# Line Graphs

## Introduction

Line graphs compare two variables, each which is plotted along an axis. Line graphs are useful because they:

- are good at showing specific values of data;
- if one variable is known the other can easily be determined;
- trends or patterns in the data can be identified; and
- predictions to be made by extending the line beyond the plotted data based on an observed trend (this is called *extrapolation*).

## Guidelines for Setting Up and Plotting a Line Graph

1. The data that is known in advance is plotted on the *horizontal* axis (x-axis) of the graph. This data is referred to as the *independent variable.*
2. The data that will be collected and *is not known in advance* is plotted on the *vertical* axis (y-axis) of the graph. This data is referred to as the *dependent* variable.
3. The scale (spaces or boxes) on each axis must be plotted with *equal increments*.
   a. Each scale must accommodate the range in the data.
   b. Use as much of the grid as possible. It may not be possible to use every space.
   c. The scale can't be changed in order to make the data "fit" the scale chosen. The scale must be adjusted so that all the given data can be plotted.
   d. It is **not acceptable** to hand draw extra lines if the scale you've chosen can't accommodate all of the data. You must change the scale.
4. The vertical scale does not have to be the same as the horizontal scale.
5. Each scale doesn't not have to start with zero.
6. All four quadrants of the graph do not have to be used. If all values are positive, only the first quadrant should be shown.
7. Each scale must be labeled. This must include what units were used.
8. If the data requires more than one line to be plotted on the same set of axes:
   a. each line must be drawn with a different color or symbol
   b. a key must be provided that identifies what data each line represents.

## Finding Rate of Change Using a Line Graph

1. Rate of change provides information on how one variable has changed with respect to *time*
2. Steps in Calculating a rate problem using a graph.
   a. Step 1: Identify the time interval of the portion of the graph for which the rate will be determined (e.g., time 10 minutes to 25 minutes)
   b. Step 2: Determine the time over which the change has occurred (e.g., 15 minutes).
   c. Step 3: Determine the change in the variable for the time interval chosen.
   d. Step 4: Substitute data into the equation for rate of change shown below and also found on page 1 of the *Earth Science Reference Tables*.

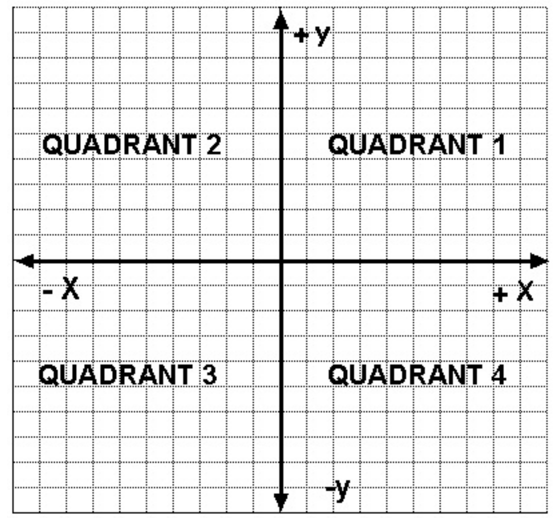
$$\text{rate of change} = \frac{\text{Change in field value}}{\text{Time}}$$

☞Note: The *field value* is the data that was collected.

   e. Step 5: Calculate the rate by dividing the denominator into the numerator of the equation.
   f. Step 6: If your answer is not a whole number always express your answer in *decimal form*. Do not use fractions
   g. Round your number if directed to do so (usually *to the nearest tenth*).
   h. Step 7: Label your answer with the correct units (determined by the values substituted into the equation).

Example: The data below represent soil temperatures recorded every five minutes, for a total of 20 minutes, as a container of soil cooled after having been placed under a heat lamp.

| **Time (minutes)** | 0 | 5 | 10 | 15 | 20 |
|---|---|---|---|---|---|
| **Temperature ( ºC)** | 45.0 | 36.0 | 29.0 | 24.0 | 21.5 |



