Lesson Title	Damped Spring-Mass Systems Lab
Length of Lesson	90 minutes
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Subject	Physics
Grade Level	11-12
State Standards	Physics: 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, estimating error.

Student Learning Goal:

Mississippi Standards:

Physics: 3a. 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 o impulse in inelastic and elastic collisions

3b. Analyze real-world applications to draw conclusions about the mechanical potential energy (the energy of configuration).

National Standards:

Physics: Conservation of Energy and the Increase in Disorder

- The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and many other ways. However, it can never be destroyed. as these transfers occur, the mater involved becomes steadily less ordered.
- 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):

- Video camera (most cell phones have video cameras now)
- Something to hold the camera steady
- A large graduated cylinder
- A set of masses that have a hook on them
- Springs that have hooks on them to attach something at both ends
- Something to mount one end of the springs to

- Water and liquid soap
- Optional: Logger Pro or some other motion capture analysis software

Lesson Performance Task/Assessment:
The students will learn about systems that loose energy, and how to model them. They will be required to write a lab report on their findings in the lab.

Lesson Relevance to Performance Task and Students:
The students will measure the energy loss from a damped spring system, and model it in the time domain.

Anticipatory Set/Capture Interest:
We set this up by doing a standard conservation of energy lab where a weight is on the end of a spring bouncing up and down in air, which provides little resistance, the previous lab period. Also at the beginning of this lab period, we started the lab by talking about what happens when there is resistance to the system, and we went over the lab handout.

Guided Practice:
The teacher should go over the handout and talk to the students about what happens when there is resistance in the spring-mass system. The students will need to estimate the exponental decay of energy in the system when it is oscillating. This can be done by getting Excel to estimate the decay of the local maximums on the displacement vs. time curve. The students can just copy these local maximums into a separate chart and have Excel compute a trend line.

Independent Practice:
The students will collect data by filming the mass oscillating up and down at the end of a spring in air, water, and liquid soap. The size of the mass and spring can be varied if you want. Then the students will load their video filed in to Logger Pro (or some other motion analysis software) and determine kinetic energy and potential energy as a function of time. They will then try to fit this to the equations given in the handout.

Remediation and/or Enrichment:
Enrichment: Change the spring or the mass of the system.

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:
We closed by talking to the students about their lab reports.

Possible Alternate Subject Integrations:
Math (differential equations...you can leave that out though)

Teacher Notes:
There is a handout and some sample videos that go with this lesson plan. I hope this helps you replicate the lab.