Lesson Title	Centripetal Force Lab
Length of Lesson	90 minutes
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Subject	Physics
Grade Level	11-12
State Standards	Physics: 1 and 2d
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, experiment design.

Student Learning Goal:

Mississippi Standards:

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.).

Physics: 2d. 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)
- *Concept of centripetal acceleration undergoing uniform circular motion*
- Kepler's third law
- Oscillatory motion and the mechanics of waves

National Standards:
Physics:
Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F=ma, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

Materials Needed (supplies, hand-outs, resources):

- 1 stand
- 1 small bar
- 1 clamp
- 1 Pasco force sensor
- string
- 1 set of masses
- 1 computer with Data Studio installed

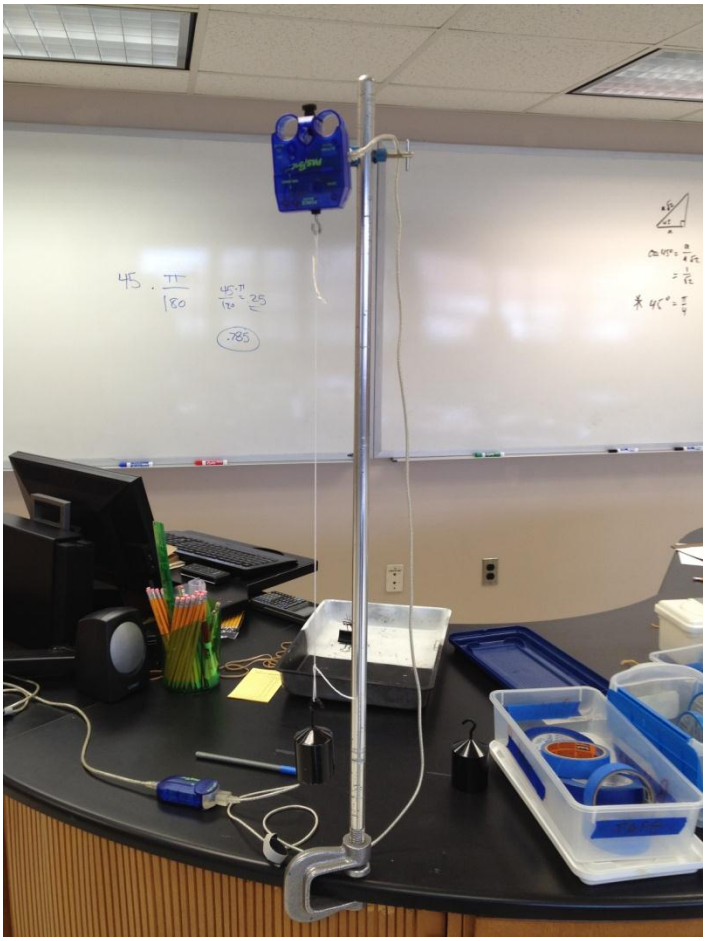

Figure 1. Picture of lab setup

Lesson Performance Task/Assessment:
The students will be required to write a lab report on their findings in the lab. It will include answering the questions:

1. What happens to centripetal force when the length of string is increased?
2. What happens to centripetal force when the mass of the weight is increased?

Also, they will have to make an Excel table that resembles the following one.

Weight	String Length	Computed Angular Velocity	Computed Centripetal Force	Measured Centripetal Force		
				Run 1	Run 2	Run 3

They are not told what weights to use, the length of string to use, or how to set up Data Studio, so they need to design an experiment that can answer their inquiry questions. They will also need to talk about how well the computed values fit their measured results in the lab report.

Lesson Relevance to Performance Task and Students:
The students will be collecting data and devising an experiment to answer the inquiry questions, and compare their measured data to the values they compute.

Anticipatory Set/Capture Interest:
This lab is about circular motion, which the students learned about the day before the lab, so the job of capturing their interest started the day before. Since the lab is so long, we went over the lab equipment setup and a little about how to compute and measure centripetal force.

Guided Practice:
The teachers go over the lab setup and remind them how to compute centripetal force. Also the students are told what they are expected to turn in.

Independent Practice:
See the handout that goes with the assignment.

Remediation and/or Enrichment:
Enrichment: Have the students collect more data points. If they collect enough data points, they can compute trend-lines using Microsoft Outlook. It is not necessary to collect more than 3 data points to answer the inquiry questions.

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

Teacher Notes:
We have included a handout that the students were given. It includes instructions on how to do the lab.