Gravity Force Lab – 90 min Lesson
PreAP Physics

PRE-PLANNING

PRIOR KNOWLEDGE

- Gravitational force is an attractive force.
- Newton's Second Law

LEARNING GOALS

- Determine qualitatively what the force of gravity between two objects depends on.
- Develop a procedure and determine experimentally, using a PhET simulation, the gravitational constant G.

Common Core Standards	Texas Essential Knowledge and Skills (TEKS)
NGSS Science Content HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects Crosscutting Concept Patterns: different patterns may be observed at each of the scales at which a system is studied and can provide explanations of phenomena Science and Engineering Practices Using Mathematics and Computational Thinking: use mathematical representations of phenomena to describe explanations	P.5B describe and calculate how the magnitude of the gravitational force between two objects depends on their masses and distances

MATERIALS

- PhET *Gravity Force Lab* http://phet.colorado.edu/en/simulation/gravity-force-lab
- PreAP Gravity Force Lab Handout

LESSON CYCLE

ENGAGE *10 minutes*

Ask students the following question on a white board with a partner. Collect student responses in front of class. Push students to explain their answers and accept any responses.

When you drop a rock from a cliff, which of the following happens?

a) Only the rock falls to the Earth
b) Only the Earth falls up to meet the rock
c) The rock and the Earth fall towards each other

Show students TED video: http://ed.ted.com/lessons/jon-bergmann-how-to-think-about-gravity

Pass out Gravity Force Lab. Ask students the following post-video discussion questions at the top of their paper with a partner. Before students begin working with computers, discuss student responses.

Part 1 – Qualitative Observations *10 minutes*

Teacher will…	*Students will…*
Circulate and assist with any technical issues. **Select** 2-3 students that will share out their observations with the class. If possible, have students show their findings using the teacher computer in front of the room.	**Explore** the simulation and make qualitative observations (Part 1 of lab).

Part 2 – Quantitative Measurements *45 - 60 minutes*

Teacher will…	*Students will…*

• **Introduce** Part 2 of the lab and have students answer the Thinking Questions (2 min). Students *do not* need to use the computers to plan their procedures. Push students to use their answers from the PreLab and Part 1 to construct their responses. • **Circulate** and select 2-3 student groups to share out their procedures for the class. (10 min) *note – if you do not have Excel you can also use Google Sheets (free) or a graphing calculator to find the best fit line. Here is a **sample** idea – *do not provide to students* 1. Click "Reset All" to get everything back to the original values. 2. Record m2 and the distance between m_1 and m_2 on your paper. 3. For at least 12 different data points, change the mass of m_1, and then record the mass and gravitational force in your data table. 4. Using Excel, graph mass 1 on the horizontal axis and gravitational force on the vertical axis. 5. Determine your line of best fit and interpret your slope to find the constant G. **Select** 2-3 groups to share their procedures with the class. Q's to follow up with – 1) How will you ensure that you are seeing the effect of one variable at a time for your calculation for the force of gravity? 2) What are your independent, dependent variables? Controls? 3) How will you set up a data table that stores the information you will need for your graph? 4) What information will you graph? 5) What does a "best fit" line show? **Instruct** students to execute their procedures and collect their data for their lab. If you are in a 45-55 min block, this will likely wrap up Day 1. A closing idea is to have students write on a post-it or notecard the first thing they will start with for their investigations on Day 2. For Day 2, have students complete collection of their data and graph using Excel. Depending on how you accept assignments, you may opt to have students send you their Excel documents via email, or share via Google Docs. **OPTIONAL MATH AND LAB EXTENSTIONS:** If time permits, you could have students find the percent difference from the accepted value for G. Limitations of the simulation could also be discussed, pushing students to consider why their value may not match the accepted value.	Answer the two thinking questions for Part 2. **Share** procedures with the class. **Critique** other student's procedures. **Update or modify** procedure based on other groups' ideas. **Complete** investigation with a partner by conducting experiment, graphing data, finding a best fit line and interpreting the slope. **Share** results with teacher.
Conclusion	*15 minutes*
Teacher will… **Allow** students time to answer their Conclusion Q's individually. **OPTIONAL**: Conclusion Q's can be turned into a class discussion depending on if you are taking them for a grade.	*Students will…* **Answer** their conclusion Q's individually.