Unit 2: Input, Output and Functions — Application: Distance to the Horizon

In this Application, you will write a program that determines the distance to the horizon from a given altitude.

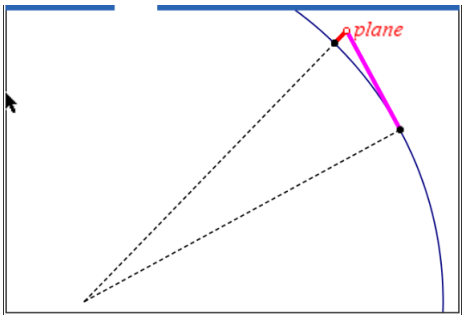
Objectives:

- Use import for additional functions
- Write a program using the menus
- Use multiple units in one problem

When a plane is flying, how far away is the horizon to the pilot? The higher they fly, the further the distance to the horizon. How do they determine the distance to the horizon given the plane's altitude?

The radius of the Earth is 3,958.8 miles.

Write a program to input the altitude of the plane in feet and produce the distance to the horizon in miles.



Teacher Tip: This project uses the Pythagorean Theorem to calculate one leg of the right triangle pictured above. The hypotenuse is the *sum* of two distances in different units.

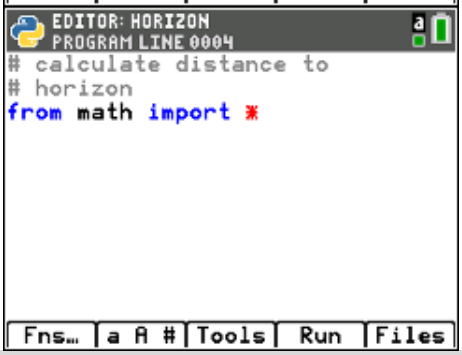
1. Start a new Python file (we call it **horizon**).

   Start with a comment explaining the purpose of the program. You can press **[2nd] [3]** for the **#** symbol and turn on alpha-lock for the rest of the text. Remember that the space is on the **[0]** key.

2. This program uses the Pythagorean Theorem and requires the square root function which is *not* part of Python's built-in operations. This function, and others, are found in a standard Python module called **math**. To use this function, you must import the math module to your code. On **menu > math**, select the statement at the top:

   from math import *

   Recall that the asterisk (*) means "everything."



Teacher Tip: You can also write **from math import sqrt** if you know you are only going to need the sqrt function. Or **import math** which requires you to write **math.sqrt()**. The math module, along with random and time, are standard Python modules.

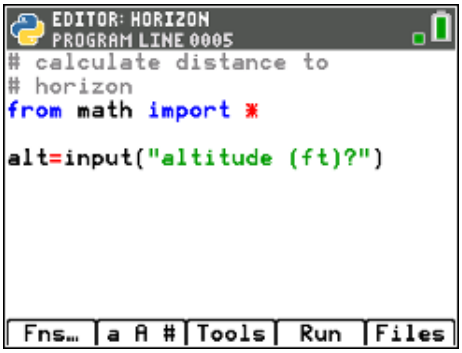
3. Use the **input()** function to enter the altitude of the plane.

   First type the variable **alt** and the **[sto ->]** to get the **=** sign.

   Then look on **<Fns…> I/O** for the **input()** function.

For the prompt inside the parentheses, write: **"altitude (ft)?"**

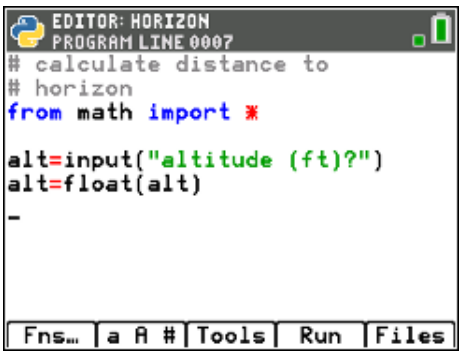
*Tip: Remember many symbols including **?** can be used from the <a A #>.*



4. Remember that input() gives a string that must be converted to a number. On the next line, convert the string alt to a float (decimal) value:

   alt = float(alt)

float() is on **<Fns…> Type**.

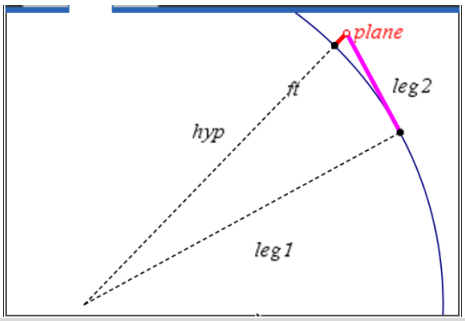


5. From our labeled diagram we see a right triangle where one leg is the radius of the Earth, the other leg is the distance from the plane to the horizon and the hypotenuse *(the radius of earth plus the altitude of the plane)*. The Pythagorean Theorem states that, in a right triangle:

   $(leg1)^2 + (leg2)^2 = hyp^2$

   or **$radius^2 + leg2^2 = (radius+alt)^2$**

So, solving for **leg2** gives: **$leg2 = \sqrt{(radius+alt)^2 - radius^2}$**



Teacher Tip: How do we know it is a right triangle? The distance to the horizon is tangent to the circle, and the tangent to the circle is perpendicular to the radius at the point of tangency.

