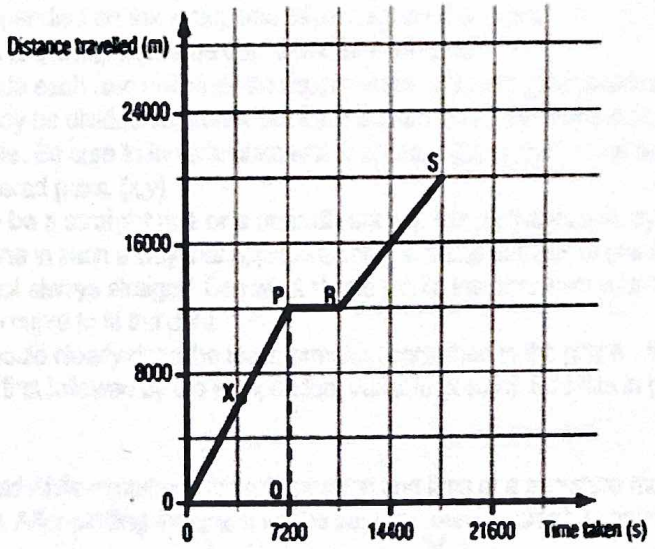
Skill 1 – Reading Graphs

You must be able to pull out and explain information about data from an experiment just by looking at a graph of this data. This will include recognizing relationships and trends in the data.

Graph 1: Distance a Person Walked vs. Time



* ind. variable is on the x-axis.

* dep. variable is on the y-axis.

Answer the following questions using the graph above.

1. What is the independent variable for this graph? What units are used to measure this quantity? time, seconds
2. What is the dependent variable for this graph? What units are used to measure this quantity? distance, meters
3. At what position did the person start? 0 m
4. What was the position of the person at 2 hours? 12,000 m (2 hrs = 7200s)
5. What was the position of the person at 4.5 hours? 18,000 m (4.5 hrs = 16,200s)
6. Approximately, at what time (in seconds) did the person reach 4,000 meters? 2,400 s
7. Approximately, at what time (in seconds) did the person reach 14,000 meters? 12,600 s
8. At what time, in seconds, did the person reach its maximum position? 18,000 s
9. Describe the motion of the person from point P to point R. How long (in hours) did they do this for?

   the person stayed in the same position (remained at rest at 12,000 m) for 1 hour
10. Rank the **speed** of the person during the following intervals (1 = least, 3 = greatest). Explain how you determined this.

    3 from X to P 1 from P to R 2 from R to S

* Speed = $\frac{\text{distance}}{\text{time}}$ ← rise on this graph / ← run on this graph

* So, Speed = SLOPE! Steepest slope = fastest

Skill 2 – Constructing Graphs (Graphing Data)

Graphs are useful tools in physics because trends in data and relationships between variables are easy to visualize when represented graphically. Now, instead of just reading a graph, you must also create your own before analyzing the data. Review the steps below for making graphs in science to be sure you have included all of the necessary components.

Following the steps below will help you to make certain that all components of the graph are correctly presented.

1. **Identify the variables.** Independent on the x-axis and dependent on the y-axis
2. **Determine the range.** What is the highest value data point for each axis?
3. **Select the scale units.** Divide each axis uniformly into appropriate units using the maximum amount of space available. (Remember that the axes may be divided differently but each square along the same axis must represent the same interval.)
4. **Number and label each axis.** Be sure to include units where appropriate as part of the axis label.
5. **Plot the data points** as ordered pairs. (x,y)
6. **Draw the best fit line (may be a straight line or a smooth curve).** For a straight line, eyeball it. "Eyeball it" means: use a straight edge to draw your line in such a way that approximately the same number of points lie above and below the line. Note: Lines in physics are not always straight! See what shape works the best from your "Relationships on Graphs - Cheat Sheet" and sketch a smooth curve to fit the data.
7. **Title the graph.** The title should clearly describe the information contained in the graph. It is common to mention the dependent variable (y-axis) first followed by the independent variable (x-axis). See title in graph on previous page.

