

# Three Investigations Merging Math and Science with the Same Inexpensive Apparatus

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# The Pendulum (Park Swing)

- Beginning of school year, grades 5-13.
  - Introduce students to structured investigations.
    - No science knowledge needed, supports proportional reasoning.
    - Analysis depends on student math skills.
    - Surprising results, note book needed.
    - Discuss role of science in changing our ideas.
    - Use investigation lesson plan: focus, answer, plan, work, discuss.
- Cheap materials!
  - Pencil, string, paper clip, tape, some washers

If you have any questions, stop me and ask.

# Building the Pendulum

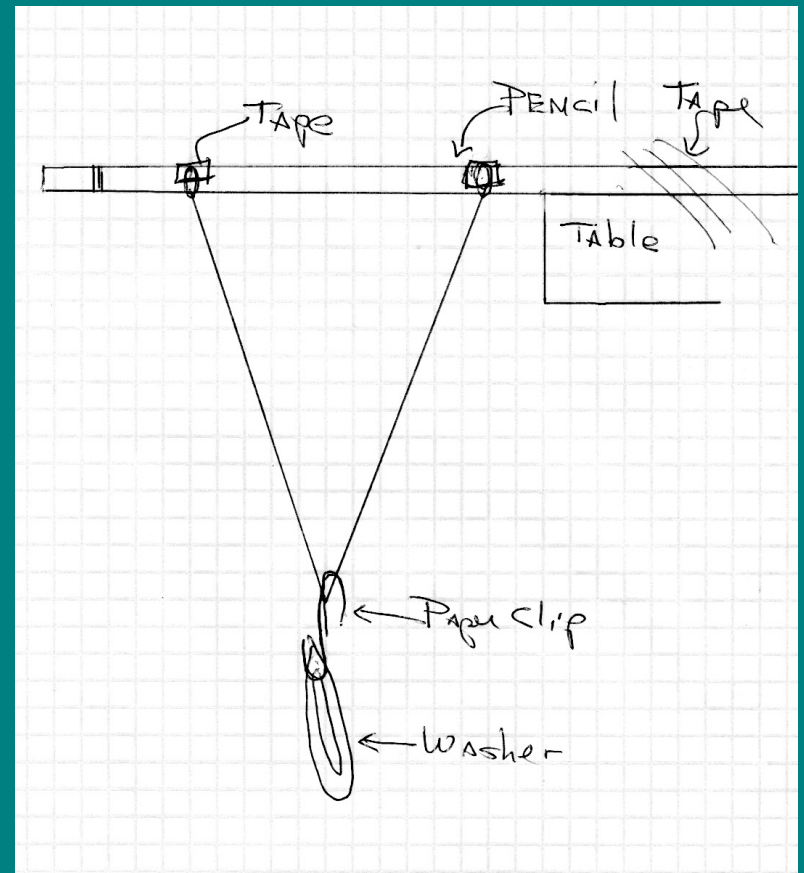
Bifilar, to keep swing in a plane.

Different groups have different string material and lengths, and different weights.

Bend open (slowly) the large paperclip to make a hook.

Students build swing, test, observe others and rebuild if necessary.

You will measure time intervals.



# Three Pendulum Investigations

- Does each swing, back and forth, take the same amount of time?
- What aspects of the pendulum affect the time for each swing?
- How do the aspect(s) affect the time for each swing?

- Does the time for each swing decrease, remain the same, or increase as the swing “slows down”?
  - Chat with your neighbor.
- **Measure number of swings in standard time**, rather than time for a number of swings.
- Does the number of swings, in a fixed time interval e.g. 20 sec, change as the swing “slows down”?
- How could we design an investigation to answer the question? Chat with your neighbor. Share ideas.

