Lesson Title	Conservation of Energy
Length of Lesson	3 hours
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Subject	Physics
Grade Level	11-12
State Standards	Physics: 1 and 3a,b
DOK Level	DOK 4
DOK Application	Analyze, Draw Conclusions, and Develop a Logical Argument
National Standards	Physics B
Graduate Research Element	Data analysis, model fitting.

Student Learning Goal:

Mississippi Standards:

Physics: 1. Apply inquiry-based and problem-solving processes and skills to scientific investigations.

a. Use current technologies such as CD-ROM, DVD, Internet, and on-line data search to explore current research related to a specific topic.
b. Clarify research questions and design laboratory investigations.
c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development).
d. Organize data to construct graphs (e.g., plotting points, labeling x-and y-axis, creating appropriate titles and legends for circle, bar, and line graphs) draw conclusions and make inferences.
e. Evaluate procedures, data and conclusions to critique the scientific validity of research.
f. Formulate and revise scientific explanations and models using logic and evidence (data analysis).
g. Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.).

Physics: 3. Develop an understanding of concepts related to work and energy.

a. Explain and apply the conservation of energy and momentum.
    - Concept of work and applications
    - Concept of kinetic energy, using the elementary work-energy theorem
    - Concept of conservation of energy with simple examples
    - Concepts of energy, work and power (qualitatively and quantitatively)
    - Principles of impulse in inelastic and elastic collisions
b. Analyze real-world applications to draw conclusions about mechanical potential energy (the energy of configuration).

National Standards:

Physics:

- 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.
- Everything tends to become less organized and less orderly over time. Thus, in all energy transfers, the overall effect is that the energy is spread out uniformly. Examples are the transfer of energy from hotter to cooler objects by conduction, radiation or convection and the warming of our surroundings when we burn fuels.

Materials Needed (supplies, hand-outs, resources):

This lab uses:

- 1 Pasco ultrasonic motion detector,
- 1 Pasco rotary motion detector,
- 1 lab stand
- 2 clamps
- 2 short metal bars
- 1 spring to metal bar attachment
- 1 spring
- 1 set of masses to hang from the spring
- 1 pendulum attachment for the rotary motion detector.

You will set it up as shown in figure 1.

Figure 1. Lab setup.

Lesson Performance Task/Assessment:
The students will study two systems that contain potential and kinetic energy. The data they collect will allow them to compute the potential and kinetic energy, which they can sum to get the total energy. This will allow them to see that in the short run, the total energy is constant, and in the long run, the total energy decays. The students are required to show 2 plots of their data for both the pendulum and spring systems. The first shows kinetic energy, potential energy, and total energy for about 4 cycles. This shows them that the sum of the energy is approximately constant in the short run. The second shows total energy for a long time, so they can see that the system is losing energy.

Lesson Relevance to Performance Task and Students:
The students will demonstrate that they understand the concepts of potential energy, kinetic energy, conservation of energy, and entropy.

Anticipatory Set/Capture Interest:
A short discussion about energy is a good way to build anticipation for this lab.

Guided Practice:
We demonstrated how the students should collect their data. They collect data by measuring the spring oscillating up and down, and the pendulum moving back-and-forth.

Energy for the spring is computed using the following two equations.

$$KE = \frac{1}{2}mv^2 \quad (1)$$

$$PE = \frac{1}{2}kx^2 \quad (2)$$

In the equations, m is the mass of the weight in the spring system, v is the velocity of the weight, k is the spring constant, and x is the position of weight relative to the equilibrium position.

The energy in the pendulum system is computed using the following two equations.

$$KE = \frac{1}{2}m(l\omega)^2 \quad (3)$$

$$PE = mg(l - l\cos(\theta)) \quad (4)$$

In the equations, m is the mass of the weight at the end of the pendulum, l is the length of the pendulum from the pivot to the center of the weight, g is 9.81 m/s^2, and θ is the angle in radians of the pendulum (0 radians is vertical).

Independent Practice:
The students collect their data and generate plots of their data. They also can turn in a lab report for this lesson.

Remediation and/or Enrichment:
You can enrich the lesson by having the students compute trend-lines using Microsoft Outlook. There is a lesson plan describing how to do this, but you can also find information about it on the Internet.

Remediation: individual IEP; partner help throughout the lesson; the teacher can observe the students and intervene during the independent practice.

Check(s) for Understanding:
During the lab, the teacher can walk around and observe the students. If some of the students appear to not understand how the equipment works or what they are expected to do, ask them some leading questions.

Closure:
Answer questions about analyzing the data and ask them what they observed.

Possible Alternate Subject Integrations:
Math

Teacher Notes:
We have included a handout we gave the students for this lab.