Lesson Title	Anchors away! Newton's first law in action
Length of Lesson	1-2 days
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Subject	Physics
Grade Level	9-12 (Physics)
State Standards	Physics: 1 b, c, d, e, f; 2 a, c
DOK Level	Physics: 3
DOK Application	Inquire, hypothesize, design, collect, interpret, investigate, connect, explain, prove, draw conclusions, predict, explain
National Standards	9 – 12 A: Inquiry; B: Physical Science
Graduate Research Element	Importance of experimental design and investigation of testable hypothesis's. Application of basic knowledge to answer more complex situations. Working on an oil rig insight.

Student Learning Goal:
The purpose of this lesson is to promote student understanding of vector forces and Newton's first law of motion through investigation and inquiry of an oil rig platform achieving equilibrium under varying situations. The students will learn the importance of experimental design by using force tables, weights, and lab sheet handout (data set) to represent the oil rig that they will be trying to stabilize under varying current forces, anchor placement, and unknown variables. Students should be able to use the model to test their hypothesis of anchor placement first and then explain why it works using math; or use the math to validate their hypothesis first and then replicate results on model through testing to confirm answer. At the end of the lab they should have mastery over basic geometry, vectors, force, and calculus concepts.

Mississippi State Standards
Physics: 1: (b) Clarify research questions and design laboratory investigations; (c) Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations; (d) Organize data to construct graphs to 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; 2: (a) Use inquiry to investigate and develop an understanding of the kinematics and dynamics of physical bodies; (c) Analyze real-world applications to draw conclusions about Newton's three laws of motion.

National Science Education Standards of Content 9 – 12
A: Inquiry: identify questions and concepts that guide scientific investigations

- Students should formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding the hypothesis and the

design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and a conceptual understanding of scientific investigations.

B: Physical Science: motion and forces

- Objects change their motion only when 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 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.
- 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):

Force table with pin, pulleys, O ring with four strings attached, and paper clips tied to ends of each string. Anchors away handout detailing objective, real life scenario, and varying data sets to test and answer. Two sets of standard weights ranging from 5g to 500g. A mystery weight that can be easily tied to string that does not equal any standard weight (end of handout example).

Lesson Performance Task/Assessment:

- Ability to use force table to replicate problems described in handout
- Generating Hypothesis's and testing using force table and data from handout
- Showing inquiry, critical thinking, and exploration to solve problems with multiple outcomes
- Completion of handout with correct answers and well thought out explanations
- Ability to connect and explain the importance of oil rig stability using Newton's first law and other basic physics concepts learned in previous class lectures

Lesson Relevance to Performance Task and Students:

- Learning how to use force tables
- Practice with the scientific method
- Practice with critical thinking, inquiry skills, and basic knowledge to answer more complex problems
- Development of problem solving skills
- Insight and application of real world problem set
- Understanding of vector forces and geometry through physical inquiry rather than pure lecture

Anticipatory Set/Capture Interest:

You are a petroleum engineer working for PETRO INC. on a floating multibillion dollar oil rig. Keeping the oil rig stable (in equilibrium) over the drill site is your top priority.

Real time data arrives in from your subordinates detailing the ocean current direction and force that impacts the rig. Using the force table on your desk, and the real time data, decide what types of anchors, how many, and at what angles the anchors should be placed to counteract the current and keep the rig in equilibrium. Remember the safety of your crew and your reputation is on the line. Good luck!

Guided Practice:
Briefly show how to set up and use the force table and given weight sets, make sure students pay attention. Also explain what equilibrium is, the ring should remain in center when pin is pulled, and briefly go over vector forces and Newton's first law as a refresher. Also explain what not to do with the force table; in other words, no excessive weight usage and use the pulleys to reduce friction when weights pull on strings. Give the students the anchors away handout and let them work in groups of two or three. Walk around room to help when needed and to make sure students are on track. Be prepared to walk through problems step by step without giving the answer. Seed questions into student minds and allow them to struggle a bit with the problem sets.

Independent Practice:
Allow time for students to work on lab as homework. Completion of handout can be in group or independent activity.

Remediation and/or Enrichment:
Remediation: individual IEP, partner with helpful student, make lesson more walk through intensive.

Enrichment: Create more complex problem sets, ask for greater explanation or different ways to answer current problem set. Introduce other variables such as wind force to add to ocean current. Set limitations such as specific anchor weights, number of anchors, and or set angles with respect to current. Ask for what is the most efficient setup? How many ways can this problem be solved? What other real world applications would benefit from vector forces analysis?

Check(s) for Understanding:
- Successful completion of handout
- Ability to explain what they have just learned
- Creation of their own rig problems if asked to add to activity
- Ability to prove hypothesis's and or intelligently discuss follow up activity concepts and questions
- Being able to explain, inquire, and argue "does this make sense" using the knowledge available to them before and after activity

Closure:
End with class discussion/walkthrough of worksheet. Congratulate class and let them know that what they just did correlates directly to graduate schooling; in other words, using the basics to explore real life problems and the application of experimental design.

Possible Alternate Subject Integrations:
Geometry: Right triangles, angles, symmetry, and Pythagoras theorem
Geology: Introduction of interdisciplinary physics and petroleum exploration
Calculus: Regression models, line equations, vector math, and formula/algebraic calculations

Teacher notes:
Be sure to show how to setup force table and make sure students surround you to watch. Emphasize use of pulleys because students will set the strings and weights according to the handout which only shows 2D outlook and no pulleys. Walk around the room because students will struggle, that is the point of this activity.