Sample Data Set A:

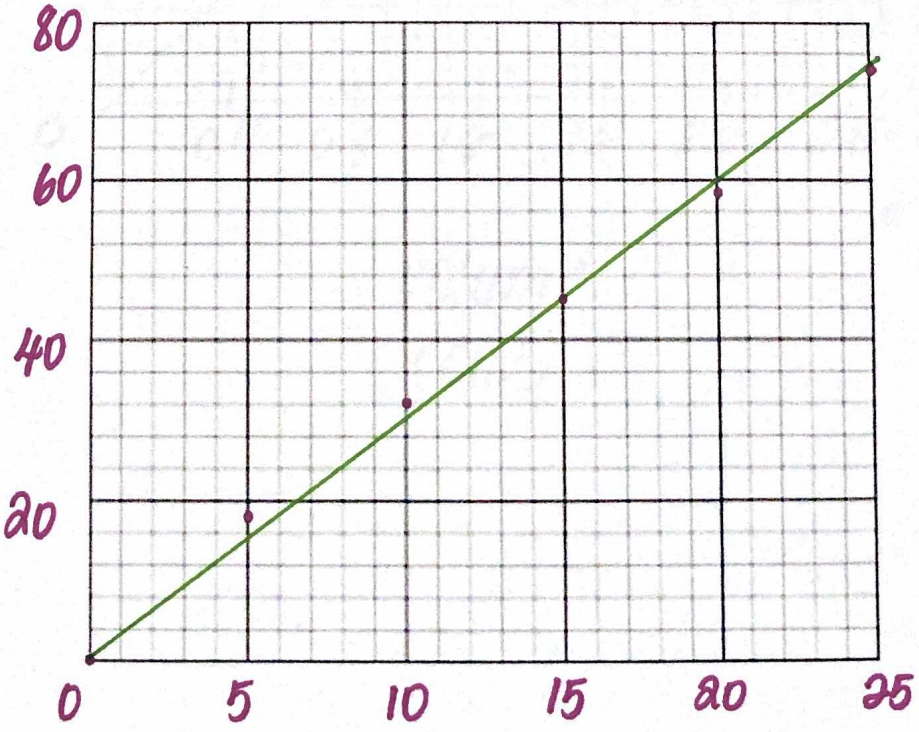
The following set of data was collected while experimenting with position and time of a miniature motorized car traveling on a straight track. Plot the data below on the grid. After plotting the graph for the data set, use the graph to answer the analysis questions in Skill 3.

x Time (minutes)	y Position (meters)
0	0
5	18
10	32
15	45
20	58
25	74

*notice that I have used as much space as possible. Don't squish your graph into one corner.

Position vs. Time Graph for the Motion of a Car

*"eyeball" your best fit line. See step 6 above.



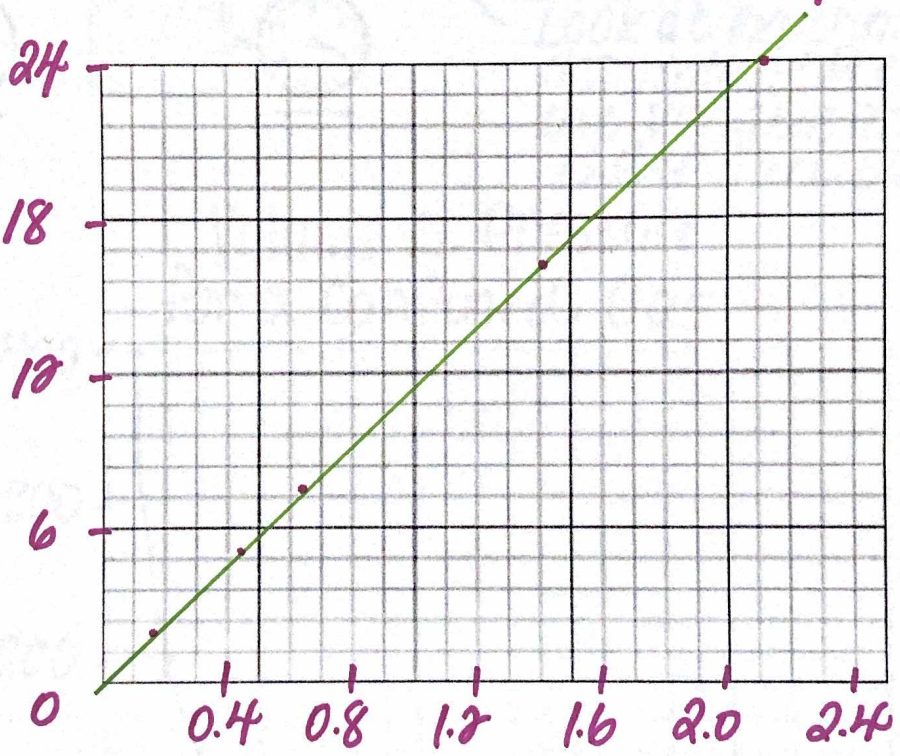
Sample Data Set B:

The following set of data was collected during an experiment to find the density for an unknown pure metal. Five different volumes of the same unknown pure metal were massed and the data was recorded below. After creating the graph for the data set, use the graph to answer the analysis questions.

X Y

Volume (cm^3)	Mass (g)
0.18	2.00
0.44	5.00
0.66	7.50
1.41	16.00
2.11	24.00

Mass vs. Volume for an Unknown Metal Sample



mass (g)

volume (cm^3)

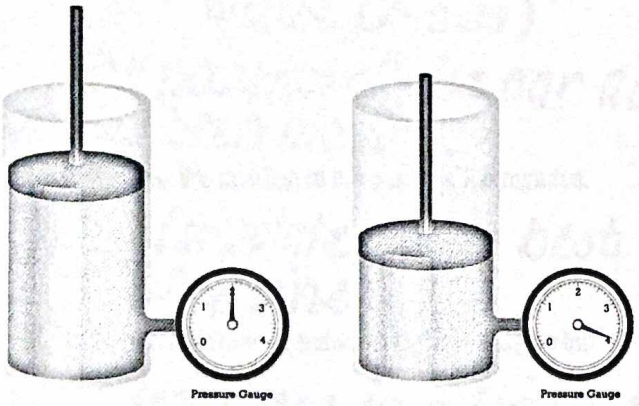
means ind. variable

Sample Data Set C:

The following set of data was collected during an experiment where an amount of a confined gas is being compressed by a moveable piston pressing downwards on the gas, which exerts pressure on the gas. (See diagram of lab apparatus below.) A known pressure is exerted using the moveable piston and the volume of the confined gas was then measured and recorded in the table below. After creating the graph for the data set, use the graph to answer the analysis questions.

← means dep. variable

Apparatus for Pressure and Volume Lab:



