Lesson Title	Multi-Regression Analysis
Length of Lesson	45 minutes
Created By	Matthew Lee, William Funderburk, and Henry Stauffenberg
Subject	Physics
Grade Level	12
State Standards	Physics: 1
DOK Level	DOK 4
DOK Application	Analyze, Draw Conclusions, and Develop a Logical Argument
National Standards	
Graduate Research Element	Data analysis, model fitting, estimating error.

Student Learning Goal:
The goal of this lesson is to teach the students powerful data analysis techniques that they can use on future labs. These techniques will help them extrapolate and interpolate as well as verify that the data matches a theory or devise their own theory that matches the data.

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.).

Materials Needed (supplies, hand-outs, resources):
Students will need some data (perhaps from a lab) and Excel.

Lesson Performance Task/Assessment:
The students are going to model the data they collect or are given. They can demonstrate proficiency by showing accurate results or by demonstrating that they know how to accomplish the task.

Lesson Relevance to Performance Task and Students:
This lesson shows the students how to accomplish the performance task. It teaches a skill to the students that they can use on labs for the rest of the class as well as the rest of their lives.

Anticipatory Set/Capture Interest:
The students should have some data that was captured from a physical phenomenon, or some other phenomenon with some randomness. Ask the students how they can use this data to estimate a value outside the domain of the data (extrapolation), or between points (interpolation).

Guided Practice:
The teacher will guide the students on how to use multi-regression on the data they have. There are two ways to do this:
- using the graphing tools,
- and using the linear regression tools.

It is much simpler to use the graphing tools, and I recommend that most students use this technique unless they are mathematically advanced. However, the students may wonder how the model constants are obtained using this technique. If some of the students ask about how these constants are obtained, you can explain that it is minimizing the function $error = \sum(y_x - f(x))^2$, where y_x is the measured value, and $f(x)$ is the predicted value of y obtained from the trend line function. In order to use the graphing tools technique, follow these steps.

