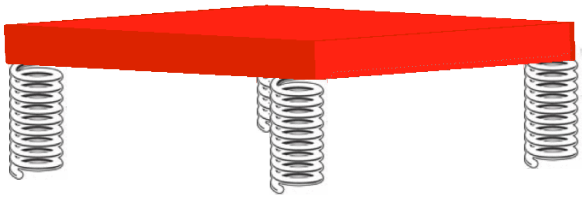
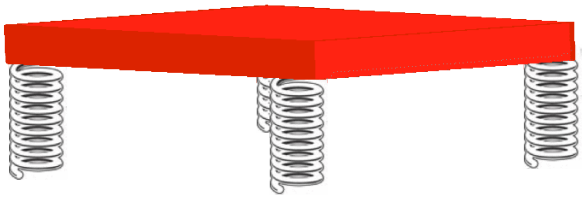


FUN WITH SPRINGS!

BACKGROUND

Overview:

The students will need to learn about slope of a line and have an understanding about plotting. This lesson aims to provide that knowledge.



FUN WITH SPRINGS!
HOMEWORK 1A
STRAIGHT LINE DATA SET

Overview:

Todays lesson involves plotting different sets of data to familiarize the students with creating line graphs from data points. Hopefully observations will be made from that data.

Data Set:

Mike wants to buy a new car so he went to the dealers and took several cars on a test drive over the period of several weeks. Sometimes Mike only had enough money for a few gallons and sometimes he had enough to fill the tank. He kept track of how many miles he drove before running out of gas and how many gallons he used. Since Mike is a good scientist he repeated this several times to get enough data. He put his data in the table below,

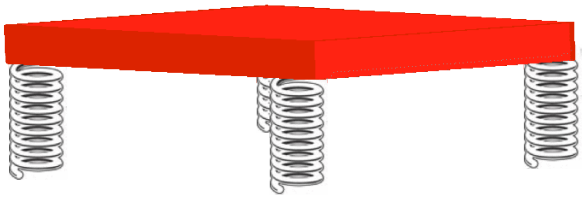
Honda Accord			**Ford Mustang**		
Gallons (X)	Miles driven (Y)	Miles per gallon	Gallons (X)	Miles driven (Y)	Miles per gallon
2	50		3	45	
5	125		5	75	
8	200		7	105	
12	300		17	255	

To Do:

(1) Please create your X and Y axis using the gallons as the data of the X axis and the miles driven as the data on the Y axis.
(2) Label the axis correctly including the proper units.
(3) Plot each set of data on the same graph but only doing one car at a time and starting with the Honda Accord. When you are done with the data for the Honda Accord then draw a line through the data points. Plot the data points for the Ford Mustang and also draw a line through those data points. It might be a good idea to use different line types (dashed, solid, etc) or different color so that you know which line is for which car.

Questions:

1) Which car has the greatest fuel efficiency? Why?
2) Divide the units of the Y-axis by the units of the X-axis. What is the result?
3) Calculate the slope of each line including your units. Which car created the line with the steepest slope? What does this mean? How do these numbers compare with the miles per gallon calculated in the table above?
4) Assume gasoline costs $2.50 per gallon. How much would it cost to drive 50 miles in the Honda Accord? How much would it cost to drive 50 miles in the Ford Mustang?



FUN WITH SPRINGS!
HOMEWORK 1B
BEST FIT LINE DATASET

Overview:

Todays lesson involves plotting different sets of data to familiarize the students with creating line graphs from data points. Hopefully observations will be made from that data.

Data Set:

Mike wants to buy a new car so he went to the dealers and took several cars on a test drive over the period of several weeks. Sometimes Mike only had enough money for a few gallons and sometimes he had enough to fill the tank. He kept track of how many miles he drove before running out of gas and how many gallons he used. Since Mike is a good scientist he repeated this several times to get enough data. He put his data in the table below,

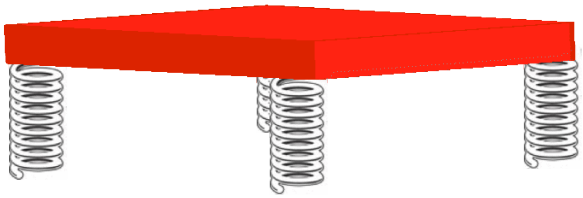
Honda Accord			**Ford Mustang**		
Gallons (X)	Miles driven (Y)	Miles per gallon	Gallons (X)	Miles driven (Y)	Miles per gallon
2	46		3	39	
5	120		5	70	
8	208		7	112	
12	324		17	289	
Average miles per gallon ->			Average miles per gallon ->		