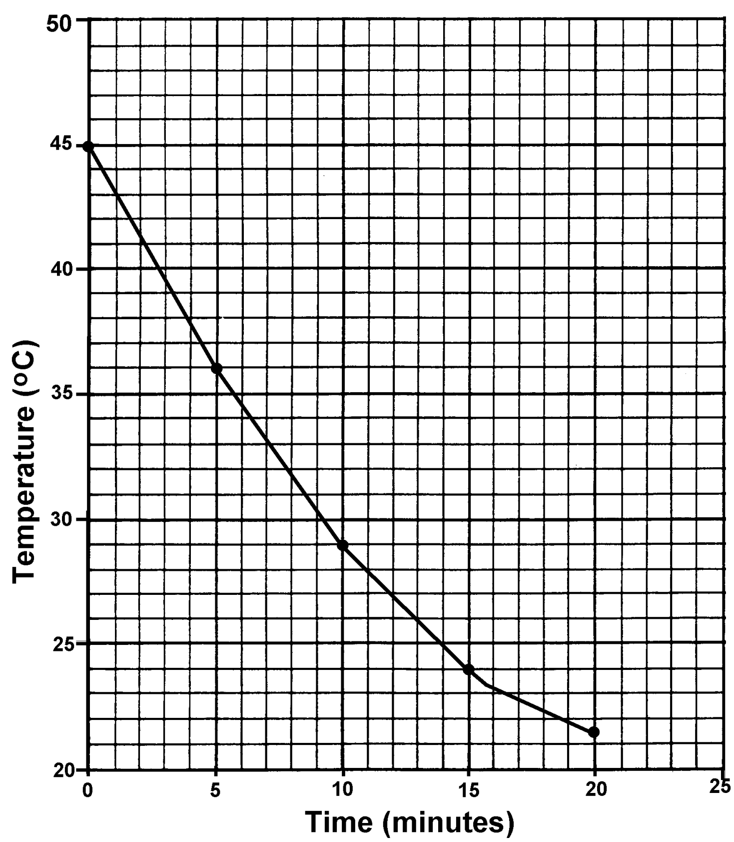

1. Determining what quadrants to use:

   a. The data has only positive values.
   b. Only *quadrant* 1 should be used.

2. Determining the independent variable and the dependent variable:

   a. The data that was collected were the temperature values.
      i. Since temperatures were not known ahead of time, temperatures are the dependent variable.
      ii. Temperature is plotted on the *vertical axis*.

   b. Prior to the experiment it was determined that data would be collected for 20 minutes.
      i. This is known ahead of time and is the *independent variable.*
      ii. Time is plotted on the *horizontal axis*.




3. Setting Up the Horizontal Axis

   a. The initial temperature of the soil is considered "time 0."
   b. The best scale to use is one box equals one degree even though a few boxes will not be used.
   c. Note that the label is "Time (minutes)." The units must be included.

4. Setting Up the Vertical Axis:

   a. The temperature data ranges from a low of 21.5 º C to a high of 45.0 ºC.
   b. Since there were no temperatures recorded less than 20 º C the vertical axis doesn't have to start with zero. Starting with 20º C will allow each box to equal one degree.
   c. This is the best scale to use even though some boxes will not be used.
   d. Note that "º C" is labeled so that the temperature that was scale used is identified.

5. Drawing the line:

   A smooth line is drawn through the plotted points. A key isn't necessary because only one set of data were plotted on the graph.

6. Calculating Rate of Change

a. The following example illustrates how to determine the rate of change between the five minute measurement and the measurement taken at 20 minutes of elapsed time.

b. Finding the Change in *field value*
   - i. The temperature at Time = 5 minutes was 36.0 °C.
   - ii. The temperature at Time = 20 minutes was 21.5 °C.
   - iii. The change in temperature was 14.5 °C. This is the numerator in the rate equation.

c. Finding the Time
   - i. The interval used is from the five minute measurement to the 20 minute measurement.
   - ii. This is a total time of 15 minutes.
   - iii. This value is the denominator in the rate equation.

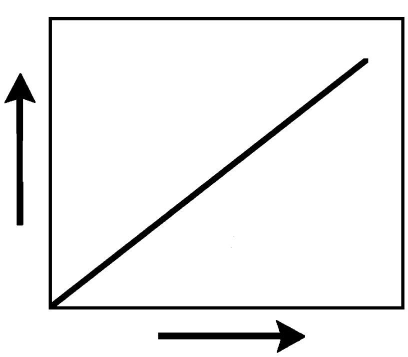
**Units**

$$\text{rate of change} = \frac{\text{Change in field value}}{\text{Time}} = \frac{14.5 \boxed{^\circ C}}{15 \boxed{\text{minutes}}} = 1.0\ ^\circ\text{C/minute}$$

