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Pythagorean Theorem & Slope

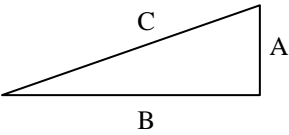
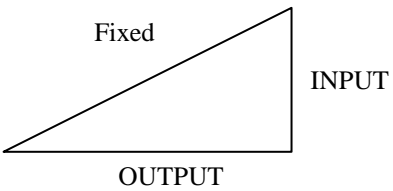
This project explores the Pythagorean Theorem and slope. There is also a bit of trigonometry involved. The 3rd opportunity solves a system of equations.

Opportunity 1 is all about the Pythagorean Theorem. Given a fixed horizontal distance, the module will calculate the hypotenuse (length of the ramp) if a height is given by the user.

Opportunity 2 will calculate the length of the missing side of a right triangle given the other two sides. An optional add-on would be the ability to determine the angle, θ , by using the arctan function.

Opportunity 3 combines the Pythagorean Theorem and the concept of slope to solve for changes in vertical and horizontal distances using a system of two equations.

Opportunity 1

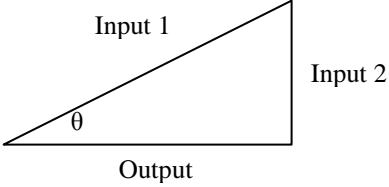
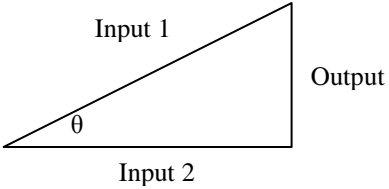
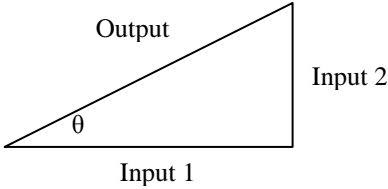
<p>Pythagorean Theorem: For any right triangle</p> $A^2 + B^2 = C^2$  <p>Where C is the length of the hypotenuse (longest side) and A and B are the lengths of the legs.</p> <p>Game:</p> <p>Given a fixed length of the ramp (hypotenuse of the triangle), adjust the height and determine the horizontal distance the car travels by using the Pythagorean theorem.</p> 	<p>Example:</p> <p>If the length of the ramp is 89 feet long and the ramp is 39 feet high, what is the horizontal distance the car travels? (Ans: 80ft)</p>
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How Opportunity 1 is Coded

In the starter application, you programmed this with the following function:

```
private function ChangeAngle(event:Event):void {
    rampHeight=Number(RampHeight.text);
    angle=Math.atan(rampHeight/ramp.width)*180/Math.PI;
    ramp.height=Math.tan(angle*Math.PI/180)*ramp.width;
    Hypotenuse.text="Hypotenuse is: " +
String(Math.sqrt((Math.pow(rampHeight,2)+Math.pow(ramp.width,2)))).toFixed(2));
    Angle.text="The angle is: " + String(angle)
}
```

Opportunity 2

<p>Be able to enter any two dimensions of a right triangle and have it calculate the third side (to one decimal point) using the Pythagorean Theorem. Length = Width = Diagonal =</p> <p>Add the ability to determine the angle, θ, by using the appropriate Inverse Trig function.</p> <p> $\theta = \text{Sin}^{-1} \left(\frac{\text{Input 2}}{\text{Input 1}} \right)$  </p> <p> $\theta = \text{Cos}^{-1} \left(\frac{\text{Input 2}}{\text{Input 1}} \right)$  </p> <p> $\theta = \text{Tan}^{-1} \left(\frac{\text{Input}}{106} \right)$  </p>	<p>Example, If the ramp (hypotenuse) is 65 feet long and the height is 33 feet, what is the length and angle, θ? (Ans: 56 feet, $\theta \approx 31.6^\circ$)</p>
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How Opportunity 2 is Coded.

- The angle, θ , can also be solved for by just using one of the inverse trig functions (ArcTan for example) by calculating the third side to complete the triangle and then evaluate for θ .

You can program the function along the following lines:

```
private function ChangeAngle(event:Event):void {
    var angle:Number=Number(Angle.text);
    ramp.height=Math.tan(angle*Math.PI/180)*ramp.width;
}
```

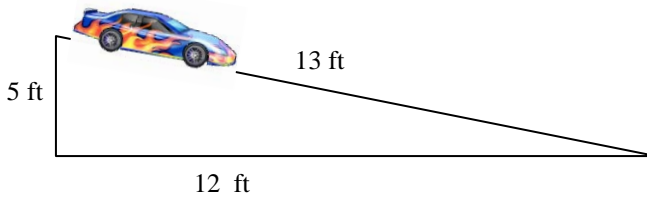
Opportunity 3

Perhaps one of the most important concepts in higher mathematics is that of finding the slope. The slope is defined as

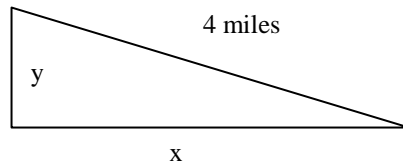
$$\frac{\text{rise}}{\text{run}} = \frac{\text{change in } Y}{\text{change in } X} = \frac{Y_2 - Y_1}{X_2 - X_1} = \frac{\Delta Y}{\Delta X} . \text{ Slope}$$

can also be thought of as the change in the vertical direction divided by the change in horizontal direction and is sometimes called “pitch”. Consider a car driving down a ramp. The car travels a total of 13 feet down the ramp but is also 5 feet lower and 12 further along in the horizontal. Therefore the slope/pitch of the ramp is

$$\frac{\text{Vertical Change}}{\text{Horizontal Change}} = \frac{5}{12} \approx 0.42$$



Often times, when dealing with roads, the term “Grade” is used rather than “slope”. Grade is similar to slope except that is expressed as a percent. In the example above, the slope is approximately 0.42 which would mean the car is traveling down a grade of 42% over the course of 12 horizontal feet. A 42% grade is considered very steep for a vehicle to travel down. Most roads (especially highways) have much smaller grades. Consider the sign below which indicates a 14% grade over 4 miles. With these two pieces of information we can calculate both the horizontal and vertical distances by using both the Pythagorean Theorem and the formula for slope.



$$0.14 = \frac{y}{x} \text{ and } x^2 + y^2 = 4^2 . \text{ Solving for } y \text{ in the}$$

first equation yields $y=0.14x$. Plugging $0.14x$ into the second equation and solving gives $x = 3.961$ and $y = 0.555$ miles. This means a vehicle would descent approximately 2928 vertical feet ($0.555 \text{ miles} \approx 2928 \text{ ft}$) in just under four miles (3.961).

When heading west on I-70, one travels over Vail Pass which peaks at 10,603 ft before encountering a 7% grade for 10 miles. What is the total vertical descent and new elevation after 10 miles?

(Ans: Vertical descent (0.698 miles \rightarrow 3685 feet. New elevation 6918 ft)

When heading west on I-70, one travels through the Eisenhower Tunnel which peaks at 11,158 ft before encountering a 7% grade over the next 11 miles. What is the total vertical descent and new elevation after 11 miles? (Vert descent = 0.768 miles \rightarrow 4056 feet. New Elevation 7102 ft)