To Do:

1) Please create your X and Y axis using the gallons as the data of the X axis and the miles driven as the data on the Y axis.
2) Label the axis correctly including the proper units.
3) Plot each set of data on the same graph but only doing one car at a time and starting with the Honda Accord. When you are done with the data for the Honda Accord then draw a line through the data points. Plot the data points for the Ford Mustang and also draw a line through those data points. It might be a good idea to use different line types (dashed, solid, etc) or different color so that you know which line is for which car.

Questions:

1) Which car has the greatest fuel efficiency? Why?
2) Divide the units of the Y-axis by the units of the X-axis. What is the result?
3) Calculate the slope of each line including your units. Which car created the line with the steepest slope? What does this mean? How do these numbers compare with the miles per gallon calculated in the table above?
4) Assume gasoline costs $2.50 per gallon. How much would it cost to drive 50 miles in the Honda Accord? How much would it cost to drive 50 miles in the Ford Mustang?



FUN WITH SPRINGS!

OVERVIEW

Overview

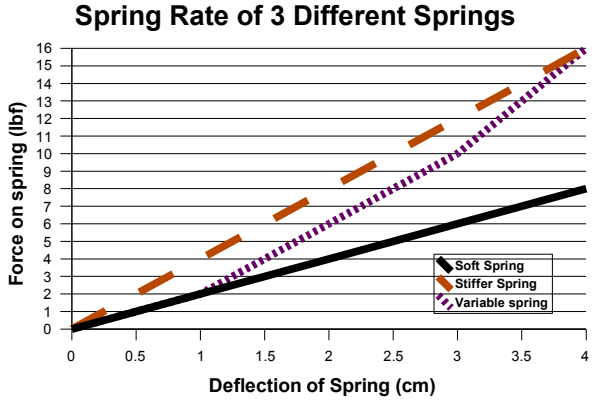
This lesson is designed to provide the students with experiences that are similar to an engineers. They will come up with theories, explore their theories through an inquiry lesson, create a basic mathematical model to explain the deflection of the plate from their observations, and then use that model to predict future behavior. The springs used are linear compression springs and a final discussion involves the use of nonlinear compression springs (e.g. variable rate springs).

This unit exposes the students to science, mathematics, measurements, statistics, regression analysis, and units of measurement. The students will estimate the spring rate of the springs by plotting the measured deflections created by the varying weights.

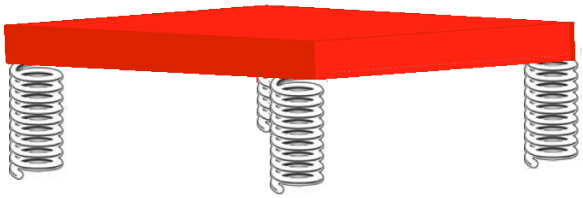
Background

- Most springs that students are exposed to are linear compression springs
- linear compression springs deflect proportionally to the load placed on them usually following the following equation,

  Force on spring = Spring rate * Deflection of spring, also noted as
  $F = K * X$ (Eqn 1)
- Springs wound with larger diameters (with the same wire diameter) have a "softer" spring rate than a spring with a more tightly wound spring. This can also be seen graphically in the plots below,



- Springs using larger diameter wires are stiffer than a spring using a smaller diameter wire.
- Longer springs are softer than shorter springs if all other variables are equal.
- This unit has a plate with 4 springs so there can be a brief discussion of Newtonian physics where the force of the weight must be countered by the force provided by the 4 springs which results in the springs each deflecting $1/4^{th}$ of the distance predicted by equation 1.
- The students can perform multiple measurements and calculate the averages and deviations to incorporate into their plots.



FUN WITH SPRINGS!

LESSON 1

Overview:

This lesson should begin with a discussion about springs, their compressibility, and how the force increases as you compress the spring. The students should be encouraged to express what they know about springs. Promote discussion by asking the students whether the diameter of the wire matters, the diameter of the loops, length of the coil, or any other ideas that the students might have about varying spring stiffness and how they might make a variable spring rate spring.

