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Homework 4: Projectile problem (20 pts)

Make sure that your scripts run without error in order to get credit. Do not hesitate to ask for help if needed!

We'll be working on the projectile problem described in Lecture Notes 04. Again, the specific problem is the following:

> A stone of mass $m = 200\,\mathrm{g}$ and linear dimension $L = 6\,\mathrm{cm}$ is thrown from an initial height $h_0 = 1.54\,\mathrm{m}$ at an initial speed v_0 at an angle θ_0 above the horizontal. Calculate its landing point.

All of what follows should be done in a single `Python` script file to be submitted on Canvas.

We now want to get numerical values for different initial velocities $\vec{v}_0$ (i.e., speed v_0 and angle θ_0). We'll follow the following steps (although this is not the only way to do it):

Step 1 Define variables for the quantities that will not change. That is m, L, h_0, and g. (Note that we might not use all of them for this assignment, but let's define them anyway.) Include a comment next to each variable specifying the units in which these quantities are expressed and what they represent!

Step 2 Define a function `xdist` of 2 variables, `v0` and `theta0`, that will return the "range" or horizontal distance to the landing point. (We already solved for this in the notes, Eq. 7, so you just need to code the equation.)

The function will be called by providing the launch angle in degrees since this is easier for us to visualize. Be careful to consider what the trigonometric functions in the `Python` math module expect...

Be sure to make use of the documentation line (docstring) in the function definition to describe carefully what your function does. This is good practice for real-world programming where you must comment everything.

Step 3 Evaluate that function for at least six different combinations of values of `v0` and `theta0`. Use a calculator and CHECK that your function is working properly for at least one of the combinations. If not, go back to Step 2 and find your error.

Print out the results of your tests and include in this information what input values were used to generate each result. For example,

```
For v0 = 8.00 m/s and theta0 = 20.9 degrees, the range is 6.81 m.
```

Go back and review what we did last week with formatting strings to remind yourself how to accomplish this.

While doing this step, try to avoid having to explicitly write 6 calls to the function and 6 print commands (*Hint:* maybe use a loop?)

Step 4 Now let's make a second function `xdist2` of a single 2-tuple variable that will do all the printing to the screen for us.

In other words, it will print a sentence similar (or identical) to what you did for step 3, showing the initial speed and angle along with the resulting range. It will therefore never be necessary to call `print()` on `xdist2`, as calling `xdist2` does all the printing. Make sure this is how your `xdist2` functions. This function should also return the resulting range.

Call this function for a couple of combinations of the parameters.

Hint: You should have `xdist2` call `xdist` instead of re-coding the range equation.

Step 5: Exploration Choose a reasonable value for the initial speed `v0` of the stone. What is reasonable?

How fast can a person throw a baseball? Maybe 25% of that or so is reasonable. Also, pay careful attention to units.

In defining your variables in step 1, you did decide on a particular choice of units (specifically in defining h_0 and g). Make sure that the initial speed you choose here is with respect to that particular choice of units.

Now we're going to do some exploration:

- At what angle do you need to throw the stone for your chosen initial speed to maximize the range?
- Does this angle depend on the initial speed (you'll need to choose a different, reasonable speed to check)?

There is no solving allowed for this question. Explore through trial and error. Note that using loops to sweep through various angles might make your life easier...

Hint: the answer is not necessarily 45 degrees.

Step 6: Assumption 1 We've assumed the stone to be a point in obtaining our solution, but the problem states that it has a dimension $L = 6\,\text{cm}$.

How does the answer change if we take this finite size into account?

Since no shape is specified, let's assume a sphere of diameter L.

As we will still assume no air resistance, spinning of the sphere is still irrelevant, but there is one change that can be easily incorporated in the solution (assuming that the position of the stone is defined by its center).

How is the solution modified? How much of a change is it numerically for one of your `(v0, thetha0)` combinations in step 3? Was the assumption that the stone is a point particle reasonable based on this?