Graphing Nonlinear Data — Name:

AP Physics C — Period:

Let's say a mouse accelerates from rest away from a range finder. The following table of position *vs*. time is made.

| Time $t$ | Position $x$ |
|---|---|
| 0.00 | 0.00 |
| 0.21 | 0.04 |
| 0.42 | 0.17 |
| 0.59 | 0.32 |
| 0.79 | 0.65 |
| 1.04 | 0.98 |
| 1.19 | 1.27 |
| 1.40 | 1.98 |
| 1.60 | 2.59 |
| 1.81 | 3.20 |

What is the mouse's acceleration? Not so easy to figure out!

Here's a clue: if you assume that position varies with time according to the equation

$$x = \tfrac{1}{2} at^2$$

then you can make a plot of $x$ vs. $t^2$. The reason this is an interesting thing to do is that the data should form a more-or-less straight line with slope ½ $a$. Draw a "best fit" line, measure its slope, then multiply by 2, and you've got the acceleration $a$. Try it!

This method works for all sorts of things. Basically, the idea is this: if you make the right choice of $x$ and $y$ axes, <u>any</u> function can be "linearized" (turned into a line) and the slope can be measured.

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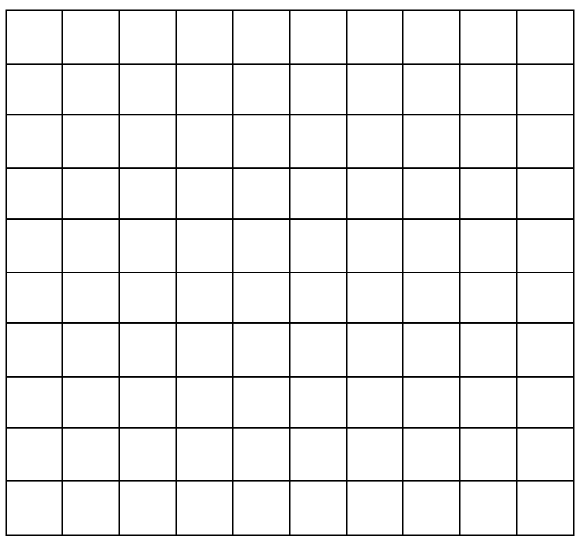
Let's measure the mass of the Sun. According to Newton's theory, the relationship between the orbital period *P* of a planet, measured in seconds, and the average distance *a* between the planet and the Sun, measured in meters, can be expressed as follows:

$$P^2 = [4\pi^2 / GM_{SUN}]\, a^3$$

Plot $P^2$ vs. $a^3$, measure the slope, and use this slope to determine the mass of the Sun.

| Planet | *P* (years) | *a* (AU) | *P* (sec) | *a* (m) | $P^2$ ($sec^2$) | $a^3$ ($m^3$) |
|---|---|---|---|---|---|---|
| Mercury | 0.24 | 0.39 | | | | |
| Venus | 0.61 | 0.72 | | | | |
| Earth | 1.00 | 1.00 | | | | |
| Mars | 1.88 | 1.52 | | | | |
| Jupiter | 11.86 | 5.20 | | | | |
| Saturn | 29.46 | 9.54 | | | | |
| Uranus | 84.01 | 19.19 | | | | |
| Neptune | 248.54 | 39.53 | | | | |



What is the Sun's mass?