The students will learn about the stiffness of springs by experimenting with pipe cleaners and varying dimensions as they desire in the attempt to determine which parameters make a spring stiffer or softer in compressibility.

Some things the students might vary are listed below,

- spring length – use a longer pipe cleaner and wrap it around something of uniform diameter such as a marker, pen, or pencil and compare the stiffness to a spring of similar diameter but shorter length.
- spring loop diameter – have the students wrap the pipe cleaner around a pencil and another around an object with a much larger diameter.
- wire diameter – combine 2 pipe cleaners by twisting them together (to simulate a cleaner with a bigger wire diameter) and have them create a spring with it and comment on the stiffness.
- number of wraps – the students can create 2 springs of the same length (differing wire lengths) by wrapping them using a different number or wire wraps.

Materials:

- Pipe cleaners of differing lengths
- Paper & pencil for the students to record their observations. A tabular format might help.

15 minutes – spent on preconceptions and how they'll test their ideas.

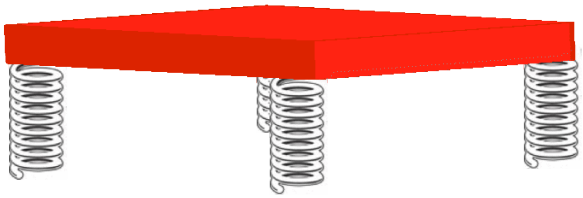
A table will be created that contain their preconceptions, what they how they'll test their ideas, and finally what they did find out through the experiment.

Table 1 – Concept Table

Preconceptions	What they'd like to know	What was discovered

25 minutes – have the students go to their lab stations and test out their ideas.

15 minutes – have the students return to their seat and fill out the remainder of Table 1 through a question session. It would be a good idea to fill the table out on the overhead and have the students copy it into their science notebook.



FUN WITH SPRINGS!

LESSON 2

Overview:

Todays lesson should begin with a discussion about what was learned from the previous lesson about springs. In Lesson 2 they will be exposed to a spring/plate apparatus that models a car's suspension system. It might motivate some students if it is brought to their attention that this simple apparatus is a decent model for the suspension of a vehicle and some discussion can be had at the end of the unit with regards to effects of using springs with different spring rates at the front versus the back. The students should be able to guess which spring systems are stiffer or softer based on what they learned in Lesson 1.

They should be reminded that scientists don't just use their powers of observation to come to scientific conclusions. Even though they used pipe cleaners yesterday to model various springs that they came to some conclusion about the spring properties that in science that isn't enough. Science is a field where experiments are created to rigorously test their ideas. Lesson 2 involves using an apparatus to quantify their observations from Lesson 1.

The students should be measuring and documenting the deflection of the plates using the provided weights and the students should take care to make sure that the weights are in the center of the board. There are several different combinations of springs so the students should also measure the characteristics of the springs (e.g. coil loop diameter, wire diameter, spring length, etc).

The students are encouraged to measure the height at the 4 corners of the plate and average those values as the plate tops may not be parallel to the table top as the weights which are placed on the plates will more than likely not be centered.

In our experience it is usually a good idea to ask the students how they will measure the springs deflection (i.e. static height minus the measured height when weight is placed on it). They should always measure to the same point on the plate, either the top surface of the bottom surface as consistency is important.

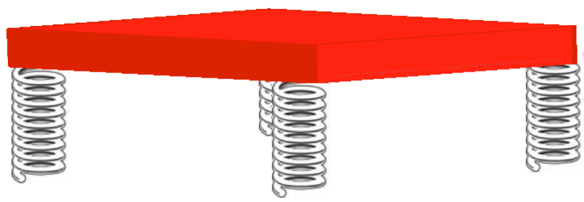
Materials:

- Spring/Plate apparatus
- weights
- rulers
- pencil or pen to record measurements
- calculator if they get done early

15 minutes – spent on preconceptions and how they'll test their ideas.

30 minutes – have the students go to their lab stations and test out their ideas but make sure that their methods are valid and safe. Provide the following worksheet if desired.

10 minutes – have the students return to their seat and fill out the remainder of their record sheets and calculate the averages and deflections.



