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| **Lesson Title** | Measuring Stress |
| **Length of Lesson** | 50 minutes |
| **Created By** | Corey Ladner |
| **Subject** | Trigonometry |
| **Grade Level** | 12th |
| **State Standards** | 3.d |
| **DOK Level** | DOK 3 |
| **DOK Application** | Cause/Effect, Infer, Interpret, Distinguish, Make Observations, Relate, Compare. |
| **National Standards** | Measurement<br>Apply appropriate techniques, tools, and formulas to determine measurements.<br><br>Connections<br>Recognize and apply mathematics in contexts outside of mathematics |
| **Graduate Research Element** | In my research, it is important to have an understanding of geologic forces and stresses that present hazards. Slope angles of topography, stability of rock or soil layers, as well as normal and shear stresses acting on a soil or rock layer affect the potential occurrence of geologic hazards such as slope failures, reservoir dam failures, and ground subsidence. These forces and stresses occurring in nature can be calculated using trigonometric equations in order to predict the risks of geologic hazards. |

**Student Learning Goal:**
Students solve trigonometric equations in real-world situations. This lesson will focus on using trigonometric formulas to calculate normal stress, shear stress, and factor of safety of a simulated geologic setting. Students will recognize how mathematics can help understand and predict real-world phenomena.

National Standards:

*Measurement*

- Apply appropriate techniques, tools, and formulas to determine measurements.

*Connections*

- Recognize and apply mathematics in contexts outside of mathematics

**Materials Needed (supplies, hand-outs, resources):**
Pre-cut 1ft$^2$ square plywood section, 2 different grades of sand paper, wood glue, angle protractors

**Lesson Performance Task/Assessment:**
The students will be assessed on their understanding of Normal Stress, Shear Stress equations used to measure two-dimensional stress acting on a plane. As the assessment (INSPIRE_LP_Ladner_10.15.12_handout.doc), students will be presented with a geologic scenario involving two principle stresses acting in the vertical and horizontal directions on an area containing geologic fault plane. Students will use the provided Normal Stress and Shear Stress equations to calculate the specific stresses acting on the fault plane; and furthermore, interpret the stability of the fault and suggest factors that may reduce the stability of the fault.

**Lesson Relevance to Performance Task and Students:**
The lesson provides the students with a real world experience involving the practice of using trigonometric formulas to calculate stresses acting on an area. Students will incorporate numerical values of soil cohesion, density of soil layer and water layer, thickness of soil layer and water layer, slope angle, and slope friction into an additional theoretical equation to calculate the factor of safety for a geologic slope failure such as a reservoir dam breach, landslide, debris flow, or avalanche.

**Anticipatory Set/Capture Interest:**
The teacher will capture the students' interest by first showing a video of a several severe geologic disaster such as slope failures causing land deformation, infrastructure damage, landslides, and debris flows (Outrunning a landslide.mp4).

**Guided Practice:**
The teacher will guide a hands-on demonstration of a geologic slope failure or fault line activation. The demonstration will involve the investigation of angles of failure for assorted weights on angled surfaces of varying friction. The teacher will present a 1square foot sheet of plywood with one side being surfaced with rough grade sandpaper and the other side left smooth. A known weight will be placed onto the center of one side of the plywood sheet resting horizontal. The angular incline of the plywood sheet will then be raised in small, equal increments until the weight reaches its angle of failure and slides off of the plywood surface. This process will be repeated on the other side of the plywood sheet. The demonstration is intended to show how the slope angle, mass of weight, and degree of frictional surface all together determine the angle of failure. Several sizes of weights should be used in the demonstration to show the weight vs. angle of failure relationship. Following the demonstration, the teacher will introduce and

explain variables involved in the Normal Stress and Shear Stress formulas that geologists use to calculate the stress acting on a fault plane. Next, the students will be shown how forces and stresses caused by soil cohesion, density of soil layer and water layer, thickness of soil layer and water layer, slope angle, and slope friction can be incorporated into a trigonometric equation that develops a factor of safety for the risk of a slope failure (INSPIRE_LP_Ladner_10.15.12_powerpoint).

**Independent Practice:**
Following the guided practice, students will be presented with several real-world geologic scenarios, in which they will use Normal and Shear Stress formulas to calculate the stresses acting on a fault plane. The Factor of Safety formula will be used in a scenario to predict the risk of a slope failure for a location having specific geologic, hydrologic, and topographic characteristics.

**Remediation and/or Enrichment:**
Remediation:
In the case that remediation is needed the student can meet with the instructor for individual tutoring. The student can also be grouped with a higher performing student that understands the lesson.
Enrichment:
In situations where there is complete understanding and performance, the lesson can be extended by having the students to manipulate the geologic, hydrologic, or topographic characteristics to find ways to increase or decrease the stability of the slope in the scenario.

**Check(s) for Understanding:**
The teacher will check for understanding by asking the students the following questions:

- What is the relationship between normal stress and shear stress in a fault plane scenario? What can be expected to happen in the fault if normal stress is greater than shear stress?
- What type of soil and water properties would be best to produce a more stable slope?
- What probable affect would an earthquake, large rainfall, or increase of slope angle have on a fault plane or mountain side.

**Closure:**
The teacher will close the lesson by showing students factors of safety and stresses are incorporated into building a safe and effective dam impoundment for a reservoir lake.

**Possible Alternate Subject Integrations:**

This lesson can be incorporated into high school algebra, physical science, and physics courses.

**Teacher Notes:**

Assessment : INSPIRE_LP_Ladner_10.15.12_handout.doc

Guided Practice Aid: INSPIRE_LP_Ladner_10.15.12_powerpoint.ppt

Anticipatory Set: Outrunning a landslide.mp4