Physics I – Summer Project Name: _____

Discovering a Rule of Nature

Dear incoming physics students,

Welcome to physics! Let's get right down to business. You are alive at an incredibly exciting time in human history. Your species has recently (ok, in the last few hundred years) discovered that the natural world follows rules! In fact, it follows very exact, mathematical rules. The heart of physics is testing the world around us to figure out what those rules are. Once we know the rules, we can control the world, and then we get spaceships, iPhones, laser pointers, and lots more cool stuff.

Your job this summer is to try to find one of these rules that the universe follows! To find a rule, you first have to ask a question about the natural world. **You will write a scientific paper explaining what your question is, how you answered it, and what the rule that you discovered as a result is. This will be the only thing that I will collect**. The rest of this packet is a guide to help you answer your question and write the scientific paper.

Have fun discovering a rule of nature – I look forward to meeting you in the fall!

Sincerely,
Mr. Kardon
Physics Teacher
bkardon@bluehills.org

Possible questions:

- How does changing the amount of water in a bottle affect how long it takes for the bottle to fall to the floor?
- If I hang a weight from a string, then pull it back, and measure how long it takes to swing back and forth 10 times, how does the length of the string affect the time it takes to swing 10 times?
- How does my distance from a wireless router affect the strength of the WiFi signal?
  Hint: There are apps that can measure WiFi signal strength.
- How does the ratio of volume of soap to water affect how long soap bubbles last?
- How does the diameter of a soap bubble floating on water affect how long the bubble lasts?
- How does changing the angle at which I shoot a rubber band affect how far away it lands?
- If I inflate a balloon, then drive the balloon up a mountain, how does my altitude affect the diameter of the balloon?
  Hint: There are smart-phone apps that will tell you your altitude.
- How does the angle of elevation at which a star appears in the night sky affect how fast it moves across the sky?
  Hint: You can build a simple sextant to help you measure this
- How does the size of the light spot that a magnifying glass creates affect the temperature of the surface?
  Safety: The answer can be "very hot", so don't burn yourself!
- How does the diameter of an inflated balloon taped to a toy car affect how far it can push the toy car when the air is released?
- How does the height at which a 3" clay sphere is dropped affect how thick the clay ball is after it hits the floor?
- How does the speed of a car on the highway affect the RPM of the engine?
  Safety: Use a responsible adult for this one

- How does the weight of the cargo in a car going 60 mph on the highway affect the RPM of the engine?

  Safety: Use a responsible adult for this one
- How does the amount of time an egg is boiled affect how much weight it can support without breaking?
- How does the diameter of a rubber balloon affect how much weight it can support without breaking?
- How does the number of rubber bands supporting a weight affect how far the rubber bands are stretched?
- How does the amount of weight a rubber band supports affect how far the rubber band stretches?
- If I fill a water bottle with water, then poke a hole in its side, how does the height of the hole affect how fast the water comes out of the hole?
- How does the depth of water in a glass affect the pitch it makes when I tap it with a stick?
- How does the length of time an egg was boiled affect how long it takes to stop spinning once I start it?

  Note: How will you make sure you start the eggs spinning at the same speed every time?

Here is the process you should follow to answer your chosen question:

1. Select a question that seems interesting to you. If none of the questions I thought of seem interesting, think of your own! To make your life easier, stick to questions that sound like this: "How does changing [something you can measure] affect [another thing you can measure]?" These are your independent and dependent variables, respectively.

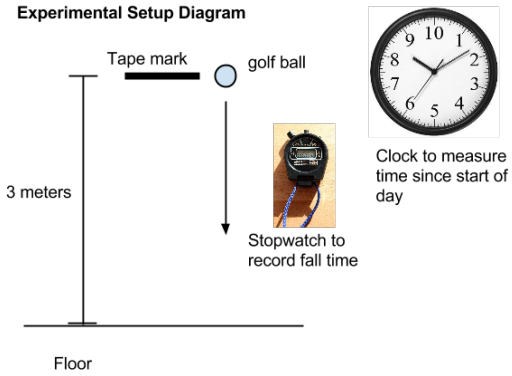
   Silly example: How does the time of day affect how long it takes for a golf ball to hit the ground from a height of 1 meter?

2. Decide how you will take **data**, and write the process down. Your data will probably be a set of measurements of [something you can measure], and the corresponding measurements of [another thing you can measure].

   Silly example:
   I will use a clock to determine how many seconds have passed since the beginning of the day. I will mark a spot on the wall that is 1 meter above the ground (using a tape measure). I will drop the golf ball, and use a stopwatch to time how long it takes to hit the ground.

3. Try out your experiment! It probably won't work on the first try – experiments usually don't on the first (or second or third) try. Re-design your procedure to make the experiment more accurate! If possible, include a picture or a diagram of your experimental setup.

   Silly example:
   It was very difficult to start and stop the stopwatch accurately enough to time the golf ball falling. I should drop the ball from 3 meters instead, so the drop takes longer. I will also drop the ball 3 times in a row, and take the average to reduce the amount of error I introduce.



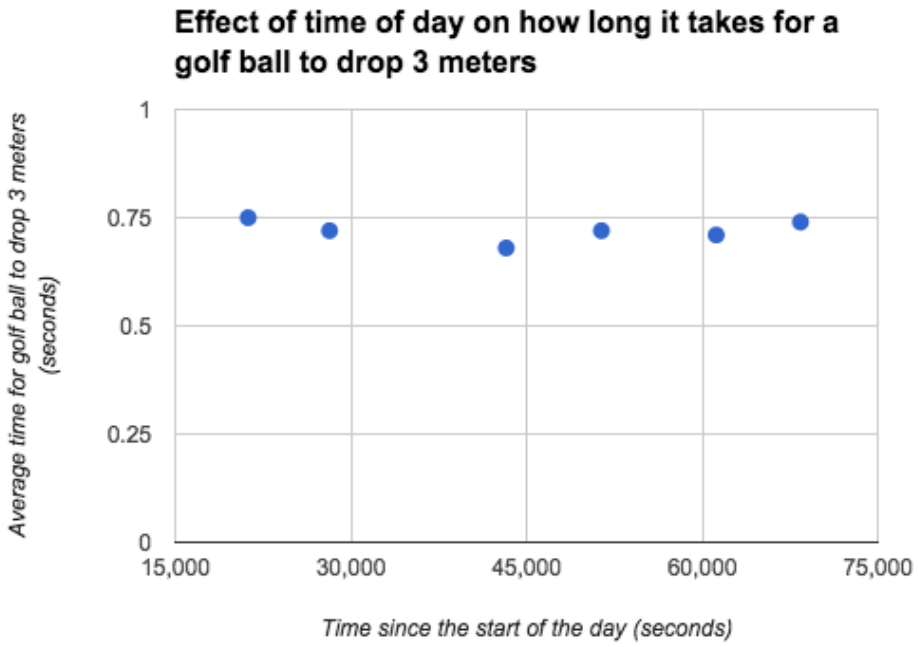
4. Write down your data in a table. Make sure you label all the columns so someone else can easily tell what the data is, and what it means.

Silly example:

T_{day} - time since start of day (seconds)	T_{drop} - Average time for golf ball to drop 3 meters (seconds)
21,230	0.75
28,185	0.72
43,271	0.68
51,402	0.72
61,205	0.71
68,401	0.74

5. Graph your data! Graphs are an indispensable way to see patterns in the data that could reveal the rule you are looking for.

Silly example:



6. Analyze your data. Figure out what your data means. Find the answer to your initial question by looking for a pattern in your data. Think of what errors exist in your data due to measurement or other sources that need to be accounted for. The golden standard here is to find a mathematical equation that represents the relationship between your two variables – this is a rule that the universe follows!

Silly example:
The graph shows that as the time of day increases, the amount of time it takes doesn't seem to change. The small amount of variation is most likely due to random errors in starting and stopping the stopwatch, or errors in the initial placement of the golf ball before dropping. I conclude that the time it takes for the golf ball to fall is not related to the time of day; therefore the mathematical equation that describes this data is $T_{drop} = 0.75$ s.

7. Write a scientific paper that explains exactly what you did, and what you found out! This is how scientists communicate the rules they discover to other scientists, so they can build on and double-check each others' work. Use the checklist below to organize your paper.

Scientific paper template:
Your scientific paper should be organized into sections like the template below. Read the checklists to see what should go into each section of your scientific paper.

TITLE

Author: YOUR NAME
Date of publication here

General guidelines:

- *The purpose of this is to communicate to other scientists what law of nature you discovered, and how you discovered it.*
- *Aim for a professional, scientific tone - write as though you are a scientist describing an experiment you did, not as a high school student doing a class project.*
- *All writing in your own words*
- *Avoid vague words like "it"*

Introduction:

Introduce your experiment – explain what you were trying to find out, and what you did.
Your introduction must include (approximately in this order):

- *The experimental question for the experiment - what question were you trying to answer?*
- *A brief description of the setup (does not need to include all details, just the main idea)*
- *A definition of any non-everyday terms used in the experiment*
- *A brief description of any background knowledge required to understand the experiment*

Experimental Setup and Procedure:

Explain your experimental setup & procedure in enough detail for someone to repeat your experiment and verify your results.
Your experimental setup must include (approximately in this order):

- *All materials and tools used*
- *How you used the materials/tools*
- *Enough detail so someone else could repeat your experiment.*
- *Writing in your own words*

Results and Analysis:

Show your data, explain what it means and how the data leads to an answer to the question.
Your results and analysis must include (approximately in this order):

- *Data tables showing your results*
- *Graphs of your data, and an explanation of what each graph shows*
- *An explanation of calculations, diagrams, etc to explain how you arrived at your conclusion*
- *An analysis of what inaccuracies or errors are present in the data, and how big they are*
- ***An answer to your original question***

Conclusions:

Someone should be able to skip to the conclusion and get a basic idea of what experiment you did and what the major result was.
Your conclusion must include (approximately in this order):

- *A restatement of the purpose of the experiment*
- *A brief summary of what you did*
- *A brief summary of your conclusions based on the data*

Physics I

Name: _____

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Standard Grades

The table below explains how you will be graded.

Standard		Meaning	Grade	Feedback
S1.1	Designing Experiments	Did you choose a clear experimental question? Did you design, execute, and explain a valid procedure that you used to answer the question?	/ 4	
S1.2	Representing Data	Did you organize and display data in a easily understood and professional format using graphs, data tables, and/or other means?	/ 4	
S1.3	Mathematical Interpretation of Data	Did you clearly interpret and explain the data and any calculations you did with the data? Did you explain how the data lead you to a conclusion about your question?	/ 4	
S1.4	Error Analysis	Did you recognize, explain, and estimate multiple sources of error, and identify strategies for reducing the errors? Note that experimental error is always present, even in a perfect procedure.	/ 4	
S1.6	Formatting and Organization of Ideas	Did you organize your paper with appropriate titles, headings, and sequence of paragraphs, and use professional fonts, formatting, spelling, and language conventions?	/ 4	
S1.7	Honors Deadlines	Did you complete and hand in your paper on time?	/ 4	