FUN WITH SPRINGS!

LESSON 2 – RECORD SHEET

Instructions

1. Center the weight on the springboard when performing the measurements.
2. Each member of your group should perform each measurement.
3. The deflection is calculated by subtracting the measured height from the height of the plate with no weight.

Plate No.______________________________ Spring loop diameter___________________

Spring length _________________________ Spring wire diameter __________________

Weight (Kg)	**Height – Measured to the top of the plate (cm)**					**Deflection (cm)**
Column A (Y axis)	1st reading	2nd reading	3rd reading	4th reading	Average	***Column B (X axis)***
0						

Plate No.______________________________ Spring loop diameter___________________

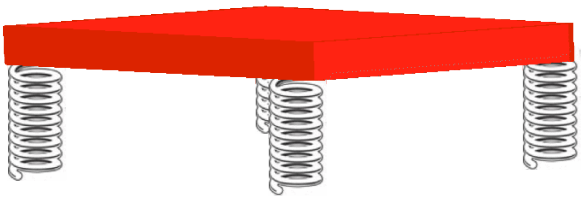
Spring length _________________________ Spring wire diameter __________________

Weight (Kg)	**Height – Measured to the top of the plate (cm)**					**Deflection (cm)**
Column A (Y axis)	1st reading	2nd reading	3rd reading	4th reading	Average	***Column B (X axis)***
0						

Plate No.______________________________ Spring loop diameter___________________

Spring length _________________________ Spring wire diameter __________________

Weight (Kg)	**Height – Measured to the top of the plate (cm)**					**Deflection (cm)**
Column A (Y axis)	1st reading	2nd reading	3rd reading	4th reading	Average	***Column B (X axis)***
0						



FUN WITH SPRINGS!

HOMEWORK 3

Overview:

Todays lesson involves plotting the data you collected during the spring experiment. Your plots should have multiple lines on them.

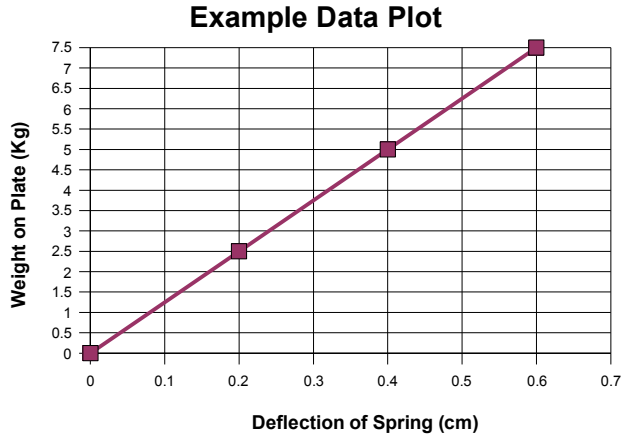
Example Data Set

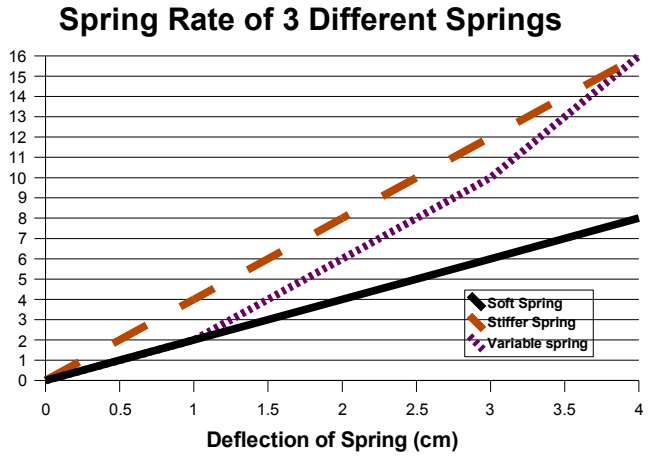
Plate No._____1_____ Spring loop diameter_____1 cm_____

Spring length _____2 cm_____ Spring wire diameter _____1 mm_____

Weight (Kg)	**Height – Measured to the top of the plate (cm)**						**Deflection (cm)**
Column A (Y axis)	1st reading	2nd reading	3rd reading	4th reading	Average		***Column B (X axis)***
0	2.1	2.2	1.9	1.8	2	**A**	0
2.5	1.9	2	1.7	1.6	1.8	**B**	.2 (A-B)
5	1.7	1.8	1.5	1.4	1.6	**C**	.4 (A-C)
7.5	1.5	1.6	1.3	1.2	1.4	D	.6 (A-D)

