Concept: Kinematics equations/ understanding gravitational acceleration (little g)

Modeling in the Classroom:

We propose a short activity where students could investigate for themselves how to mathematically represent one of the kinematics equations ($x_f = x_i + \frac{1}{2}gt^2$) and discover the value of g. The classroom activity will involve dropping a ball from various heights and measuring the time it takes for the ball to hit the ground. They should time multiple trials and take the average and do this for multiple heights. They can then plot these points and will (hopefully) see the quadratic relationship between them. The quadratic slope of how these things are related is the gravitational acceleration, g. The students should identify what type of relationship exists between the variables, height and time. Only after they have come to the conclusion that the relationship is quadratic or square root (depending on how they represent the data), will we reveal the equation they are deriving. From there, they can solve for *g* using the fit of their data.

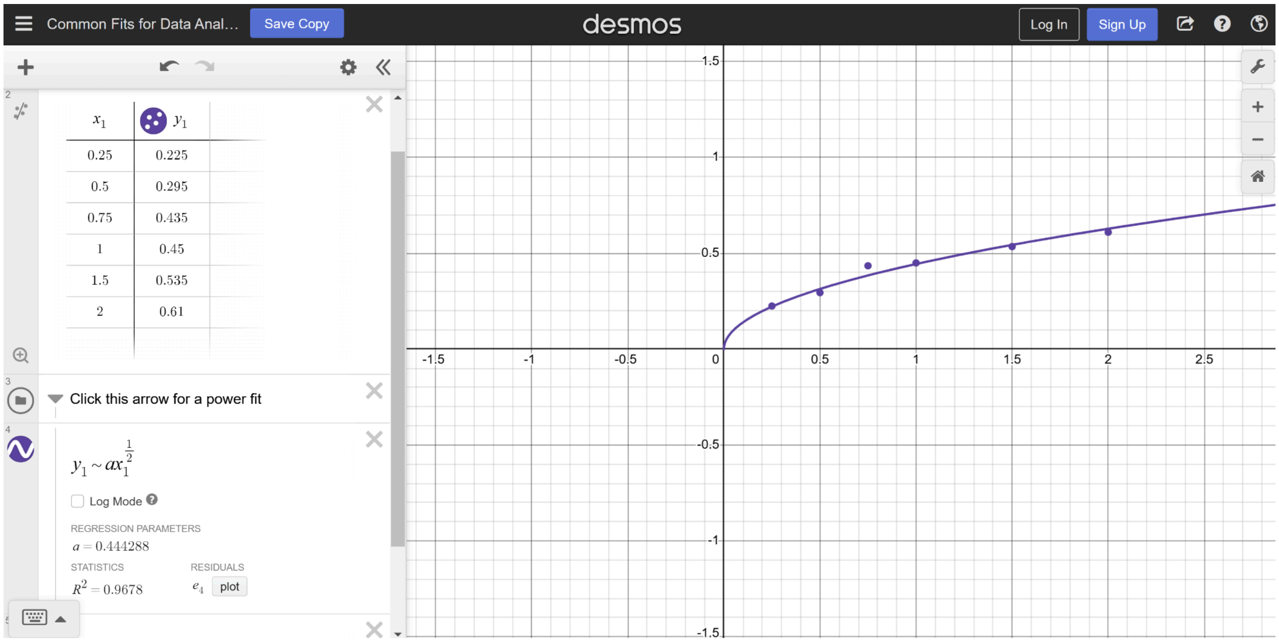
Example of Student Work:

Example Data Table:

Height (m)	**Trial 1 (sec)**	**Trial 2 (sec)**	**Average Time (sec)**
0.25	0.21	0.24	0.225
0.5	0.29	0.30	0.295
0.75	0.41	0.46	0.435
1	0.44	0.46	0.45
1.5	0.52	0.55	0.535
2	0.60	0.62	0.61

Options for relationship: Linear, exponential, **Square Root**

Fit for parameters:



Math Formula Received:

$$t = 0.44h^{1/2}$$

Validation:

To validate their model, they should pick one additional height they did not test already and try to estimate how long the time will be for that height.

Questions for Thought:

Once students have completed the experiment we could ask some probing questions about how different set ups might change the equation we just found.

Would the number change for an object with different weight?

What are some sources of uncertainty in this experiment?

What would happen if you gave the ball some initial velocity?

Final Thoughts:

We at this point could ask them to change around the formula to more resemble the traditional formulation of, $h = 5.2t^2$ (given their data). Then this could continue on into a full lesson of what this and the other kinematic equations are (equations of motion) and what their normal mathematical representations look like. Hopefully, this activity would help students get a physical understanding for what we mean by “equations of motion” having seen the relationship play out in real life.