Lesson Title	Investigation of Hooke's Law Lab
Length of Lesson	1 day
Created By	Jed Leggett, William Funderburk, Dustin Spayde
Subject	Physics
Grade Level	11-12
State Standards	Physics: 3 a, b; 4 a;
DOK Level	DOK 3
DOK Application	Investigate, Draw Conclusions
National Standards	9-12: B (physical);
Graduate Research Element	Measurement of a periodic signal with noise

Student Learning Goal: Develop student understanding of Hooke's Law and its effect on the motion of elastic systems.

Physics: 3. Develop an understanding of concepts related to work and energy: (a) Explain and apply the conservation of energy and momentum; (b) Analyze real-world applications to draw conclusions about mechanical potential energy (the energy of configuration) - Concept of conservation of energy with simple examples.

4. Discuss the characteristics and properties of light and sound: (a) Describe and model the characteristics and properties of mechanical waves
- simple harmonic motion.

National Science Education Standards of Content 9-12
B (Physical): Conservation of energy and the increase in disorder: All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves.

Materials Needed (supplies, hand-outs, resources): Lab posts and booms, Springs, Masses, Index cards, Motion detectors (available from several vendors, e.g. Pasco), Access to a personal computer with spreadsheet software and DataStudio.

Lesson Performance Task/Assessment:
In this lesson, students will measure the spring constant of a spring using two different methods and compare the results. First, they will place various masses on the spring measure its displacement. The spring constant can then be found from the slope of a Force vs. Displacement graph. Second, students will set a mass in motion on a spring and use a motion detector to record its position vs. time. They will then perform a sinusoidal fit to position and time data extracting the period of the motion. From the measured period and the mass on the spring, the spring constant can be determined.

Lesson Relevance to Performance Task and Students:
Many physical systems can be modeled by Hooke's Law, most importantly the force between 2 atoms or molecules. Through the investigation of a single spring, students will gain a better understanding of the resultant motion of objects under the influence of an elastic force when perturbed from equilibrium.

Anticipatory Set/Capture Interest:
The teacher will show a video of a bungee jumper and ask students to describe the forces acting on the jumper at various points in the motion.

Guided Practice:
The teacher will set up an example apparatus and demonstrate the method for taking data and entering it into excel.

Independent Practice:
Students will set up a lab post with a boom and hang a spring and mass from the boom. Students will also tape an index card to the bottom of the mass and align the motion detector to measure the motion of the mass.

Method 1: Students will first lift the mass from the top to the lowest position at which the spring is not stretched collect a few seconds of data from the motion detector. They will record this position as the initial position of the spring. Students will then slowly lower the mass until it comes to rest. They will record this position as the resting position for the first mass. Students will continue to add various masses to the spring and record the resting position. Students will calculate the amount of displacement for each mas by subtracting the resting position from the initial position. They will also calculate the force by multiplying the mass by the acceleration due to gravity. Finally, the students can construct a graph of force vs. displacement and calculate the slope, which is the spring constant of the spring.

Method 2: Students will choose one particular mass, and set the mass into motion by lifting it slightly. Students will record the motion of the mass using the motion detector and DataStudio. The position and time data can then be fit with a sinusoidal curve, giving the period. From the period, the students can use the formula: $k = m*(2\pi/T)^2$.

Remediation and/or Enrichment:
R: individual IEP; partner help throughout lesson

E: Students can investigate more complicated aspects of the motion of the mass, including damping, vibrational noise, and coupled systems.

Check(s) for Understanding:
Why is the force in Hooke's law referred to as a "restoring force"? Why is the second method more accurate?

Closure:
Students can calculate the percentage difference between their two measured values and discuss why they are different.

Possible Alternate Subject Integrations:
*Math- The motion of the mass provides a good example of a sinusoidal function.