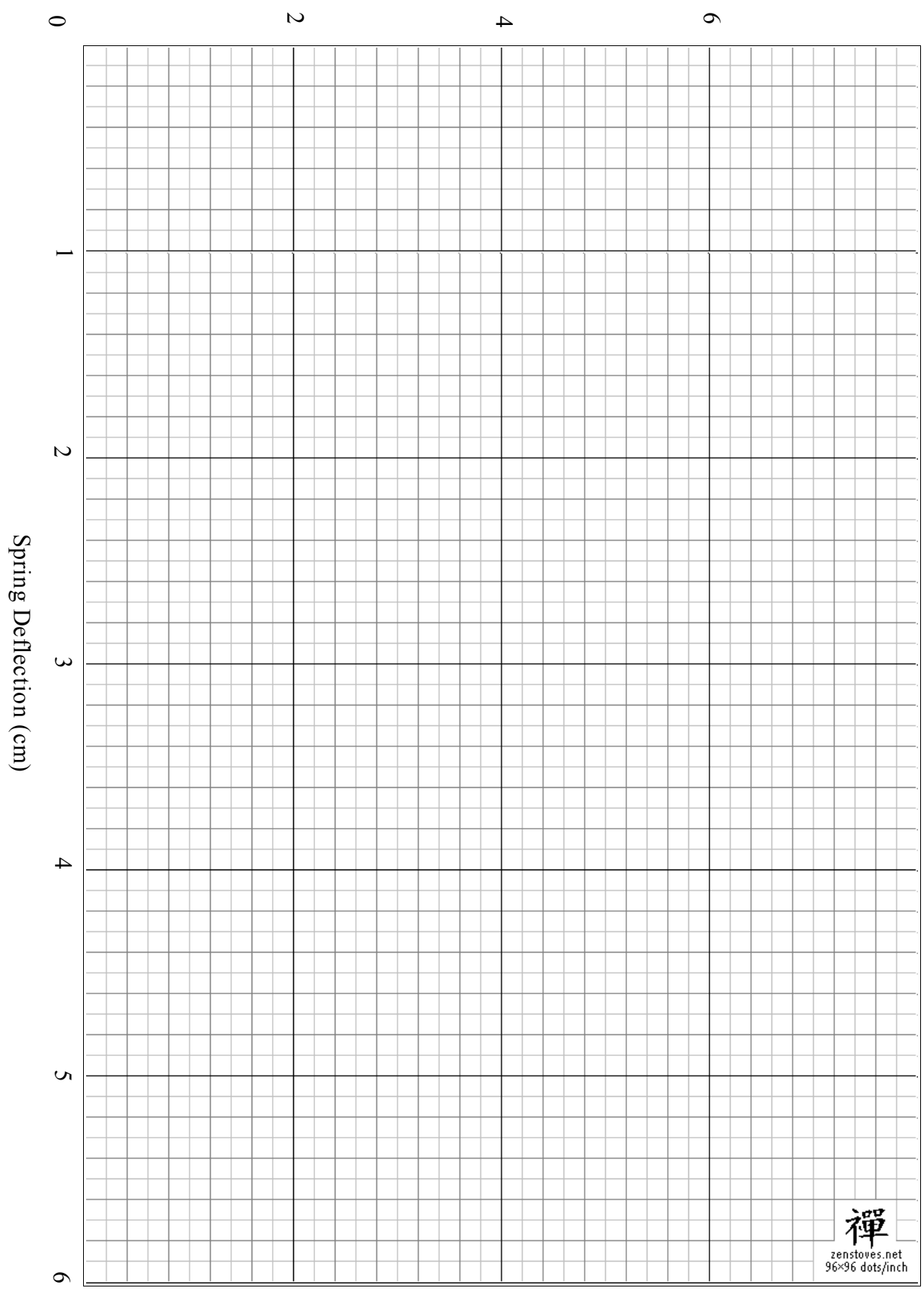
Plot weight versus deflection

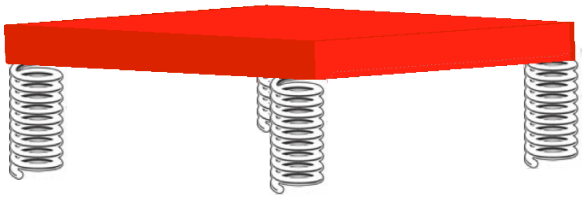




To Do:

1. For each plate/spring combination plot a line. All the lines should be on the same graph and in different colors or linetypes (dotted, dashed, etc.) The students' data may not seem linear so there might be a need for some discussion about best-fit lines.
2. Label the lines properly and make comments in your science notebook about why you think the lines are different. What was it about the different springs that made them behave differently?
3. Try to come up with some some general observations about the springs characteristics that caused them to be stiffer or softer (example, longer springs are softer/stiffer or springs with big loops are softer/stiffer).


Weight On Springs (Kg)
0
2
4
6
Spring Deflection (cm)
1
2
3
4
5
6
禅
zenstoves.net
96×96 dots/inch



FUN WITH SPRINGS!

LESSON 3

Overview

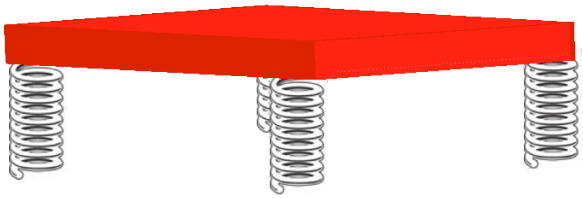
Todays lesson should begin with a discussion about what they learned fromyesterday's measurements as it should be used to summarize what the students have discovered so far. Promote discussion by asking the students whether their theories from the pipe cleaner experiments were shown to be true or false in the plate/spring experiments.

It might be a good idea to remind the students that this simple apparatus is a decent model for the suspension of a vehicle and it would be a good idea to start discussing the effects of different spring rates at the front versus the back. Trucks usually have stiffer springs in the back due to the increased loads that they'll need to carry so as to not bottom out. Why would someone want softer springs versus stiffer springs?

Ask the students if there would be any value to creating variable springs. Variable springs are used in vehicles to provide a softer ride over small bumps but then to provide enough stiffness for large deflections (big bumps or high speed turns) so that the vehicle doesn't bottom out.
This is commonly done and 3 methods are,

- varying the wire diameter. The wire is thinner near the ends and thicker towards the middle.
- varying the loop diameter where it starts off at a larger diameter and finishes at a smaller diameter and the spring is conic shaped.
- varying the pitch of the springs so that the springs near the end compress first and then contact each other forming a steel block which automatically shortens the spring thereby making it stiffer.

See if the students can come up with the aforementioned methods ofcreating variable springs. Guide the students to the correct answers if they are struggling. At this point they should realize the effects of loop diameter, wire diameter, spring length, and spring pitch (distance between each coil) and they should be encouraged to using their knowledge to come up with various configurations for a variable spring.



FUN WITH SPRINGS!

LESSON 3 CONT'D

	Loop Dia. (cm)	Loop Dia. Indicator	Length (cm)	Length Indicator	Wire Dia. (cm)	Wire Dia. Indicator
1	1	■□□□□	2	□■□□□	.09	□□■□□
2	1.6	□□■□□	3	□□□■□	.12	□□□■□
3	1.3	□■□□□	2.1	□■□□□	.09	□□■□□
4	2	□□□■□	2	□■□□□	.15	□□□□■
5	2.4	□□□□■	7	□□□□■	.09	□□■□□
6	variable		2.6	□□■□□	.1	□□■□□

Guiding questions:

1. Which springs were stiffer?
2. Why do you think that they were stiffer?
3. Does loop diameter influence stiffness and if so, how?
4. Does spring length influence stiffeness and if so, how?
5. Does wire diameter influence stiffness and if so, how?
6. Was there anything interesting with the variable spring plot (plate 6) and if so, what?

Application questions:

1. How would I make a really stiff spring and how many ways can you think of? Please explain your different ideas.
2. How would I make a really soft spring and how many ways can you think of? Please explain your different ideas.
3. How would I make a variable stiffness spring and how many ways can you think of? Please explain your different ideas.