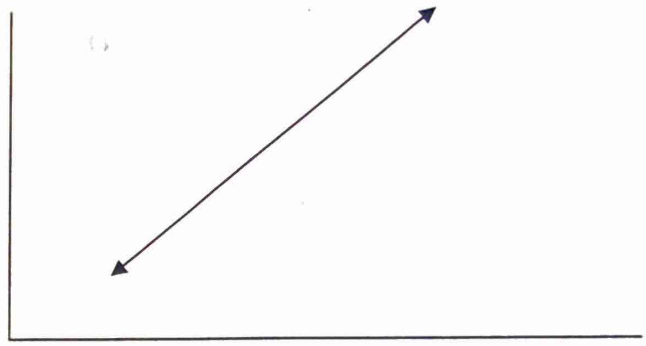
Position- Time Graphs

Example:

Descriptive Title

Dependent Variable (y-axis)

(Distance) ***Position***
(cm, m, km)
*add direction if needed

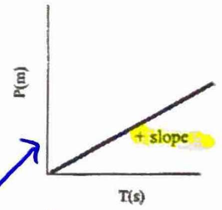


Time
(s, min, h)

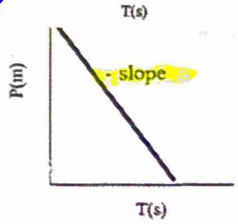
Independent Variable (x-axis)

Describing Position-Time Graphs:

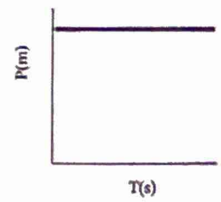
- Positive slope is forward (in direction given); negative slope is backwards (opposite direction).



- A horizontal line means the object is not moving.

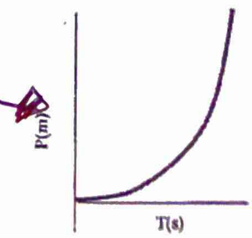


- * A straight sloping line indicates a constant velocity, where as a curvy line means velocity is changing (non-uniform).



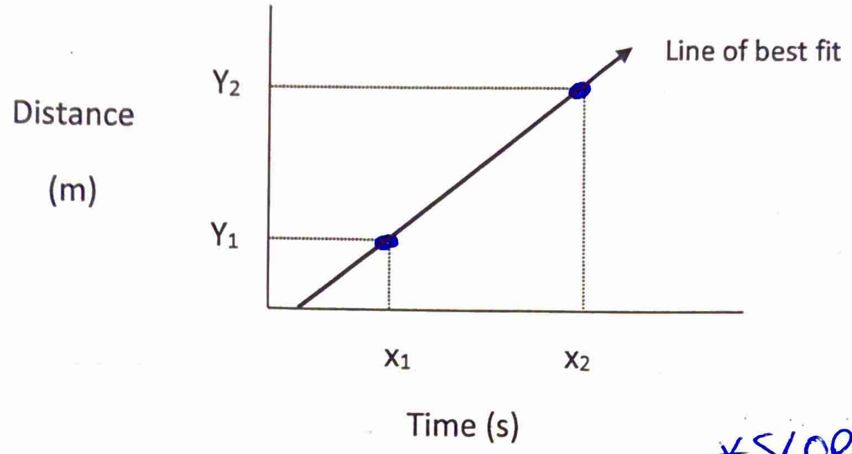
- Slope represents how fast the object is going (velocity); therefore, a steep slope means the object is going faster than a less steep line. (see next page)

- * A straight-line on a position-time graph shows that velocity is fairly constant or **"uniform"**. If the shape of the line is more curved or varied, then velocity is **"non-uniform"**, or non-constant (they are speeding up or slowing down).



Finding Slope or Velocity

Chose two points on the line of "best-fit" (the further apart they are the better) and, using a dotted line, show what values these represent on both the y and x axis.



*SLOPE will be the speed or velocity!

$$\text{Slope} = \frac{\text{rise}}{\text{run}} = \frac{(y_2 - y_1)}{(x_2 - x_1)} = \frac{\Delta\text{position}}{\Delta\text{time}} = \frac{m}{s}$$

What does slope tell us?

Since y = mx + b is equal to Δd = v Δt, we can say that the slope of a "best-fit" line on a distance-time graph equals speed.