1. Create a scatter plot of the data by selecting the data cells and clicking on the insert tab and selecting scatter in the chart section of the menu.
2. When the chart comes up, change the chart type so that there is a trend-line with the function. See the illustration below. If the "chart layouts" is not available, click on the "chart tools" button.
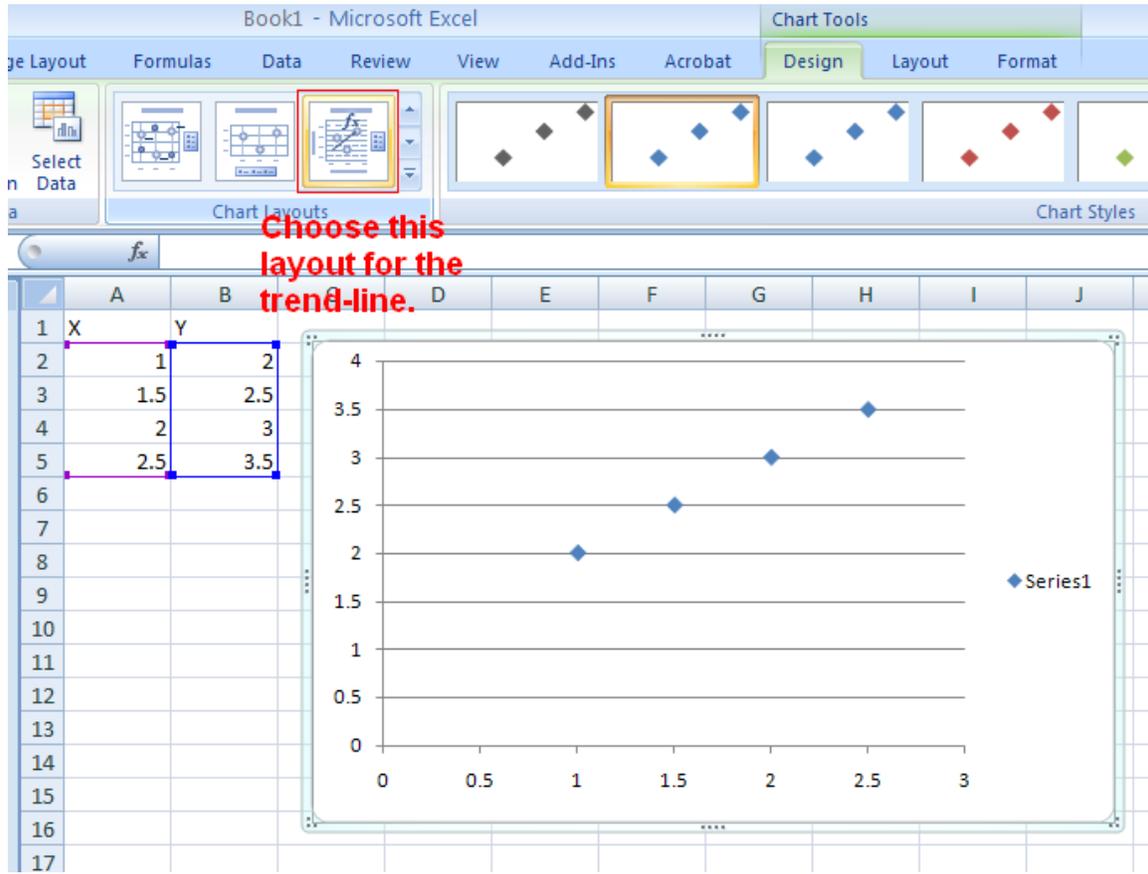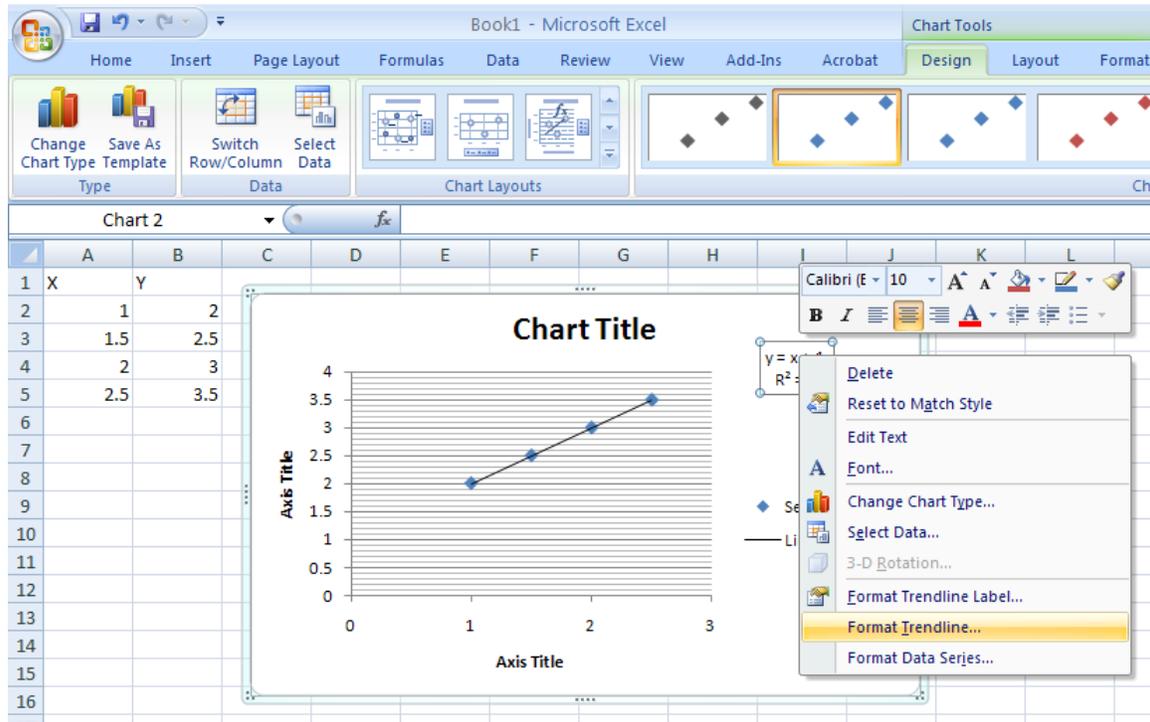
3. By default, you will get a linear trend-line as seen below.
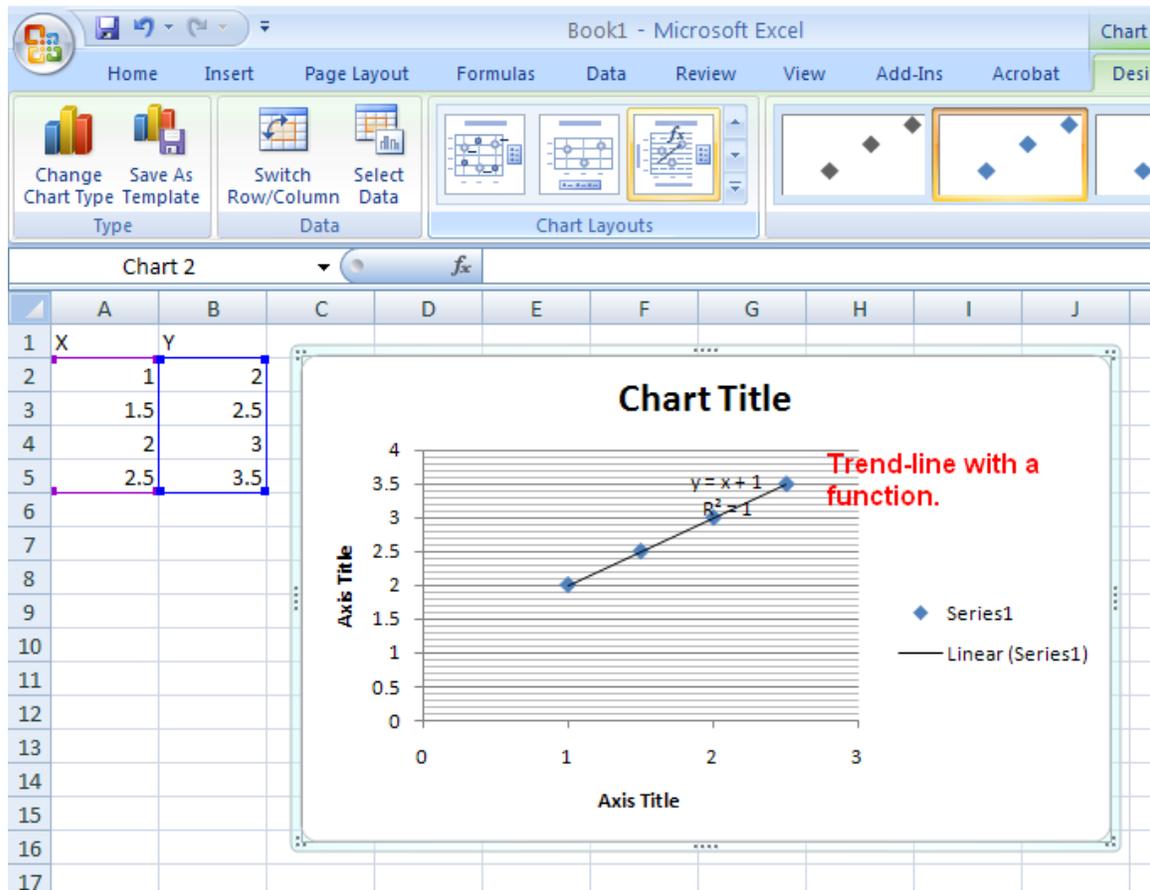
4. When you have the trend-line and function, you can move the function around in the chart space to make it easier to read. The trend-line function can be changed by right clicking on it and selecting "format trend-line."

