**Stretching Our Knowledge
Teacher Notes**

Last year you learned about how a spring stretches which the elasticity is called the k value. The k value represents the force divided by distance which would be Newtons per meter. This means that it takes a certain force to stretch the spring a certain distance. Now we will use this information to investigate how springs work together.

**Content Area: PreCalculus/Algebra 3 and AP Physics**

**Connection to common core and standards:**

*Physics:*

- WO.9.P.2 Calculate the spring force using Hooke’s law.

- NS.16.P.1 Describe why science is limited to natural explanations of how the world works.

- NS.16.P.3 Summarize the guidelines of science.

*NGSS:*

- HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

- HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

- HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

*CCSSM:*

*Algebra 3:*

-FOP.3. AIII.3 Read values of an inverse function from a graph or a table, given that the function has an inverse

*Precalculus:*

-F.6.PC.3 Read values of an inverse function from a graph or a table given that the function has an inverse

-F.7.PC.7 Build functions to model real-world applications using algebraic operations on functions and composition, with and without appropriate technology

**NGSS Science and Engineering Practices**

1. ASK QUESTIONS AND DEFINE PROBLEMS

2. DEVELOP AND USE MODELS

3. ANALYZE AND INTERPRET DATA

4. PLAN AND CARRY OUT INVESTIGATIONS

5. CONSTRUCT EXPLANATIONS AND DESIGN SOLUTIONS

6. USE MATHEMATICS AND COMPUTATIONAL THINKING

7. OBTAIN, EVALUATE AND COMMUNICATE INFORMATION

8. ENGAGE IN AN ARGUMENT FROM EVIDENCE

**Eight Standards for Mathematical Practices**

Standard 1: Make sense of problems and persevere in solving them

Standard 2: Reason abstractly and quantitatively

Standard 3: Construct viable arguments and critique the reasoning of others

Standard 4: Model with mathematics

Standard 5: Use appropriate tools strategically

Standard 6: Attend to precision

Standard 7: Look for and make use of structure

Standard 8: Look for and express regularity in repeated reasoning

**Level of complexity:**

 Students would have experienced The Spring Thing in their Algebra 2 and Physics class during the previous year. This activity is just an extension of our exploration of connections between math and science through the study of springs. This is an open ended and includes several variations which the teacher can use as they see fit.

**Description of the project:**

The teacher needs to collect the following equipment (This is per group):

* Set of slotted masses (50 or 100 grams up to 500 grams)
* Two mass hangers
* Collection of springs with at least two different k values
* Support system as should in the photograph with an additional small diameter pole
* Meter stick
* Masking tape
* String
* Scissors
* Level (optional)

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**Pre-Lab:**

Teacher will model the set up before the day of the investigation. Teacher may want to review The Spring Thing with some questions as shown below or on the Nspire document.

* Use this data to calculate the k value

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mass (g) | Length (cm) | Mass (kg)g/1000 | Weight (N)Kg \* 9.8 | Length (m)cm/100 |
| 0 | 2 | 0 | 0 | 0.020 |
| 100 | 4.7 | 0.1 | 0.98 | 0.047 |
| 200 | 7.3 | 0.2 | 1.96 | 0.073 |
| 300 | 10 | 0.3 | 2.94 | 0.100 |

* The k value from this data would be approximately 36.84 N/m
* Review with students how to find the inverse of a function.

**Assessment component:**

During the investigation, the teacher should circulate and observe in service to formative assessment which could be conducted through quick polls. If using the Nspire Navigator, use the screen shot on auto refresh to show student work.

1. Assume you have two springs each with the same k value of 47.2 N/m. Calculate the k value of this two spring system connected in series. Then in parallel. (Answer: k1 + k2  +…… = k so 94.4 N/m for series and $\frac{1}{k\_{1}}+\frac{1}{k\_{1}}+…= \frac{1}{k}$ so 23.6 N/m for parallel)
2. Assume you have three springs each with the following k values, 24.5 N/m, 42.7 N/m, and 51.4 N/m. Calculate the k value of this three spring system connected in series. Then in parallel. (Answer: 118.6 N/m for series and 11.9 N/m.
3. If you took one of the springs to the moon, what would happen to its k value? Justify your answer.