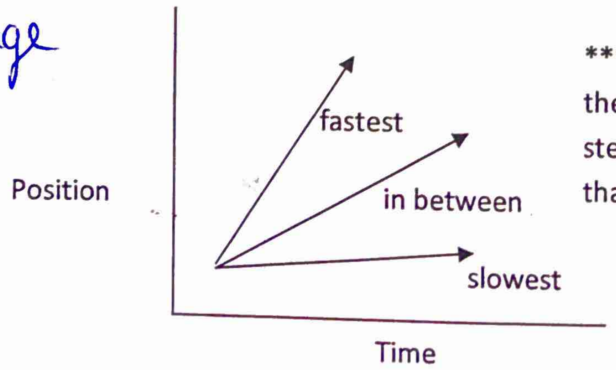
Just For Your Own Knowledge

y = mx + b

y = dependent variable
m = slope of line
x = independent variable
b = y-intercept of the line

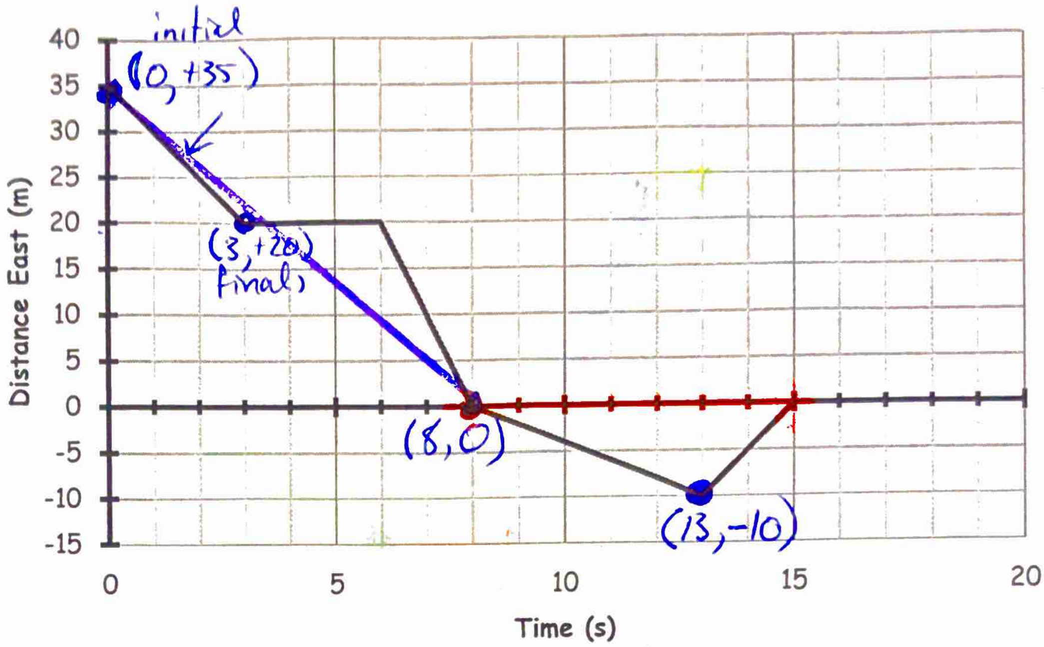
Δd = v Δt

Δ*d* = dependent variable
v = slope of line
Δ*t* = independent variable



*****Remember:** Slope represents how fast the object is going (velocity); therefore, a steep slope means the object is going faster than a less steep line.

Position-Time Graphs Practice 1



a. Where does the object start? +35m [or] 35m [E]

b. When does the object reach the reference point? y=0 t=8s and t=15s

c. Where is the object at t=13 seconds? -10m [or] 10m [W]

d. What is the velocity of the object during the first 3 seconds?

slope of the line.

$$SLOPE = \frac{RISE}{RUN} = \frac{\Delta y}{\Delta x} = \frac{y_f - y_i}{x_f - x_i} = \frac{20-35}{3-0} = \frac{-15m}{3s} = -5 m/s \text{ [or] } 5 m/s [W]$$

e. What is the velocity of the object during the interval from t=8 to t=13 s?

$$SLOPE = \frac{RISE}{RUN} = \frac{\Delta y}{\Delta x} = \frac{y_f - y_i}{x_f - x_i} = \frac{-10-0}{13-8} = \frac{-10}{5} = -2 m/s \text{ [OR] } 2 m/s [W]$$

f. When is the object at rest? from 3s to 6s

horizontal

g. What is the average velocity of the object during the first 8 s?