## Does the number of swings stay the same?

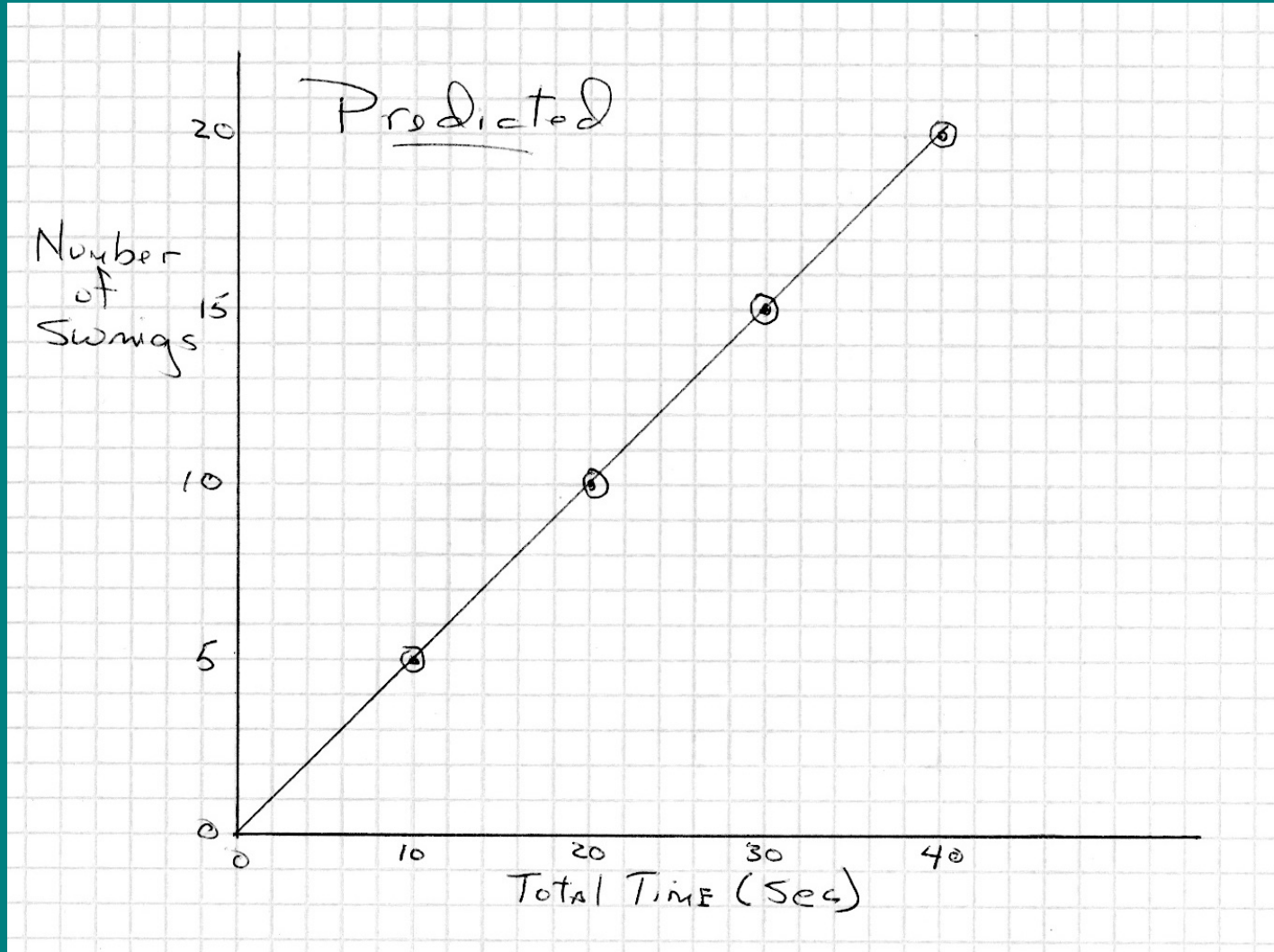
### Plan 1:

- Count number of swings in first 10 seconds, then in second, and the third 10 second intervals.
  - Start the same way each time.
- Repeat as time allows and average results for each time period.
- Make a table, and a histogram showing average and range.
- Questions, Comments?