**Safety and equipment issues:**

Students should avoid swinging the meter sticks around. There is some danger with dropping masses to toes and feet and the masses chip off which changes their mass. Avoid stretching the spring too much. As people move around the room, avoid colliding with the poles.

**Procedures:**

1. Collect materials for your group.

One set of slotted masses

 Two mass hangers

Two springs of the same color (May need other springs and equipment for later in the investigation)

 Support system as demonstrated by the teacher

 Meter stick

 Masking tape

 String

 Scissors

 Level (optional

 Protractor or protractor app

1. Set up the support system and select one spring to calculate the k value. Recall, you need to put an initial mass to stretch the spring as a starting point and you will need to convert your masses to kilograms then into weight (Newtons). The lengths will need to be in meters to get the k value in the units of Newtons per meter. 1000 grams = 1 kilogram, weight = mass times acceleration due to gravity (i.e. g = 9.8 meters per second per second), 100 centimeters = 1 meter. Record the data below.

|  |  |
| --- | --- |
| **Mass** | **Length** |
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|  |  |
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1. Show your calculation for the k value.
2. Explain what would happen to the k value if you connected two springs?
3. Connect two springs with the same k value (same color) and calculate the new k value.

|  |  |
| --- | --- |
| **Mass** | **Length** |
|  |  |
|  |  |
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|  |  |
|  |  |

1. Was your predication correct? If not, why do you think the k value was different than what you predicted?

Check with your teacher to see which of the following scenarios your group will do next. Recall, you need to put an initial mass to stretch the spring as a starting point.

\*Note: You will want to assign groups different scenarios and make sure all scenarios are covered. You may also want to assign more than one scenario per group. This is an opportunity for differentiation.

 I. Hang two springs of the same k value parallel to each other and determine

 the new k value of the system. You may need to tape the mass hanger to the

 connecting pole to avoid slippage. (Don’t forget to predict first).

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 II. Hang two springs of the same k value and hook them together so that an

 isosceles triangle is formed at where they are hooked. Determine the new k

 value of the system (Don’t forget to predict first).

 III. Connect two springs of the same k value in series (in line). Determine the

 new k value of the system (Don’t forget to predict first).

 IV. Hang two springs of different k values parallel. Use one of your springs and

 get a different color spring. Determine the k value of the new spring. Calculate

 the amount of mass to hang from each spring so that they are stretched to equal

 lengths (You may need to tape the mass hanger to the connecting pole to avoid

 slippage and don’t forget to predict first).

 V. Connect two springs of different k values in series. Use one of your springs

 and get a different color spring. Determine the k value of the new spring (don’t

 forget to predict first).

1. Check with other groups that had the same scenarios to see if the results are the same. Be prepared to share your results with the class.
2. Do you see a pattern connecting the springs in series, parallel, or at an angle?

**Math/Physics** **Instructional Time Line:**

In Precalculus you could do this to introduce inverses or later in the year when covering vectors, force and work.

In Algebra 3 you could do this to introduce inverses.

In AP Physics you could do this when you are studying forces or circuits.

You will need 15 – 30 minutes for the pre lab one day depending on how many of the students have completed The Spring Thing in Algebra 2. At least one class period for the data collection and analysis, it may take more class periods depending on how many of the optional scenarios you want each team to complete. Make sure to have time to discuss student results with the entire class.

**Instructor Reflection**:

Did you encounter any problems during the investigation?

Will you do this experiment again next year? Why or Why not?

What worked well?

What should be improved?

What would you change? Why?

**Math/Physics Concepts and Skills** **:**

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| --- | --- |
| Math Concepts: MeasurementInversesGraphsCoordinate systemLinear regressionTrigonometryAngles | Math Skills:Group workMeasurementWorking with Technology(Nspire, excel, TI84)Using a ProtractorUnit conversion |
| Physics Concepts:Experimental DesignForcesVectors | Physics Skills:Group workWorking with TechnologyUnit conversion |

**Math/Physics Language Sheet**:

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| --- | --- |
| MathParallelInverses of functionsReciprocalIndependent/Dependent Variables | Physics ParallelSeriesForce versus massIndependent/Dependent VariablesParallex |
| Differences  | Similarities  |