5. This will bring up the trend-line options, where you can choose a different trend-line functions.
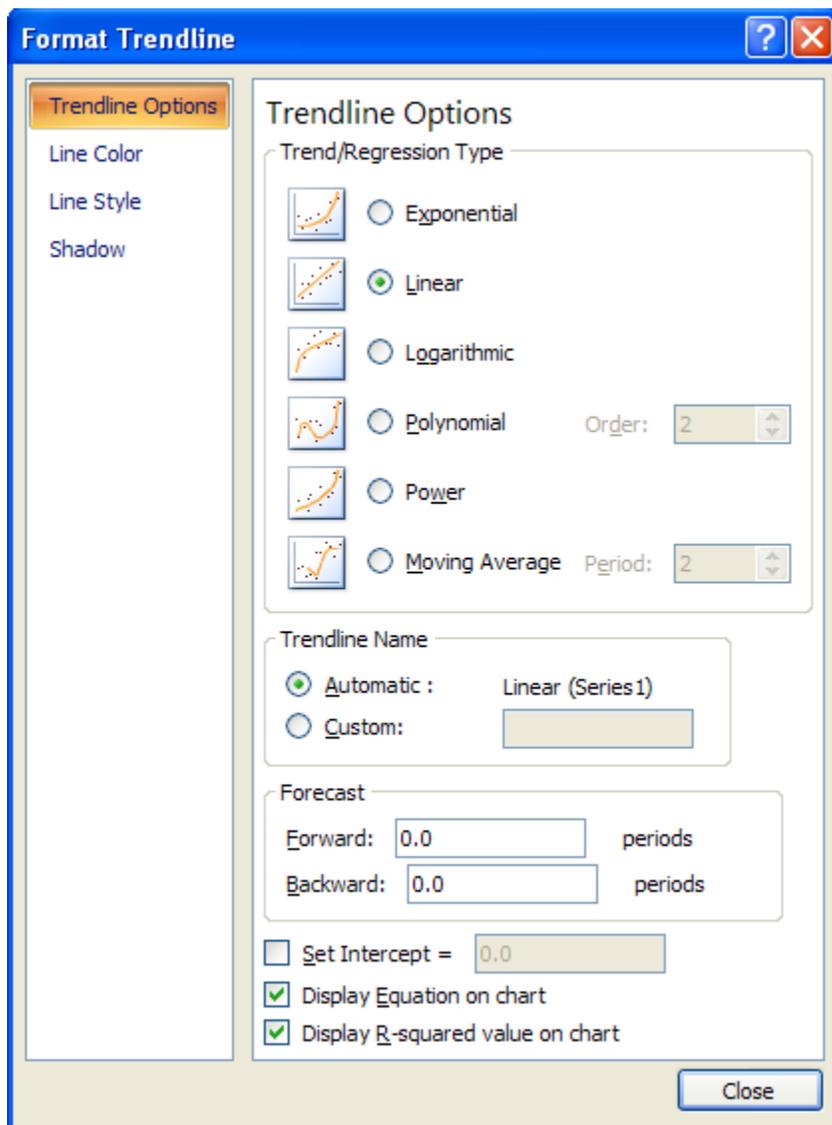
It is also important to note that the R^2 value is 1 when the trend line fits perfectly, and so it is more desirable. However, be careful with using a high order polynomial because you can over fit the data, and get a misleading function. Also you can approximate more functions by computing functions from the data and using them for your x and y variables in the scatter plot.

If you want to teach your students how to use the linear regression tools, there are many videos on YouTube that can show you how to do this. One such video can be found at http://www.youtube.com/watch?v=QWhsH1vcIaw&feature=related. One thing you will need to note is that in order to do regression of non-linear functions, you will need to use functions of the data as your inputs.

Independent Practice:
For independent practice, let the students use these techniques on some data. These techniques could be used on all future lab reports the students do in the class.

Remediation and/or Enrichment:
Give the students some very interesting data. Also, for students who have had calculus, you can teach them how to get a trend-line from the data by hand. This will require computing partial derivatives of the error function with respect to each variable to get the same number of equations as variables. Then set these partial derivatives equal to zero, and solve the system of equations.

Check(s) for Understanding:
The most obvious check is whether the students can do the task. A deeper check for understanding is whether the students can us the trend-line functions for interpolation and extrapolation. A student with an extremely advanced understanding will be able to explain how to get the trend-line from the data, but this is most likely too advanced for most students.

Closure:
The students will use the technique for their lab reports and to help them understand their data.

Possible Alternate Subject Integrations:
You can definitely use this for a math lesson.

Teacher Notes: