There's Nothing Like a Good Graph

This is your guide to making high-quality graphs. Keep it as a reference as you work on graphing projects, and, at the end of the year, frame it and save it for your grandchildren. The instructions in this guide are based on the following sample graphing project:

> ***Example Project:*** *Having nothing better to do on a rainy Sunday afternoon, Huffer McGrew began stacking pennies and then measuring the heights of the stacks. Your goal is to draw a graph to show how the height of a stack depends on the number of pennies in the stack.*

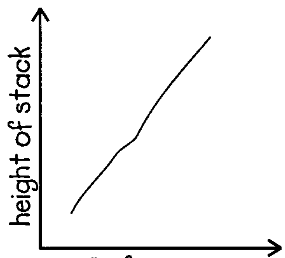
Identifying Variables

1. The word **variable** is derived from *vary* , which means "change." A variable is a factor or value that can be changed. There are two variables in the penny-stacking example: both the number of pennies and the heights of the stacks can be changed.
2. In an experiment, we usually change one of the variables and then observe or measure what happens to the other variable. In Huffer McGrew's penny stacks, he is changing the number of pennies to see what effect this change has on the height of the stack. The variable that is changed is called the **independent variable**. In the example, the number of pennies is the independent variable. The height of the stack is the **dependent variable**, because its value depends on the number of pennies in the stack.
3. Here's another example: Ms. Schmoo's age = her daughter's age + 24. Different values can be substituted for the daughter's age, so this is the independent variable. Ms. Schmoo's age depends on her daughter's age, so Ms. Schmoo's age is the dependent variable.

Drawing Tables & Mini-Graphs

4. The table on the left below has been drawn to keep track of the two variables. Notice that the right-hand column shows that the heights of the stacks will be measured in millimeters (mm). You should always include the units of measure; otherwise, people won't know whether you measured in miles, inches, kilograms, light-years, newts, fluzbottles, or eyebrows.
5. Before beginning each graphing project, draw a mini-graph (like the one on the right below) that shows your prediction of what the graph will look like. Notice that the independent variable goes along the horizontal axis and the dependent variable goes along the vertical axis. The sample mini-graph predicts that the height of the penny stack will go up as the number of pennies goes up.

# of pennies	height of stack (mm)



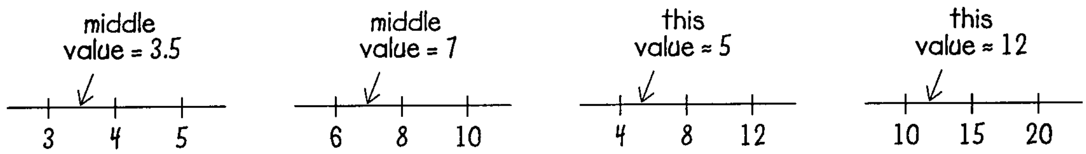
Collecting Data

6. You should be aware of the limitations of your measurements. In the penny-stacking experiment, if partners measured the same stack of 10 pennies, one person might say the stack is 15 mm high and the other might say it is 16 mm high. Who's right? They both are. The height is probably somewhere between 15 and 16 mm. Perhaps the partners read the ruler from different angles or one person's ruler was worn down at the end. Neither the rulers nor the people were exact.
7. Never record a value that is more accurate than is really possible. Suppose a rubber ball is dropped from a height of 1 m and the height of its first bounce is measured by a student to be 64.54365 cm. Is this person really capable of measuring the height to the nearest 0.00001 cm? Given that the ball was moving, it's likely that its height could really only be measured to the nearest 0.5 cm, which is 50,000 times less accurate than the student's original claim!
8. A different student tried the ball-bouncing experiment six times and got values of 64, 60, 67, 62, 59, and 37 cm. Which is the right value? They're probably all right except the last one. The ball is not going to bounce exactly the same each time it is dropped, and the student will probably make measurement errors. However, the last value (37) is so different from the rest of the group that it's probably a mistake.

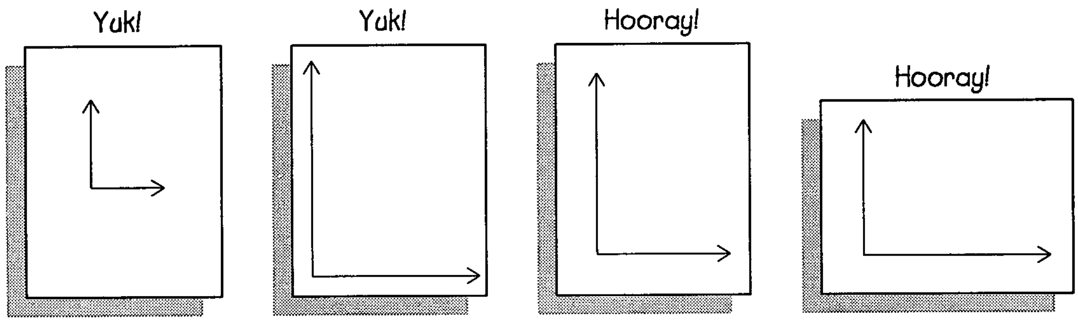
   Which of the five acceptable values should be used? You have three choices: you can use the lowest value, the highest value, or an average. Whichever method you choose, it is important that you use that method each time you conduct the experiment.

Choosing a Scale

9. Numbering the axes of a graph can be tricky. One rule to follow is to number by 1s, 2s, 4s, or 5s, which makes it easy to find the in-between values, as shown here.



   You can also number by 10s, 20s, 40s, 50s, 100s, 200s, 400s, 500s, etc., or even by 0.1s, 0.2s, 0.4s, 0.5s, 0.01s, 0.02s, 0.04s, or 0.05s.
10. The axes of the graph should fill the page but should leave enough room for margins and the numbers and labels. You can use your paper horizontally or vertically.



11. Suppose that Huffer McGrew's penny stacks range from 1 penny high to 40 pennies high. To figure out how to number the horizontal axis, follow these steps.

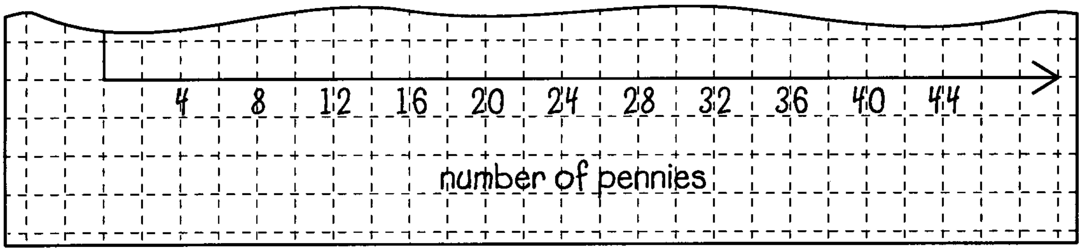
   a. Count the number of squares along the horizontal axis. In the graph below there are 24 squares.

   b. The highest value to be graphed is 40 pennies. Divide this number among the 24 squares: $40 \div 24 \approx 1.67$ pennies per square.

   c. Round 1.67 to one of the convenient numbers described in Question 9. In this case, 1.67 can be rounded to 2 pennies per square.

   d. Test your numbering system. In the graph below, count 2 pennies per square along the horizontal axis. The highest value of 40 pennies ends up being near (but not past) the right-hand side of the graph.

   e. Notice that only every second vertical line was numbered. Putting numbers on every vertical line would make the graph appear too cluttered.

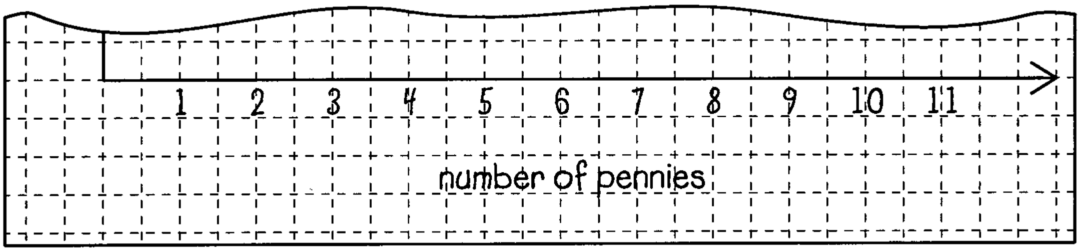


12. What if the highest number of pennies is only 10? The number of squares along the horizontal axis (24) is greater than the highest number to be plotted (10). Instead of dividing the pennies among the squares, try dividing the squares among the pennies.

   a. 24 squares ÷ 10 pennies = 2.4 squares per penny.

   b. Round 2.4 to 2 squares per penny.

   c. Number the axis. Count over 2 squares for each increase of 1 penny.



Other Little Details Worth Knowing About

13. Sometimes data points are described by coordinate pairs, such as (10, 15). For the penny-stacking experiment, the 10 stands for the value along the horizontal axis (10 pennies in the stack) and the 15 stands for the value along the vertical axis (15 mm high). These coordinates tell you where to plot the point on the graph.

14. Look for patterns. Do the points seem to lie along a straight line or a curve? If there is a pattern, draw a line or curve through the center of the group of points so half are above the line and half are below. Remember that your data aren't perfect, so all the points won't be exactly on the line. However, if there are points that don't seem to fit the pattern, try determining their value again; perhaps you made a mistake the first time.