Note that the radius of the Earth is given in miles, and the altitude of the plane is given in feet. There is some conversion to be done first.

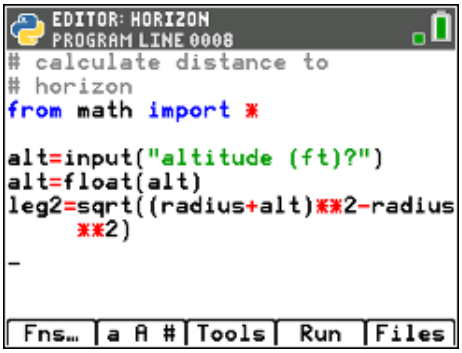
6. The Python exponent symbol is **
   Enter this formula into your program:

   leg2 = sqrt((radius + alt)2 – radius**2)**

   Yes, you may use shorter variable names!

   Be careful with the parentheses.

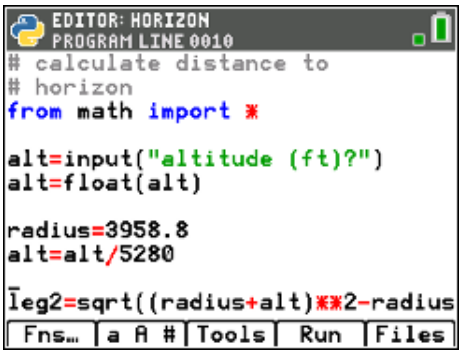
   Pressing the **[x^2]** key produces ****2** in your code.
   Pressing the caret key **[^]** produces **
   Or you can just type them yourself.



7. There are two more details to handle before we can test the program.

   - Set the variable radius to be 3958.8:
     radius = 3958.8
   - Convert the altitude variable from feet to miles:
     alt = alt/5280

   *Both of these statements must occur **before** the Pythagorean Theorem formula, as shown here. If you made a mistake, under <tools> try cut and paste the line to the new location.*

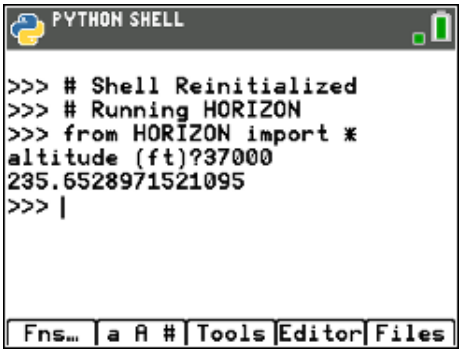


8. You are almost ready … you still must print the answer.

   print(leg2)

   gives the answer, but a more informative message would be:

print(" Distance to horizon: " , leg2 , " miles. ")

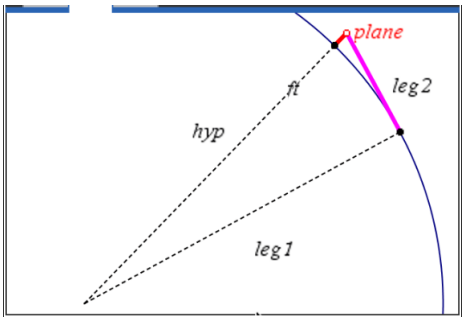


When ready, select **<Run>** to run the program. Try various altitudes.

If you see a **SyntaxError**, check your punctuation carefully.

Extra spaces have been added to illustrate order of the punctuation.

9. **Challenge:** Revise the program to use a **def**ined function to calculate the distance. There will be one argument for the function: the **alt**itude (n feet). The function **return**s the distance (in miles).



Find the altitude of the outdoor observation deck (86th floor) of the Empire State Building in NYC. Use this program to determine how far you can see in any direction. Or you can use the NYC One World Trade Center observation floor, or the highest one in the world, the Burj Khalifa observation deck in Dubai.

Can you write a metric version?

Teacher Tip: How do you know that the results are correct? Try altitude 0 feet (0 miles) and altitude 6 feet (about 3 miles). See also: Distance to the Horizon Calculator (ringbell.co.uk) . That site uses a slightly different value for the radius of the Earth, but results are close.

Sample horizon function:

```
Def horizon(alt):
  radius = 3958.8
  alt /= 5280
  h = sqrt((radius + alt)**2  –  radius**2)
  return h
```

Altitude of Empire State Building observation floor: 1,050 feet.
Distance to horizon: Approximately 40 miles.