## Does the number of swings stay the same?

### Plan 2

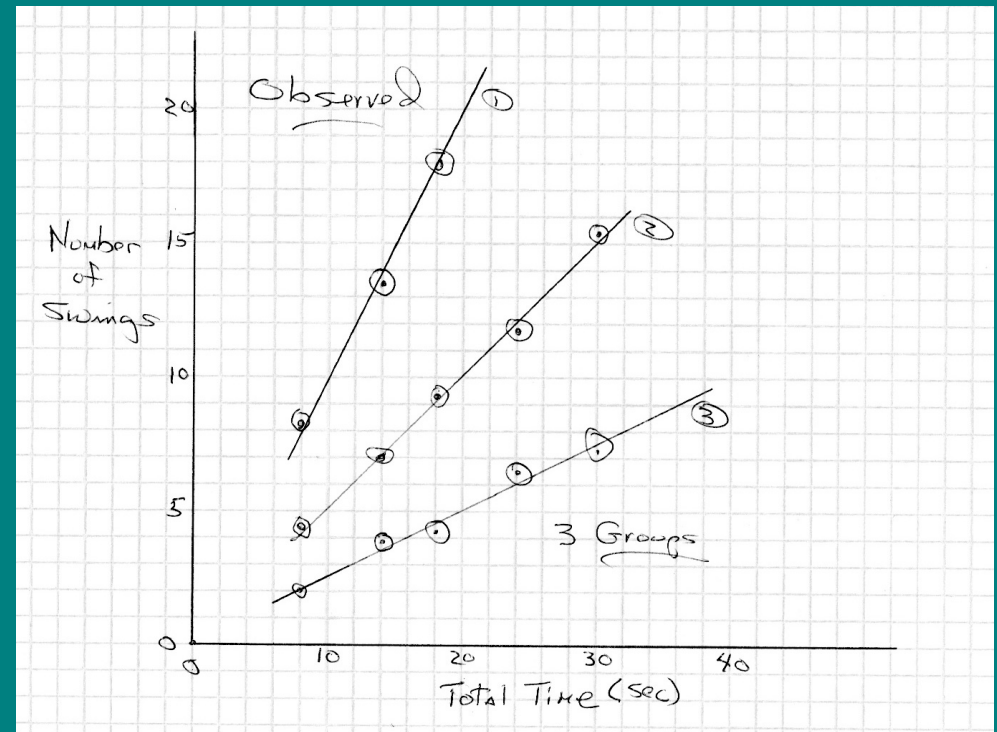
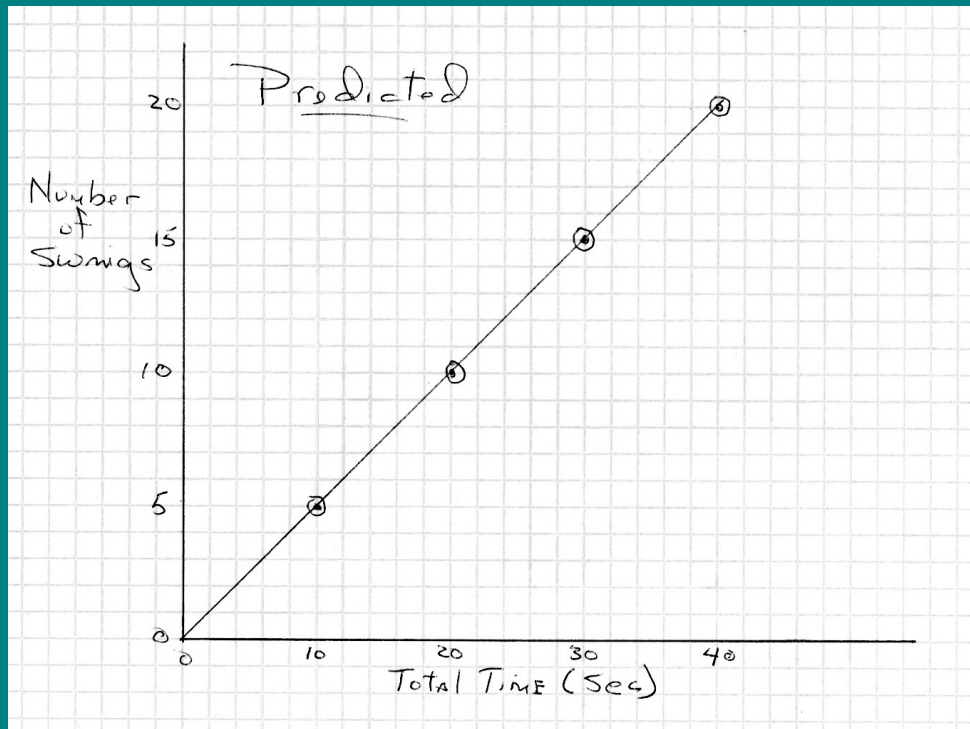
- Assume each swing takes the same time, eg. 2 seconds.
- Predict the number of swings in 10, 20, 30 etc. sec.
- Make a table of the results.(very important)
- Create x-y graph, number of swings on y, total time on x.
- What does the predicted graph would it look like?
  - Discuss slope, y-intercept, depending on grade.





