Lesson Title	Superhydro-what?! Measuring Angles and Segments
Length of Lesson	50 minutes
Created By	Emily Burtnett
Subject	Geometry
Grade Level	9th, 10th, 11th, 12th, High school topics
State Standards	4b
DOK Level	2
DOK Application	Solve real-world applications and mathematical problems to finding missing measurements in right triangles by applying special right triangle relationships, geometric means, or trigonometric functions.
National Standards	Understand measurable attributes of objects and the units, systems, and processes of measurement. Apply appropriate techniques, tools, and formulas to determine measurements.
Graduate Research Element	Measuring contact angles of droplets on various surfaces

Student Learning Goal:
Students will observe how water droplets interact with various surfaces and will learn the concept of surface wettability. They will learn the difference the smoothness of a surface makes when water droplets come in contact with the surface. For example, smoother surfaces or super hydrophobic surfaces tend to have higher contact angles and are considered less wettable. Protractors will be used to measure the contact angle of a water droplet on a variety of surfaces using the Proscope to see better and students will make conclusions about the smoothness of the surface. Students will use rulers to measure the spread of the droplet in contact with the surface and height of the droplet as it sits on the surface.

Materials Needed (supplies, hand-outs, resources):
Water, surface samples, droplet dispenser, 2-3 Proscopes, 2-3 computers and projectors, protractors, rulers

Lesson Performance Task/Assessment:
After seeing the demonstration of water droplets impacting various surfaces and observing the difference between superhydrophobic, hydrophobic, and hydrophilic surfaces, students will learn the definitions of contact angles, spread and height. Students will work in small groups to use the Proscope (with supervision) to observe water on 2-3 different surfaces. Using a ruler and protractor, they will measure the contact angle, spread and height to scale. They will realize that by holding a rule up to the picture on the

screen is not to scale. In order the measure it to scale, the measuring device must be observed next to the droplet and viewed within the Proscope.

Lesson Relevance to Performance Task and Students:
Students will understand that not all surfaces are the same. This will help students realize that not all surfaces can be used on aircraft wings if ice is to be prevented. They will also learn to use measuring devices in a real world research setting.

Anticipatory Set/Capture Interest:
The instructor will demonstrate water impacting three different surfaces without any explanation. Students may expect to see the same results on each surface, but will observe that water does not interact with each surface in the same way. This demonstration should invoke curiosity and a discussion will be prompted with the following questions:

- Which surface repels water the most?
    - Explain wettability
        - Is the surface which repels water more or less wettable?
- Which surface should be used if you do not want ice to build up on your aircraft?

The instructor will use the Proscope to show a close up of a water droplet on one of the surfaces.

- What kind of measurements can we make to describe the droplet on this surface that we can use to compare to droplets on other surfaces? (contact angle, spread and height)

Guided Practice:
The instructor will define contact angle, spread and height. Students will work in three groups and rotate between three stations. At each station will be a Proscope set up to observe a droplet on a superhydrophobic, hydrophobic and hydrophilic surface. The instructor will guide the students how to measure the three variables and the students will collect and record the data at each station on their own. The instructor will assist as needed. Once the students have collected the data the instructor will ask the students what observations they made about each station and how their data compared. The instructor will conclude with the definition of superhydrophobic, hydrophobic and hydrophilic surfaces and ask students to try to classify the sample at each station. Water on super hydrophobic surfaces generally have contact angles greater than 150°, hydrophobic surfaces demonstrate contact angles of ~120° and hydrophilic surfaces can have contact angles of up to 90°.

Independent Practice:
Students will work independently at each station to measure and collect their data on each droplet. The teacher will walk around and assist as needed. Students will be asked to discuss their data with each other.

Remediation and/or Enrichment:
If the Proscopes aren't working in the classroom or the image isn't good quality, the instructor will have handouts of a picture of a droplet on each surface available for students to use to measure. Individual IEPs will be supported.

For enrichment, or if there is extra time, the students can use surfaces in the room to observe and collect data on. These surfaces could include desktops of various roughness, chairs, textbooks, glass, etc. They can compare this data to the data collected at the stations and make conclusions about the various surfaces.

Check(s) for Understanding:
Students will be asked to classify the surfaces as superhydrophobic, hydrophobic and hydrophilic. They will be asked for examples of where and why an engineer might want to use a hydrophilic surface rather than a hydrophobic surface, and vice versa.

Closure:
The instructor will conclude with the definition of superhydrophobic, hydrophobic and hydrophilic surfaces and ask students to try to classify the sample at each station. Students will apply their understanding of each surface to a real world application. For example,

- Why would an engineer want to use a superhydrophic surface versus a hydrophilic surface?

Possible Alternate Subject Integrations: Physics to explain effects of densities, viscosity and velocity.

Teacher Notes:
Show students pictures in Power Point presentation (attached). Ensure there is an instructor at EACH STATION to monitor usage of Proscopes.