Unit 4: Simple Harmonic Motion

Unit Overview: This unit deals with simple harmonic motion, starting with a mass bobbing on a spring. Other lab activities include the torsion pendulum experiment and a theoretical treatment of the wire arc pendulum experiment. There is a section on complex exponential functions which can be very useful if students are ready for it. If necessary this material can be skipped or postponed until the second semester.

Lesson 4:1 Mass Bobbing on a Spring (SHM-1)

Objective(s): Students discover that their first guess is not always correct, but can lead to a better guess when they examine it carefully.

Skills attained: *Students will be able to use dimensional analysis to predict a behavior and use laboratory measurements to test the prediction.*

Topics: Simple harmonic motion, Hooke's equation, Dimensional analysis

Vocabulary: "Spring constant" - the slope of the spring's tension vs length graph.

Procedure: Same as previous lessons.

Materials list: *Section in book and workbook. Springs, masses, c-clamps, stopwatches.*

Suggested Teaching Strategies: Follow the worksheet. Encourage students to explore their own opinions without giving away the true formula. When making measurements it is important to hang the springs from a rigid support. If the support moves or bends while the mass is bobbing up and down then the results will be compromised. It is also important to use small amplitudes so that the motion is smooth.

Lecture Support: Students first do as much as they can as homework, then the lesson is completed in class.

Assessment: *Grade worksheet and homework problem.*

Wrap-up Activity: Set up the equation of motion and solve it, using lesson 4:2.

Homework: *Assign one problem from textbook or old A.P. exam and begin next lesson*

Lesson 4:2 Second-Order Differential Equations (M-25)

Objective(s): Students set up and solve second-order differential equations to predict the motions of objects

Skills attained: *Students will be able to predict the motions*

Topics: Newton's second law, Force, Mass, Acceleration, Linear density

Vocabulary: "Second Derivative" - the derivative of a derivative

Procedure: Same as previous lessons.

Materials list: *Section 4.2 in book and workbook.*

Suggested Teaching Strategies: Follow the worksheet.

Lecture Support: Students first do as much as they can as homework, then the lesson is completed in class. In #4 you can point out that although neither exponential solution satisfies the give initial condition ($v_o = 0$) it is possible to construct a third solution by adding the first two. The differential equation is satisfied by any linear combination of the two original solutions.

Assessment: *Grade worksheet and homework problem.*

Wrap-up Activity: Finish the SHM investigation in lesson 4.1. Update review sheet (lesson 4:13)

Homework: *Assign one problem from textbook or old A.P. exam and begin next lesson*

Lesson 4:3 Torsion Pendulum Experiment (SHM-2)

Objective(s): Understand rotational simple harmonic motion, reinforce understanding of rotational inertia.

Skills attained: *Students will be able to use a torsion pendulum to measure an unknown rotational inertia.*

Topics: Torque, period, frequency, simple harmonic motion

Vocabulary:

Procedure: Same as previous lessons.