Lesson Title	Hazards of Angles
Length of Lesson	2 days, 50 minutes each day
Created By	Corey Ladner
Subject	Geometry
Grade Level	9^{th} – 12^{th}
State Standards	3.a
DOK Level	DOK 3
DOK Application	Assess, Construct, Compare, Investigate, Differentiate, Hypothesize, Formulate, Draw Conclusions.
National Standards	Connections Recognize and use connections among mathematical ideas. Representations Create and use representations to organize, record, and communicate mathematical ideas.
Graduate Research Element	In my research, it is important to have an understanding of angular effects on geologic hazards. Slope angles of geologic surfaces are a major factor in determining the risk for geologic slope failures. Slope failures are commonly occur as slumps on mountain sides or breaches in reservoir dam impoundments.

Student Learning Goal:
Students will use inductive reasoning to make conjectures and deductive reasoning to make valid conclusions of a real-world application problem involving angle measurements. This lesson will focus on the interactions between angular change, weight, and frictional resistance.

National Standards:
Connections:

- Recognize and use connections among mathematical ideas.

Representations:

- Create and use representations to organize, record, and communicate mathematical ideas.

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

Lesson Performance Task/Assessment:
The students will be assessed on their understanding of the relationship between the weight of an object and the angle and resistance of a slope on which the weighted object rests. As the assessment, Students will be presented with the task of testing and recording the angle at which an assortment of weights slides off of three types of textured surfaces. Refer to guided and independent practice for details.

Lesson Relevance to Performance Task and Students:
The lesson provides the students with a real world experience involving the practice of testing for angles of failure (angle at which the surface resistance force is exceeded and the object slides off the surface) of an assortment of weights resting on various textured surfaces.

Anticipatory Set/Capture Interest:
The teacher will capture the students' interest by first showing a video of a severe geologic disaster involving slope failures of mountain sides. (Outrunning a Landslide.mp4)

Guided Practice:
The teacher will introduce a hands-on activity that the students will perform as the independent practice and assessment. The activity will involve the investigation of angles of failure for assorted weights on angled surfaces of varying friction. The teacher will present the students with three types of surfaces, and a range of weights that will be used for the activity. The three surfaces will consist of three square sheets of plywood, one that is sanded smooth, the other two with different grades of sand paper glued across the plywood surface. The weights will consist of 5, 10, 20, 100, 500, and 1000 grams. The teacher will show how the angle of failure for each weight will be tested by raising the angle of the plywood surface by stacking Geometry textbooks under one side of the plywood until the weight slides on the surface. The angle of failure should be tested in increments by increasing the angle of the surface by one book each time (using books with congruent thicknesses). Students will be guided in how to record collected data for angles of failure for each weight tested on each surface.

Independent Practice:
Students will receive materials for the hands-on activity introduced in the guided practice. Students will perform the activity in groups of two, with each group having their own set of materials. The students will test and record the angles of failure for each weight on each of the three surfaces. Afterwards, the students will represent the three sets of data on weight versus angle of failure line graphs.

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 weights and plywood surfaces to find ways to increase stability of the weights on slopes and increase their angles of failure.

Check(s) for Understanding:

The teacher will check for understanding by asking the students the following questions:

- What observable influences did each of the three plywood surfaces have on angles of failure?
- Why is there a trend in angles of failure with respect to increasing weight?
- Apply your observations in this activity to a mountain slope, how would slope stability of a non-vegetated mountain differ from a heavily vegetated mountain.

Closure:

The teacher will close the lesson by showing students how angles of failure for sloped sediments, or what geologists refer to as Factors of Safety, may be calculated. The teacher will also illustrate the problems and potential hazards that geologists must consider when constructing reservoir impoundments.
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Possible Alternate Subject Integrations:

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

Teacher Notes:

Attachments

Outrunning a Landslide.mp4
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