Lesson Title	Concepts in Measurement
Length of Lesson	1 Day
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Subject	Physics
Grade Level	11-12 (Physics)
State Standards	Physics: 1a, g
DOK Level	DOK 4
DOK Application	Apply Concepts, Analyze, Prove
National Standards	9-12: A (Inquiry); E (technology)
Graduate Research Element	Measurement is an essential tool for graduate research

Student Learning Goal:
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; (g) Collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., computers, calculators, SmartBoard, CBL's, etc.)

National Science Education Standards of Content 9-12
A (Inquiry): identify questions and concepts that guide scientific investigations.
E (Science and Technology): abilities of technological design; understanding about science and technology

Materials Needed (supplies, hand-outs, resources): 10 variously sized cylinders, String, Rulers, and students will need access to a computer with a spreadsheet program with graphing capabilities (ex. Microsoft Excel).

Lesson Performance Task/Assessment:
Students turn in a print out of their plots with their outlier identified, calculated pi, and the total error from the true pi.

Lesson Relevance to Performance Task and Students:
These concepts apply to everyday life, as well as an untold number of careers. Every time you look at a speedometer, thermometer, a ruler, or any measurement device these concepts should be understood.

Anticipatory Set/Capture Interest: "How long is a meter?" "How do we define the length of a meter?"

Guided Practice:
Pairs of students will be given one of the cylinders, a piece of string, and a ruler. They will be told to measure and record (in Excel) the diameter and circumference of their cylinder. Afterwards they are to pass their cylinder on to the next group until all groups have measured each cylinder. Next students should plot and curve fit (liner regression) their data. Students will now use the Dixon *Q*-Test to determine outliers and then replot their lines. Using this information they will find the slope of the line to be pi. Each group should have a slightly varying number for pi, this leads to the discussion of accuracy.

Independent Practice:
Students will learn about measurement resolution.
Students will learn some key measurement concepts:
accuracy (refers to the closeness of agreement between a measured value and the true value)
total error (the actual difference between the measured value and the true value)
Students will learn about the curve fitting (linear regression in this case) in Excel and the Dixon *Q*-Test (a method of dealing with outliers in data.)
Students will also learn how to calculate Pi and its meaning.

Remediation and/or Enrichment: individual IEP; partner help throughout lesson; shorten parts of assignment; focus upon smaller elements of the process

Enrichment/Extension:
Instead of briefly introducing the terms (*accuracy, total error, bias error, & random error*) explore them in greater detail, and discuss their importance.
systematic (or bias) error (a constant error associated with the system)
random error (an inconsistent error associated with each measurement).

Check(s) for Understanding:

Day One: Ask the students to identify errors in other common measurement systems.

Closure:

Day One: Ask the students to identify errors in other common measurement systems

Possible Alternate Subject Integrations:

*Math – can manipulate mathematical expressions to isolate needed variables

*Science – measurements are used constantly in all science labs

Teacher Notes: