COMMUNITY COLLEGE system of New Hampshire	NCC Astronomy PHYS115
	Instructor: Meg Noah
	Instructor Email: mnoah@ccsnh.edu
	Popup Experiment

Vocabulary of Science

Work with a partner to complete the sentences with words from this word bank.

Experiment	Observing	Quantitative	Qualitative
Theory	Hypothesis	Inference	Natural
Mathematical Model	Evidence	Independent (Manipulated, Control)	Dependent (Responding)
Logical Reasoning	Fallacy	Reducing	Falsifiable

1. Science is a body of knowledge that explains the _____ world.

2. Gathering information with senses and equipment: _____.

3. A logical interpretation based on observations: _____

4. All claims in science should be supported by _____ and _____.

5. Type of data that is measured with numbers (i.e. temperature) _____

6. Type of data that is in the form of a description (i.e. color) _____

7. A proposed explanation that can be tested: _____

8. A hypothesis must be _____ and testable.

9. A step-by-step procedure that is used to test a hypothesis: _____

10. The thing that the scientist changes in an experiment: _____ variable

11. What is measured or observed in an experiment: _____ variable

12. When _____ measured data, it is important to not introduce bias by committing a cherry-picking _____.

13. In science, a _____ is a very well-tested and generally accepted principle or body of principles offered to explain phenomena.

14. In science, a _____ is used to make predictions, telling us WHAT will happen.

Observation → Hypothesis

Observation leads to hypothesis. Play with the popup toy(s): push it down, and when the suction cup loses suction, the toy pops up.

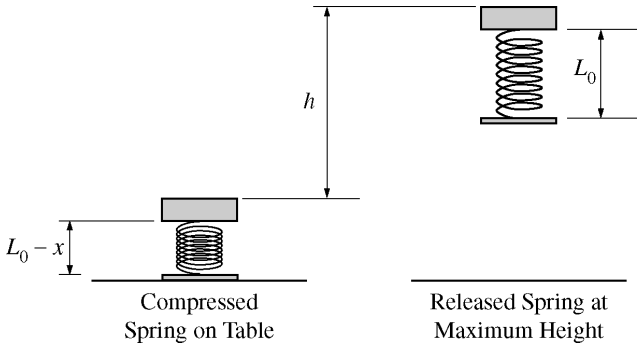
Qualitative explanation of motion:

The spring stores energy when you create the suction, and energy of the spring is converted to kinetic energy when the toy flies, and as it gains height the kinetic energy is converted to gravitational potential energy. Eventually, the all the kinetic energy is converted to gravitational potential energy and the toy begins to fall back to the surface.

Reason a hypothesis that relates mass and height:

The different toys have different heights they reach but appear to have the same spring, and hence the same spring energy.

Hypothesis: There is a relationship between the mass of the toy and the height it will rise.



Popup Toy Graphic from the 2009 AP College Exam © 2009 The College Board

Hypothesis → Experiment

To find the relationship between height and mass of the head, select one of the toys to use (just one spring). The experiment kit comes with about 24 g of play dough and the mass of the toy is noted on the bottom. Divide the 24 g of putty into 8 equal sized balls each 3 g. The mass of the head can be increased by adding a play dough hat. Create a table to record 3 trials of each of the height reached for the popup toy alone, then the popup toy +3 g of putty, +6 g of putty, +9 g, +15 g, and +18 g.