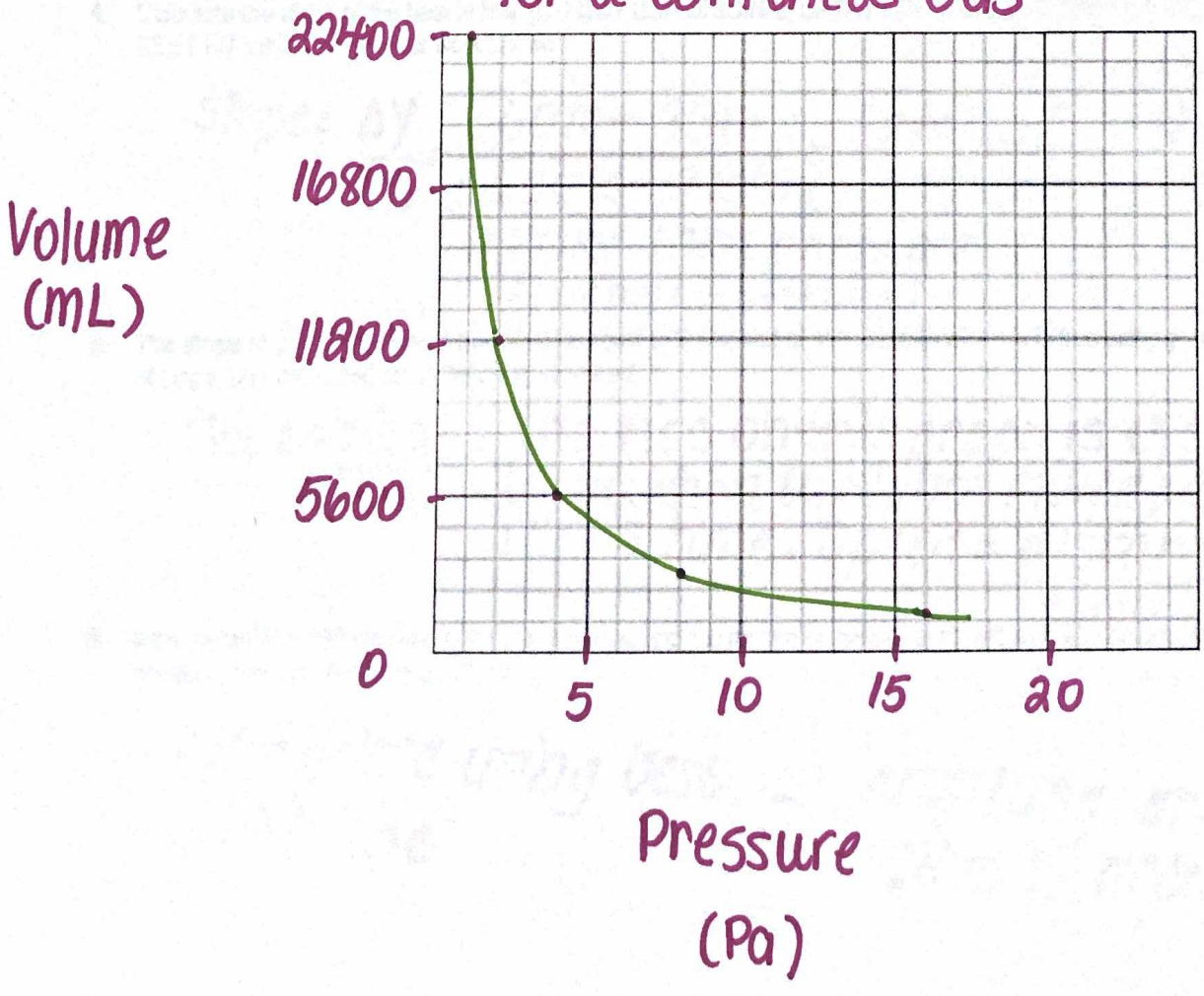
Data for Pressure and Volume Lab:

Y X

Volume (mL)	Pressure (Pa)
22, 400	1.0
11, 200	2.0
5, 600	4.0
2, 800	8.0
1, 400	16.0

Look at experiment description! Pressure is ind. variable and volume is dep. variable.

Volume vs. Pressure for a Confined Gas



Skill 3 – Analyzing Graphs

You must be able to use the graph to analyze data from an experiment. This includes predicting relationships, or using the slope, x and y-intercepts, and/or the area under the curve to tell you physical information about an experiment or relationship. This may also include interpolation or extrapolation. (P.S. Be sure you know when it is appropriate to use interpolation or extrapolation.)

Analysis Questions:

*Directions: Use your graph from **Sample Data Set A** for Questions 1-6.*

1. What is the independent variable for this graph? ...the dependent variable? Explain.

   4 time (x-axis) 4 position (y-axis)

   The position of the car depends on how long it has been moving.

2. Determine the position of the car after 2.5 minutes.

   interpolate using best fit line - between 8 m and 9m is acceptable

3. Is there a relationship between the variables on the x and y-axis? If so, what type of relationship is this? How do you know this?

   Yes, there is a linear relationship. A straight line indicates a linear relationship. (*see graph shapes cheat sheet for help.)

4. Calculate the slope of the best fit line. (DO NOT USE ORIGINAL DATA POINTS UNLESS THEY LIE ON YOUR DRAWN IN BEST FIT LINE.) Show your work below.

   $\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{60m - 36m}{\downarrow 20min - 12min \downarrow} = 3m/min$ ← don't forget the units!

   *Notice: these points are from my best fit line!

5. The **slope** of the best fit line of this graph is equal to the **speed** of car. Explain why this is true using your graph, the definition of slope, and the definition (or formula) for speed.