# Measurements

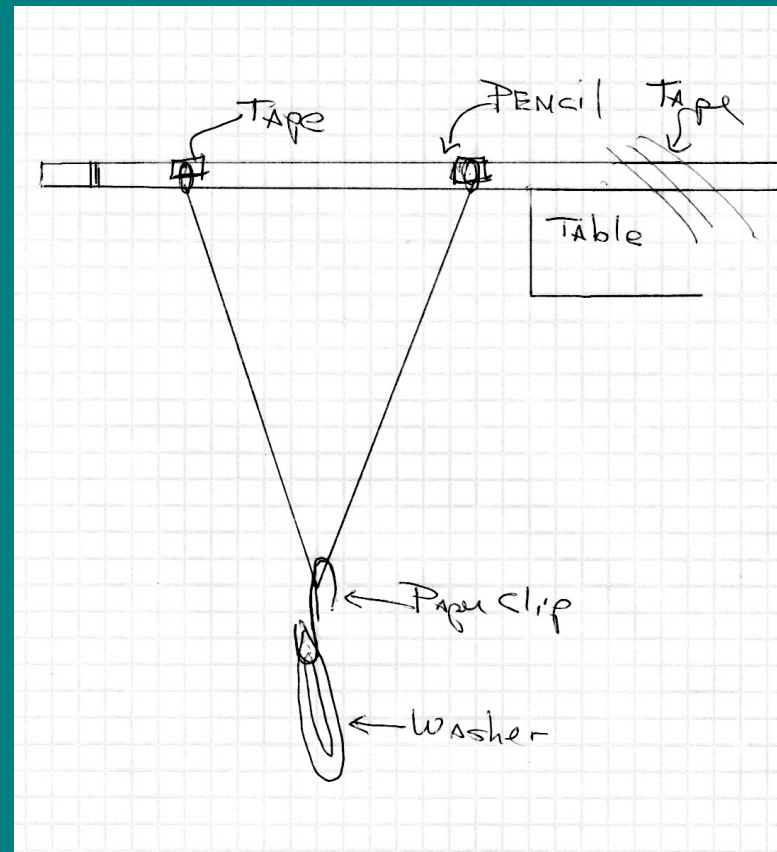
- Count the number of swings for different total times.
  - e.g. 10 sec, 20 sec, etc.
  - Always start the swing the same way.
- Make a table of the results.
- Make graph: number of swings on y, total time on x.
- Compare data graph with predicted graph and discuss.
- Depending on grade, discuss how the graph would look if the time for each swing were to change.



What can we conclude about the time for each swing?  
Chat with your neighbor. Comments, Questions?

# What aspects of the pendulum affect the number of swings in 20 seconds?

Looking at the sketch, chat with a neighbor, and list the aspects (variables) that your students think might affect the time for each swing.