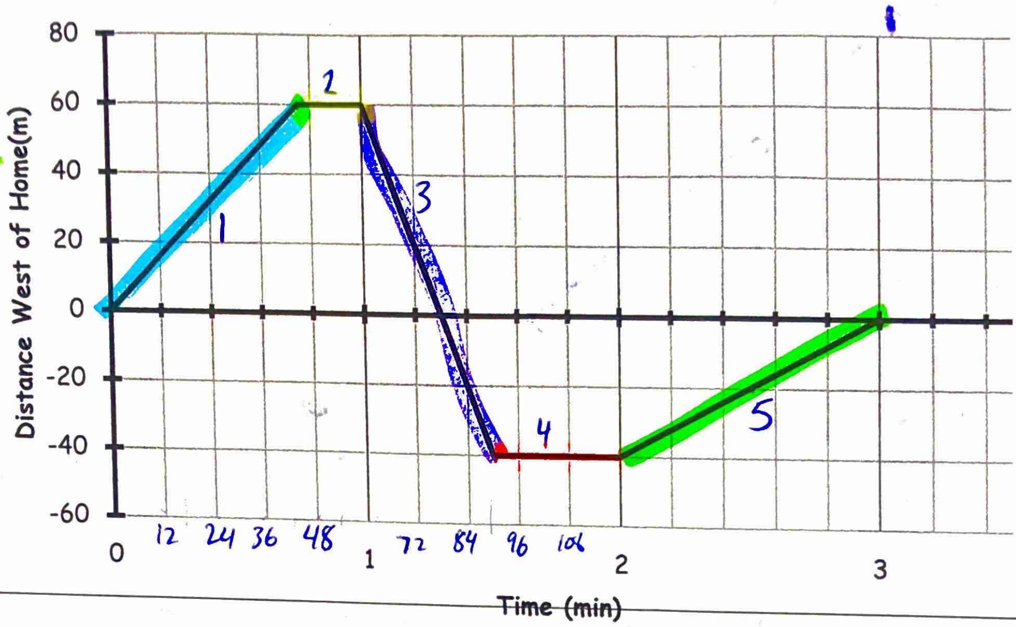
$$SLOPE = \frac{RISE}{RUN} = \frac{y_f - y_i}{x_f - x_i} = \frac{0-35}{8-0} = \frac{-35}{8} = -4.38 m/s \text{ [OR] } 4.38 m/s [W]$$

h. What is the average velocity of the object during the time interval t=8 to t=15 s?

$$SLOPE = \frac{RISE}{RUN} = \frac{y_f - y_i}{x_f - x_i} = \frac{0-0}{15-8} = \frac{0}{7} = 0 m/s$$

Answers

Position-Time Graphs Practice 2



a. What is the velocity (m/s) of the object during each section of the trip?

1 = +1.$\bar{3}$ m/s [OR] 1.$\bar{3}$ m/s [W]   2 = 0 m/s   3 = −3.$\bar{3}$ m/s or 3.$\bar{3}$ m/s [E]   4 = 0 m/s   5 = +0.$\bar{6}$ m/s or 0.$\bar{6}$ m/s [W]

b. When is the object at rest? Section 2 (t = 0.75 min − 1 min) and section 4 (t = 1.5 m − 2 min)

c. When is the object moving to the East? section 5 (t = 2 min − 3 min)

d. What is the average velocity of the object for the first minute of the trip?

V_{avg} = +1 m/s or 1 m/s [W]

e. What is the average velocity of the object from t = 1.5 min to t = 3 min?

V_{avg} = +0.$\bar{4}$ m/s or 0.$\bar{4}$ m/s [W]

Position-Time Graphs Practice 2 cont'd

f. What is the average velocity of the object for the entire trip?

$V_{avg} = 0 m/s$

g. What is the total distance traveled by the object?

$d_{Total} = 200 m$

h. What is the displacement of the object at t = 2 min.?

$\Delta d = -40m$ or $40m$ [E]

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i. What is the instantaneous velocity of the object at 2.5 min.? *Difficult, do not worry about it.

$V = +0.\bar{6} m/s$ or $0.\bar{6} m/s$ [W]

j. What is the instantaneous velocity of the object at 1.34 min.? *Difficult, do not worry about it

$V = -3.\bar{3} m/s$ or $3.\bar{3} m/s$ [W]