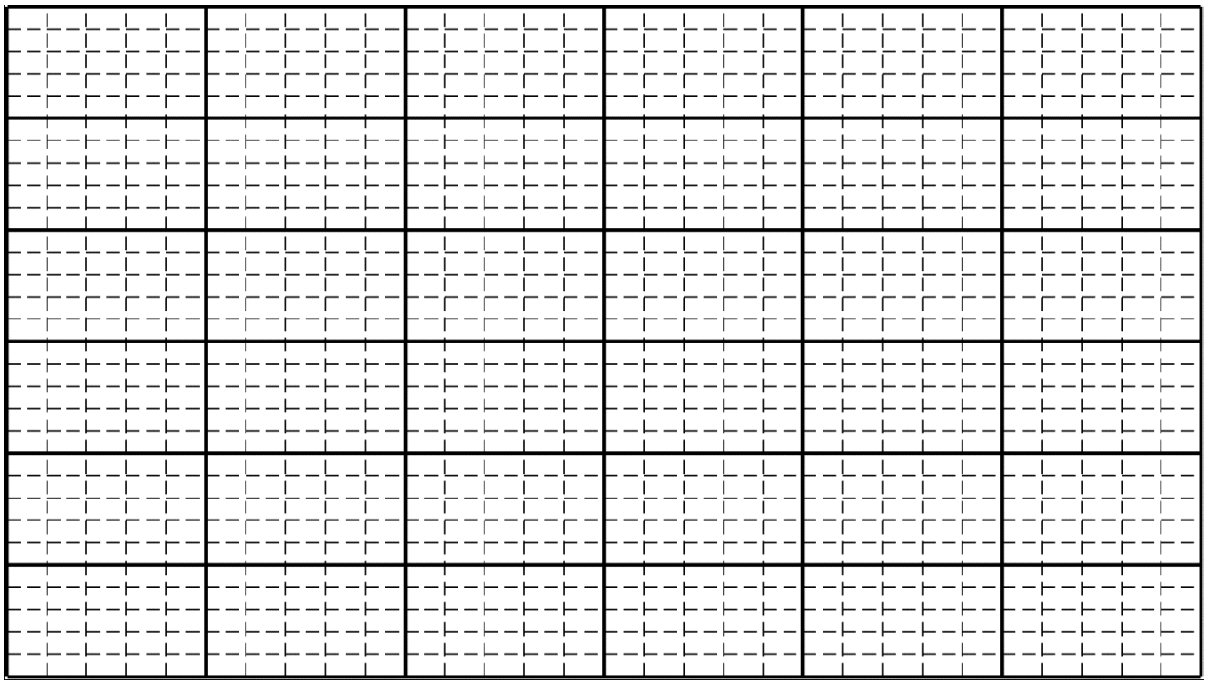
Data Reduction

Are there any obvious experimental errors? If so, remove the bad measurement and repeat the trial. It is important to recognize when you have made an experimental error and when data is real, but unexpected.

Find the average of the three trials for each mass.

Mass m (g)	Trial 1 h (cm)	Trial 2 h (cm)	Trial 3 h (cm)	Average h (cm)

For visualization, on the axes below, plot relevant data to make a straight line. Label both axes with both a description and units. Give your plot a title.



Mathematical Modeling

Find a power relationship between the height and the mass.

$$h = Cm^n$$

Find reasonable values of C and x.

Some strategies include:

- Guess-check-revise
- Make a plot (if x=1, the plot is a line; if the slope is decreasing, x<0; if the slope is increasing, x>0)
- Fit a line or curve in a spreadsheet

Rearrange the equation

$$C = hm^{-n}$$

'Guess' integer values of the exponent: n=2, 1, 0, -1, -2. Which value of n produces a nearly constant value of C for the different mass values?

Configuration		$n = 2$	$n = 1$	$n = 0$	$n = -1$	$n = -2$
m (g)	Average h (cm)	hm^{-2}	hm^{-1}	hm^0	hm^1	hm^2

Prediction and Testing

Based on your mathematical model, make a prediction for what height will be obtained if you add 12 g of play dough to the head.

$h =$

Test your prediction. What value did you measure?

Are you close to the measured value?

Does it appear to be within the experimental error?

Explanation

The forces of the system are given by

$$\vec{F}_{spring} = -k(L_0 - x)\hat{y} \qquad \vec{F}_{gravity} = mg\hat{y}$$

The energy of the system is given by:

$$E_{spring} = \frac{1}{2}k(L_0 - x)^2 \qquad E_{kinetic} = \frac{1}{2}mv^2 \qquad E_{gravity} = mgh$$

At the beginning of the trial, all the energy is in the spring and when the toy reaches its maximum height, all the energy is gravitational potential energy. Since energy is conserved:

$$\frac{1}{2}k(L_0 - x)^2 = mgh$$

The gravitational acceleration due to Earth, g, the spring constant, k, and the distance depressed, are all constants. Defining a constant:

$$C = \frac{k}{2g}(L_0 - x)^2$$

We can write:

$$h = Cm^{-1}$$