Lesson Title	Free Fall Lab
Length of Lesson	1 Day
Created By	Jed Leggett, Dustin Spayde, William Funderburk
Subject	Physics
Grade Level	11-12 (Physics)
State Standards	Physics: 1 d; 2 b, d;
DOK Level	DOK 3
DOK Application	Explain Phenomena in Terms of Concepts
National Standards	9-12: B (physical)
Graduate Research Element	Analyze Data With Variance

Student Learning Goal:
Physics: 1. Apply inquiry-based and problem-solving processes and skills to scientific investigations: (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.
2. Develop an understanding of concepts related to forces and motion: (b) Analyze, describe, and solve problems by creating and utilizing graphs of one-dimensional motion (e.g., the special case of free-fall); (d) Apply the effects of the universal gravitation law to graph and interpret the force between two masses, acceleration due to gravity, and planetary motion – Situations where g is constant (falling bodies).

National Science Education Standards of Content 9-12
B (Physical): Motions and Forces – Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the square of the distance between them.

Materials Needed (supplies, hand-outs, resources):
Digital free fall timer (available from most science education catalogs), Access to a personal computer with spreadsheet and word processing software

Lesson Performance Task/Assessment:
In this lesson, students will determine the local acceleration due to gravity – g – by measuring the time it takes for a ball to fall from various heights. Students will use a digital free fall timer to make their measurements. Students will then use a spreadsheet program to graph their data and produce different types of graphs to determine the relationship between the time of fall and the height.

Students will produce a formal lab report to explain their results.

Lesson Relevance to Performance Task and Students:
Using a simple setup, students will take precise data that should very closely follow a power law relationship. The data will also demonstrate the concept of variance. By collecting the data of the entire class, students will understand the importance of taking large data sets.

Anticipatory Set/Capture Interest:
At the beginning of class, the teacher will have an example setup of the lab at the front of class. Students will be asked to estimate the time that it will take the ball to fall from rest. The student whose estimate is closest will be rewarded.

Guided Practice:
The teacher will set up an example apparatus at the front of the room and take a few data points to demonstrate the procedure. The teacher will explain how to enter data into the spreadsheet program and produce a graph. The teacher should not set up the students labs for them.

Independent Practice:
The students will set up their apparatus and measure the time it takes for the ball to fall from at least 5 different heights. The students will enter their data into a spreadsheet and produce various types of graphs until a linear relationship is observed on one of the graphs (i.e. Log-Log plot). From the linear graph, the students should be able to write down a mathematical relationship between time of flight and height.

Students will produce a formal lab report that contains the following sections: 1) Introduction, 2) Materials and Procedure, 3) Results, and 4) Conclusion.

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

Enrichment/Extension: Students can perform a more detailed analysis of the errors and uncertainties in their measurements.

Check(s) for Understanding:
Can you relate your conclusions to equations that we have studied in class?
Why were the fall times not all exactly the same?

Closure:
Gather the data of the entire class and produce a graph.

Possible Alternate Subject Integrations:
*Math – Students perform curve fitting on their data.

Teacher Notes:
If students do not have access to a PC, data can be recorded on paper and graphed by hand.