

Sensor Starters

Grades: 4 & Up
Time: 15 Minutes -PDQ 1 & 2

Subject: Physics, Technology, Math, Data Science, and STEM
Topics: Angles, Degrees , Gravity, Rotation

Meet the Inclinometer!

Angles are amazing mathematical entities that surround us. They are fundamental elements of geometry that help us describe shapes, space, and relationships between objects. Let's explore them with the inclinometer, a sensor that detects angles using gravity, in databot.


Background

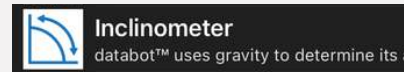
An inclinometer is a measuring instrument used to determine the angle of an inclined or "sloped" surface. databot's inclinometer uses the accelerometer on databot, a sensor that can detect the force of gravity, to determine its angle relative to the earth. Accelerometers have a tiny mass in them that moves around based on where gravity is pulling it. The sensor can tell its position by where the mass is resting and uses some cool math to calculate databot's angle. Inclinometers are used in all kinds of applications including cars, tunneling machines, ships and more!

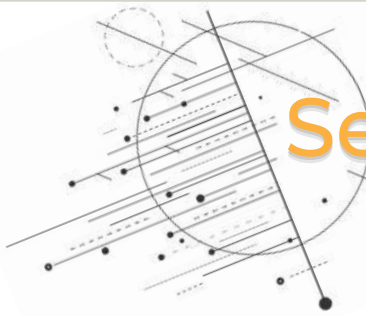
Angles are all around us - in buildings, furniture, nature, etc. We classify angles by shape. We can call angles "right" if they look like the corner of a closet, or "acute" when they are smaller than a right angle and appear sharp and pointy. What about "obtuse" angles? These are angles that are larger than a right angle and appear open, wider and smoother.

The inclinometer determines angles using data from the accelerometer on databot , a module in the IMU in the center of the databot PCB.

What You Will Need/Prep

- databot™ 2.0 & Vizeey™ 
- IOS/Android Smart Device
- Use Vizeey™ to scan the QR Code for Inclinometer.
- A protractor and a pencil.
- Different surfaces for testing (e.g. cardboard, wood, steel)





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Important Terms

Acute Angle: An angle between 0° and 90° (degrees).

Angle: A unit of angle measurement.

Degree: Units of measurement for describing angles. Degree symbol ($^\circ$) There are 360° in a full circle.

Full Rotation Angle (Circle): A full rotation angle is formed when one of the arms of the angle goes on a complete rotation (circle) or makes a 360° .

Inclinometer: An inclinometer is a sensor that is specifically designed to measure and indicate the angle or slope of an object relative to the force of gravity. It is also referred to as a tilt sensor or an angle sensor.

Obtuse Angle: An angle between 90° and 180° .

Protractor: A tool used to measure angles.

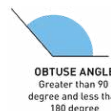
Right Angle: The angle formed by two lines that are perpendicular to each other is called a right angle. A right angle is equal to 90° .

Right Triangle: A triangle in which one of the angles is a right angle.

How do we measure Angles?

Angles are measured in special units called degrees. A degree is a unit of measure for angles, which is denoted by the symbol " $^\circ$ ". Degrees can be measured using a degree scale, which is usually represented as a semicircle or circle and divided into equal parts that indicate degrees. A protractor is an instrument you can use to measure angles and see how the degree scale works.

- **Acute or Sharp Angle:** An acute angle is less than 90 degrees. It looks sharp and has a pointed end. *Examples of acute angles may include the angle made in the letter "V".*
- **Full Rotation Angle (Circle):** The angle goes on a complete rotation (circle) or makes a 360° .
- **Obtuse or Blunt Angle:** An obtuse angle is larger than 90 degrees. It looks open and wider. *Examples of obtuse angles may include the angle at the top of a clothes hanger.*
- **Right Angle:** The right angle is 90° . It looks like a "cabinet corner" or the letter "L". *The right angle is the basis for many geometric designs.*

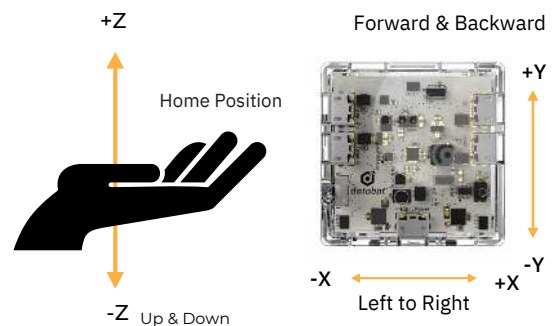


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PDQ1 : Angle Explorer

Using databot's inclinometer it is possible to measure angles and inclinations. First, let's understand how to properly orient databot and what types of data you can get.

- Open the Vizeey App on your smart device
- Turn on databot.
- Tap on **"Inclinometer"** in Vizeey™ to load the experiment.
- Place databot in the flat position with the power and programming port oriented close to you.
- Start your experiment using
 - In this position you should see values close to 0°.

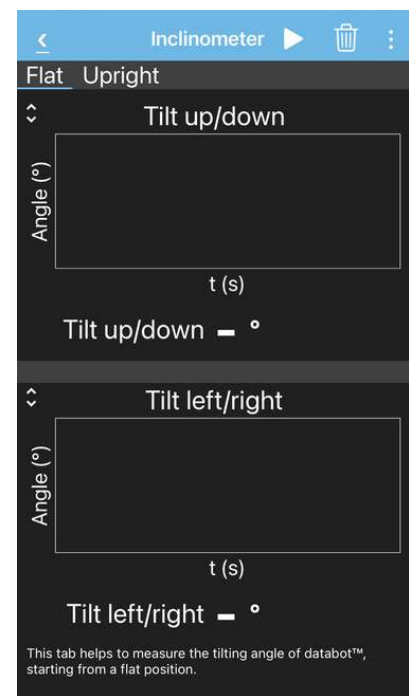


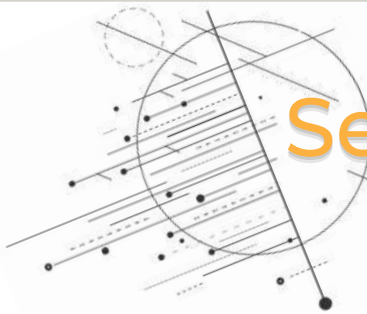
There are 2 graphs in the experiment.

- The first graph shows how many degrees you tilt databot forward or backward.
 - If you put databot so that it is facing you the value will show 90 degrees.
 - If you turn databot away from you the value will be -90 degrees.
- The second graph shows how many degrees you tilt databot to the right or to the left.
 - Put databot on the right edge and you will see the value of 90 degrees.
 - If you put databot on the left edge the values will be -90 degrees.

Don't get confused and pay attention to that graph depending on which way you tilt databot.

What do you think the values will be if you just turn databot upside down?




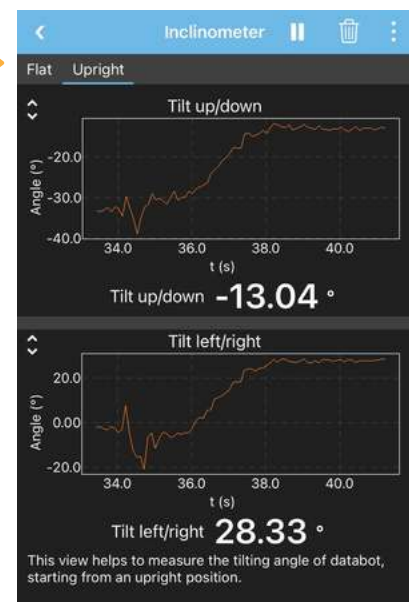
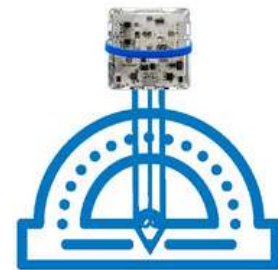


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PDQ1 : Angle Explorer (cont.)

Let's explore acute angles using databot and a protractor. As a team, one of you will use Vizeey to visualize angle data while the other holds the protractor and moves databot to various angles.

- Take a protractor and a pencil.
 - Fix databot to the pencil with a rubber band.
 - databot should be facing you with the power port pointing down.
- Hold your protractor directly behind the upright pencil holding databot, the pencil should be centered on the middle of the protractor so you can see the angle on the protractor as you tip the pencil left or right.
- Tap on **"Inclinometer"** in Vizeey and swipe left on the screen to the Upright screen.
- Start your exploration using 
- Lean the pencil with databot to the right keeping the base of the pencil in place, centered on the protractor. Watch how the angle changes as you tip right and left.
 - Compare the angle degrees displayed by Vizeey to the protractor.
 - Which tilt direction reads negative and which is positive?