# What aspects of the pendulum affect the number of swings in “20 seconds”?

- Groups build swings with different string lengths and material, and different weights.
- Ask students which aspects will affect the number.
- Each group will investigate one variable.
  - Each group chooses their variable.
- Make large table with 6 columns and a row for each group.
- First column: group number, second: which variable.

# Number of swings in 20 Sec.

Group Number	Variable	Pre measure 1	Pre measure 2	Post measure 1	Post measure 2
1	Weight				
2	Amount of swing				
3	Kind of string				
4	Weight				
5	Length				
6	Separation at top				
7	Kind of weight				

## Number of swings in 20 Sec

- You measure time, groups count the number of swings
  - Start the same way each time.
- Count as built, and repeat to check repeatability.
- Each group changes only the one variable they are studying.
  - Why only change one variable? (tomato plants!)
  - e.g. weight could add or remove weights, etc.
- Should they make a large change or a small one?
  - Chat with neighbor and discuss.

## Number of swings in 20 Sec.

Group Number	Variable	Pre change 1	Pre change 2	Post change 1	Post change 2
1	Weight	14	13	13	14
2	Amount of swing	8	7	6	5
3	Kind of string	17	18	18	17
4	Weight	10	10	11	10
5	Length	6	6	12	13
6	Separation at top	9	8	9	9
7	Kind of weight	13	13	12	13

Discuss results with your neighbor, what would you conclude?  
Questions, Comments?

## How does the number of swings in 20 seconds depend on length?

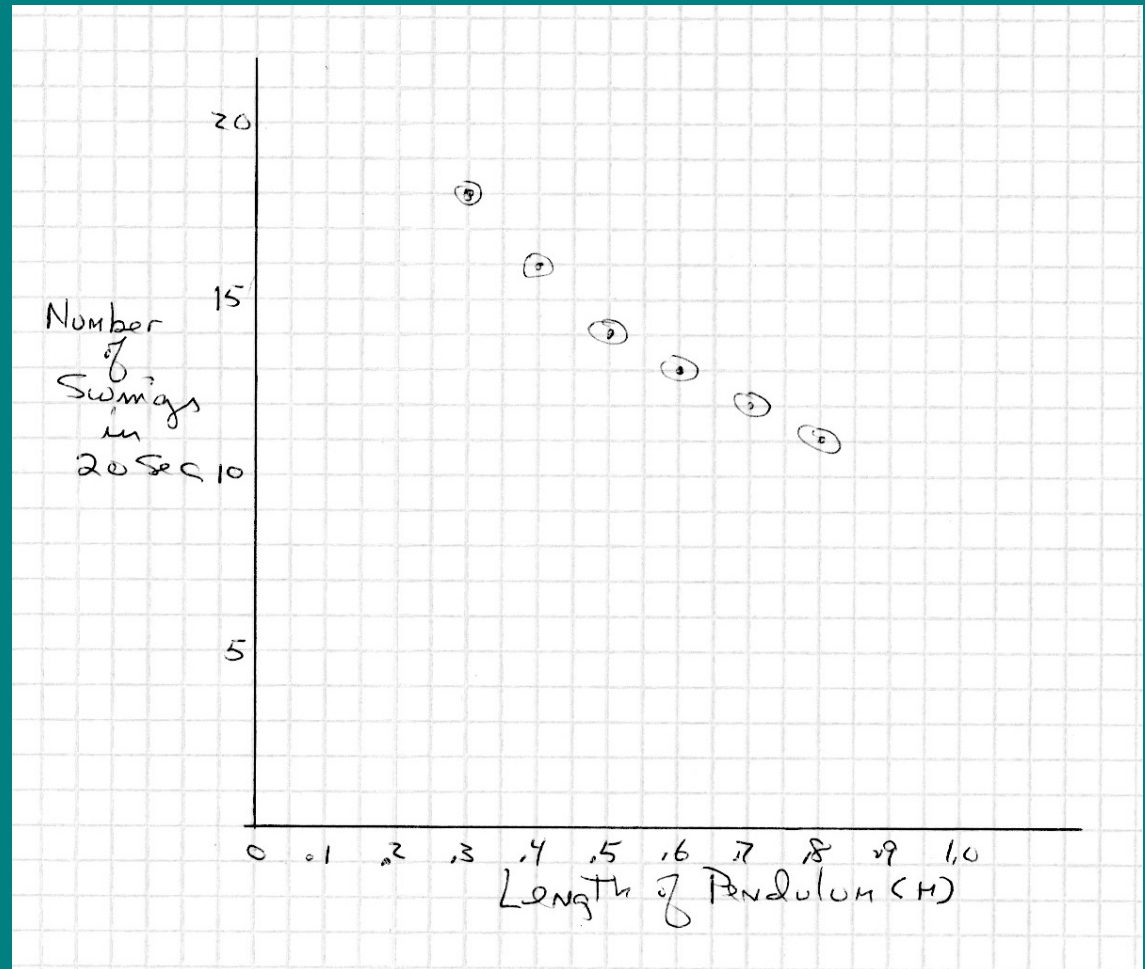
- If you have time, students could create a class table showing length of swing and the number of swings in 20 sec.
  - Look for the correlation between length and number of swings.
- Since length is the only significant variable, students design new swings so length can be measured carefully.