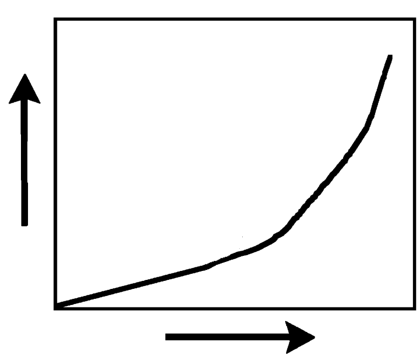
**Rounded to *nearest tenth***

d. The answer:
   - i. The numerical answer has been rounded to the *nearest tenth*.
   - ii. The units can also be written as:
     - (1) degrees Celsius per minute
     - (2) °C per min.
     - (3) $\frac{^\circ C}{\text{min.}}$

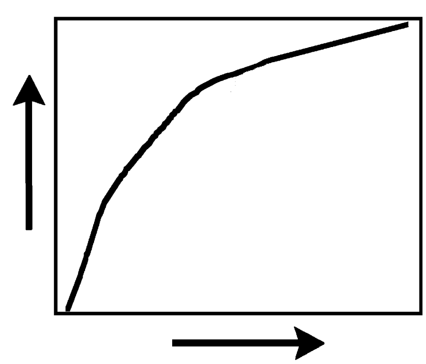
e. Interpreting Rate of Change: The rate of change can be interpreted from observing the slope of the graph line
   - i. If the line is a *straight line* then the rate of change is constant.
   - ii. If the slope of the line changes, then the rate of change is not constant.
   - iii. Steeper slope vs. Gentle Slope
     - (1) Steeper = greater rate of change
     - (2) Gentle = slower rate of change
   - iv. *Indirect* vs. *Direct* Relationships Between Variables
     - (1) *Direct* Relationship:
       - (a) As one variable increases the other variable increases.
       - (b) As one variable decreases the other variable decreases.
     - (2) *Indirect* (Often referred to as “inverse”): As one variable increases the other decreases.
   - v. Examples: (Arrows represent increasing values on each axis.)
     - (1) Direct Relationships



Direct Relationship, Steady Rate

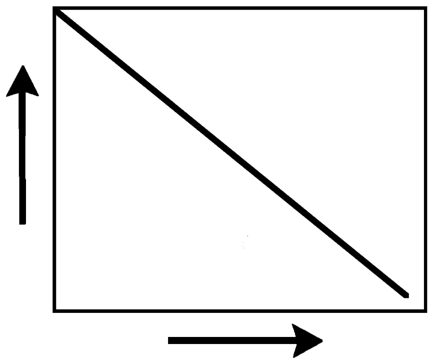


Direct Relationship, Increasing Rate

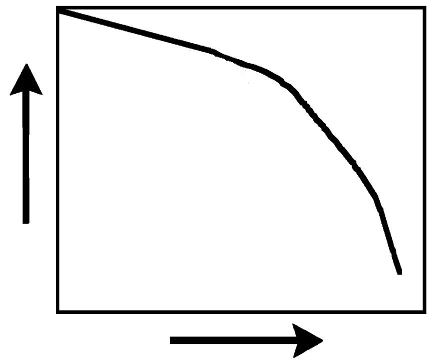


Direct Relationship, Decreasing Rate

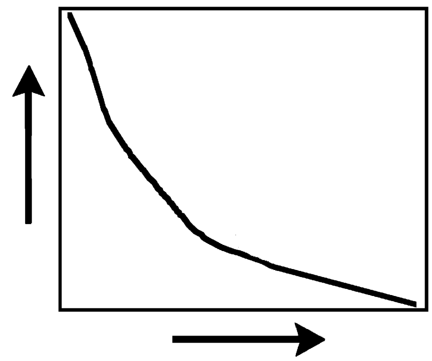
(2) Indirect (inverse) relationships



Indirect (inverse), increasing rate



Indirect, Increasing Rate



Indirect, Decreasing Rate

vi. *Cyclic* Patterns

(1) When the data shows a repeating pattern of change it is said to be *cyclic.*

(2) An example of a cyclic change is the daily rise and fall of tides along a shoreline.

(3) As a result of the observed pattern, the data can be *extrapolated* and the water level at a time in the future can be predicted.