With the pencil and protractor flat on a desk or table you can tilt a maximum of 90 degrees in either direction, so these angles are all “acute.”

- Now, remove databot from the pencil holder and explore the area around you using just databot to measure angles. Find objects in the room that form angles and identify three acute angles (less than 90 degrees) and three right angles (90 degrees).

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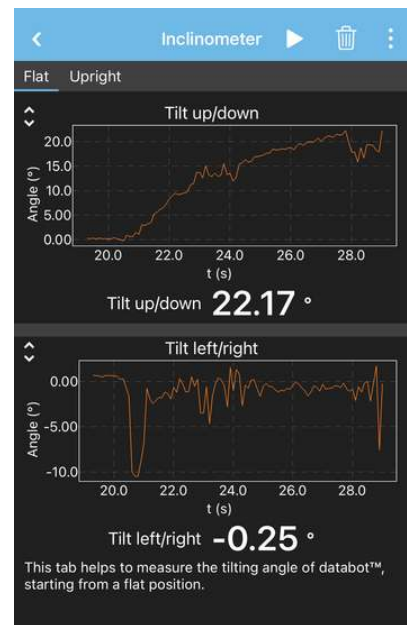
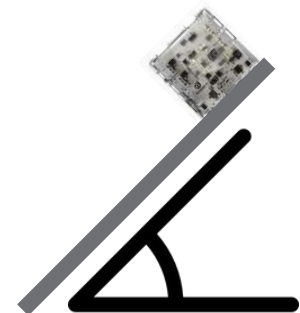
PDQ2 : Inclination and friction

Friction and tilt are closely related: as the angle of the incline increases, the component of gravity pulling the object downward becomes stronger, overcoming more of the friction force. This allows objects to slide more easily. Let's explore how the tilt angle affects friction using the databot Inclinometer.

Prepare different materials/surfaces for testing. This can be a book, wood or metal.

- Open the Vizeey™ App on your smart device.
- Turn on databot.
- Tap on "Inclinometer" in Vizeey™ to load the experiment.
- To start and pause your measurement use .
- Place the surface to be tested, e.g. a book, flat and place databot on it.
 - databot should be positioned flat with the power and programming port oriented to you.
- Now, slowly raise the surface and watch the sensor readings. As soon as databot starts to slide, memorize the angle of inclination.
 - Record the data in the table.
 - Clear your data using .
- Repeat the measurements for the next sample.

Note: For more accurate measurements, the sliding surfaces should be of the same length.



Example Data table

Tested Surface	Angle, °
Cardboard	
Wood	22.17
Steel	

Angle of inclination for the wooden surface

Check for Understanding

1. In your own words, explain what an angle is, what kinds of angles you know.
2. What are the units used for expressing angles?
3. Does everything have angles?

Standards & Alignment

NGSS Standards

- Energy (4-PS3-1)
- Motion and Stability ((5-PS2-1), (MS-PS2-2))
- Engineering Design (MS-ETS1-3)

Disciplinary Core Ideas

- Forces and Motion (PS2.A)
- Types of Interactions (PS2.B)
- Developing Possible Solutions (ETS1.B)

Science and Engineering Practices

- 3rd Practice: Planning and Carrying Out Investigations
- 4th Practice: Analyzing and Interpreting Data
- 5th Practice: Using Mathematics and Computational Thinking

TEKS -Texas Essential Knowledge and Skills

- ScienceTEKS:

Grade 5 (112.16):

- (b)(6)(D): Explore how force, motion, and energy interact in inclined planes.

Grade 6 (112.18):

- (b)(8)(C): Investigate how unbalanced forces change the speed or direction of an object.

Grade 7 (112.19):

- (b)(8)(C): Identify and describe forces that affect motion in various systems, including gravity.

- Mathematics TEKS:

Grade 4 (111.15):

- (b)(7)(B): Solve problems involving measurement of angles.

Grade 6 (111.18):

- (b)(6)(C): Measure angles in degrees and interpret data.

- Technology Applications TEKS:

Grades 6–8 (126.14–16):

- (c)(3)(C): Collect and analyze real-world data from sensors to solve problems.
- (c)(5)(A): Solve problems using data-driven experiments with technology tools.

Crosscutting Concepts

- Cause and Effect
- Patterns
- Stability and Change

ISTE Standards

- 1.1 Empowered Learner (1a, 1c)
- 1.3 Knowledge Constructor (3a, 3b)
- 1.4 Innovative Designer (4a, 4c)
- 1.5 Computational Thinker (5a, 5c)