## Affect of Length

- Some evidence that amount of swing might make a difference so always start the same way.
- Each group uses a different length.
- Count the number of swings in 20 seconds (or longer).
- Repeat several times and average.
- Share data, make table and graph, number on y, length on x.
- What pattern is observed?

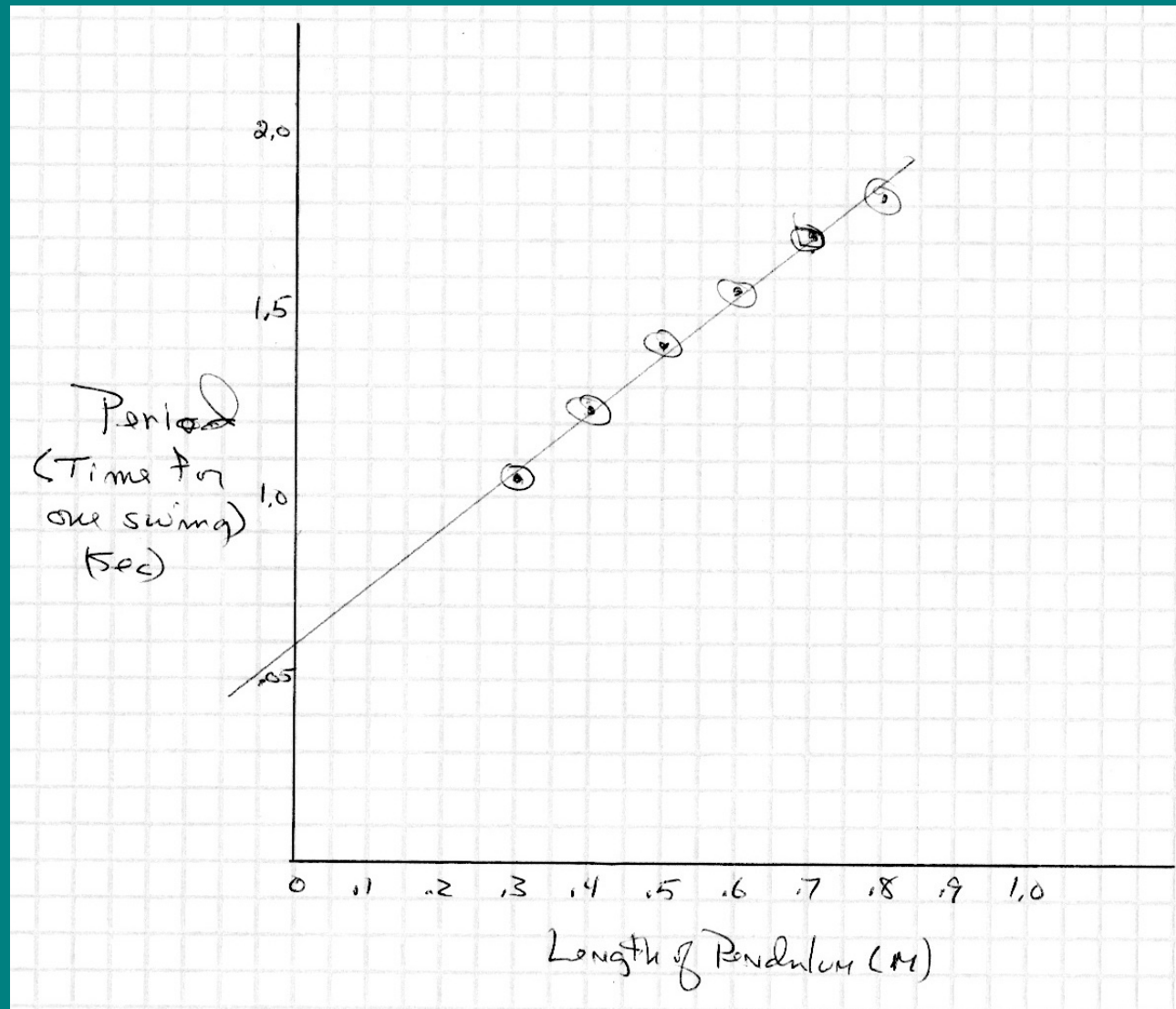
What can you  
conclude  
from this  
graph?  
Discuss with  
a neighbor  
and share.