   $\text{Slope} = \frac{\text{rise}}{\text{run}}$ The rise on this graph is the change in position (distance moved) and the run is time. Speed = $\frac{\text{distance}}{\text{time}}$ = slope of this graph.

6. If the experiment were carried out for 30 minutes, and the motion of the car remained as it was before, what would be the position of the car at this time?

   extrapolate using best fit line - anything around 84m is acceptable

Directions: *Use your graph from* ***Sample Data Set B*** *for Questions 7-14.*

7. What is the relationship between volume and mass in this experiment? How can you tell?

The mass and volume are directly proportional (a linear relationship). We can tell by looking at the shape of the best fit line - it's straight, so, linear!

8. What does a data point on this graph actually represent?

A data point represents the mass of a specific volume of a pure metal sample.

9. The **slope** of the best fit line of this graph is equal to the **density** of the unknown pure metal. Explain why this is true using the definition of slope, the definition (or formula) for density, and your graph.

Slope = $\frac{\text{rise}}{\text{run}}$ density = $\frac{\text{mass}}{\text{volume}}$ in this graph rise = mass and run = volume, so:

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\text{mass}}{\text{vol}} = \text{density}$$

10. What volume would a 10.00 gram sample of this substance occupy? What did you do to determine this?

The volume would be between 0.8 cm^3 and 0.9 cm^3. This can be determined by interpolating.

11. How could you determine the identity of unknown pure metal?

* You could determine the density of the metal by calculating the slope of the line (as mentioned in #9).
* Then look at a table of densities for pure metals. See which metal comes closest to our calculated density.

12. Now do what you said you would do in #11 to determine the identity of the unknown pure metal. Show your work below and be sure to list one or two metals that could be the unknown pure metal.

$$\text{density} = \text{slope} = \frac{\Delta y}{\Delta x} = \frac{22.8\text{ g} - 0\text{ g}}{2.0\text{ cm}^3 - 0\text{ cm}^3} = 11.4\text{ g/cm}^3$$

* between 10 cm^3 and 11.5 cm^3 is ok

* Look up density tables for pure metals (must be in g/cm^3). Silver (10.49 g/cm^3) or lead (11.36 g/cm^3) would be acceptable predictions based on your best fit line. Lead fits best for my line.

13. Write an equation for the line. (Be sure to use the calculated value for the slope in your equation.)

linear (straight line) so $y = mx + b$

y → mass
m → slope
x → volume
b → y-int

$$m = (11.4\text{ g/cm}^3)V + 0\text{ g}$$

Note: your slope and y-int may be slightly different b/c we "eyeballed" the best fit line.

14. Use your equation from #13 to find the mass when the volume is 6.00 cm^3. Show your work below.

$$m = (11.4\text{ g/cm}^3)V$$

When $V = 6.00\text{ cm}^3$, $m = ?$

$$m = (11.4\text{ g/cm}^3)(6.00\text{ cm}^3)$$

$$m = 68.4\text{ g}$$

Directions: *Use your graph from* ***Sample Data Set C*** *for Questions 15-19.*

15. Identify the independent and dependent variables in this graph. Explain.

pressure (x-axis)

volume (y-axis)

The volume of the gas depends on the pressure exerted on the gas.

16. Does this graph represent a linear relationship? Why or why not?

No, this is not showing a linear relationship because this line is not a straight line. A straight line indicates a linear relationship.

17. If you decided that this graph does not show a linear relationship, what type of relationship do you think it shows? Explain.

Based on the shape of the graph (and the cheat sheet that I gave you, if necessary)... this looks like it is an inverse relationship.

18. If the pressure on the confined gas is decreased over a period of time, what trend in volume could be expected? How do you know this in terms of the relationship you chose in #16/17?

Since pressure and volume are inversely related, if the pressure decreased over time, you'd expect the volume of the gas to increase.

19. If the pressure on the confined gas is increased over a period of time, what trend in volume could be expected? How do you know this in terms of the relationship you chose in #16/17?

You would expect the volume to decrease. Again, this graph shows an inverse relationship, meaning when P goes up, V goes down.