## Time In Each Swing

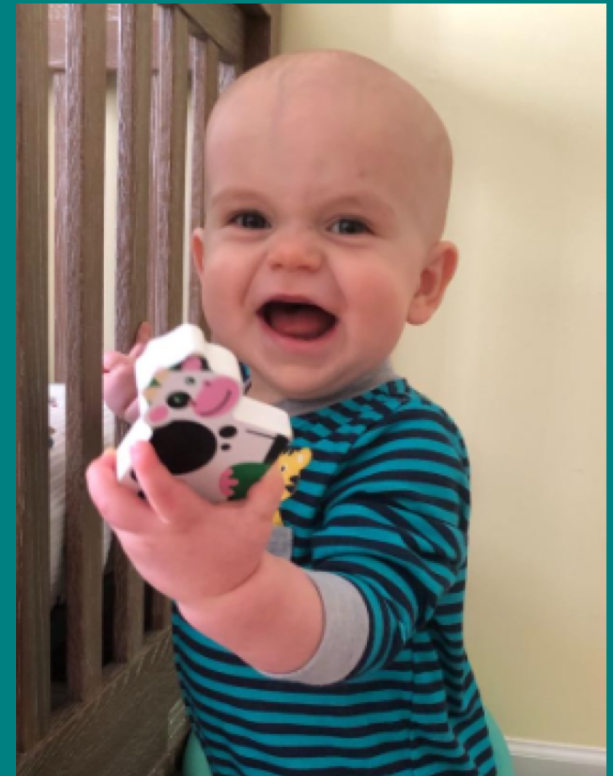
- Knowing the number of swings in 20 seconds, how could we determine the time for each swing? Chat with your neighbor and discuss.
- Make a table, convert the data and make a graph of time for each swing on the y and length on the x.
  - The time for each swing is called the period.
- Is there a pattern in how the period depends on length?

- Do these data lie along a straight line?
- If so how would you interpret the y intercept?



## Three investigations

- Simple apparatus
- Mathematics used to display and analyze results, proportional reasoning.
- No prior science knowledge needed.
  - Avoid discussing any theory at this point.
- Students have to confront their own expectations.
  - Notebooks become important.
- Hopefully they become curious and excited about doing science.



Thanks for your attention.

Any questions?

If you want a copy of the ppt, email me at

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