Phys 108 Computational Mini Lab Part 2 Name:___________________

What REALly matters

You have now investigated what happens in an ideal world and we want to make our lives a bit more complicated, that means you will include air and the associated force of air resistance.

It turns out this is a very complicated problem to solve and normally would require calculus to solve these types of problems. Fortunately, the computer does all of the hard work for us!

https://trinket.io/glowscript/c645663ded

The new simulator appears to be almost identical to the last simulator except for a new column on our bar graph!

You will repeat a similar process to what you did with the ideal ball drop in order to determine what changes how the ball drops.

This time around you will start by investigating mass. Start with the default mass of 10 kg, and a fixed height of 20 m and radius of 0.5 m. Record the total time of fall for these parameters and the values of the graphs at the start and end of each fall. Then repeat these measurements for a mass smaller than 10 kg and bigger than 10 kg.

1) What is the label on the third bar?
2) Is there a relationship between mass on how quickly the ball falls? A qualitative relationship is all I am looking for here.
3) What explanation (based on physics) can you think of that describes the above relationship.
4) What happens to the third bar as the ball falls.
5) With the ideal simulator you compared the PE column on the graph at the start of the fall to the KE column at the end of the fall for each change, does the relationship that held in the ideal simulator hold here?
6) If we add the third column and the KE bar at the end of the fall together and compare it to the PE bar at the start, what is true?

We will now investigate how size affects the ball's fall with air resistance. Since we already have data on a 10 kg ball with a radius of 0.5 m falling from a height of 20 m, we do not need to repeat this step. Instead we want to keep the 10 kg and 20 m and try a radius smaller than 0.5 m and bigger than 0.5 m and repeat the above observations.

7) Is there a relationship between the radius of the ball and how quickly the ball falls? A qualitative relationship is all I am looking for here.
8) What explanation (based on physics) can you think of that describes the above relationship.
9) Did changing the radius of the ball alter the graphs at all? If so how?
10) If we add the third column and the KE bar at the end of the fall together and compare it to the PE bar at the start, what is true?

Second to last is to determine how the height of the ball changes things. To see this, you will have to bring back the equal distance interval measurement technique. Set the mass of Start with a distance of 6 m, and try and find the time intervals of 18 m-12 m, 12 m-6 m, and 6 m-0 m, repeat with 45 m , and finally with 300 m.

11) If in each case we add the third column and the KE bar at the end of the fall together and compare it to the PE bar at the start, what is true?
12) After several second into the drop from 300 m, the graph behavior changes. What is the change?
13) KE represents Kinetic Energy, or the energy due to motion (velocity). What does the change in the KE bar tell us about the ball's motion near the end of the fall?

Finally, we want to play with the input box we have not touched yet: The fluid density.

14) What fluid are we talking about with the fluid density box?
15) What do you think happens to the fluid if the density increases?
16) What do you think happens to the fluid if the density decreases?
17) How do you think the density of the fluid will affect how the ball will drop with air resistance?

You will drop a 10 kg ball with 0.5 m radius from 20 m high. You again have already collected information about a drop with fluid density of 1.24 kg/m^3. Choose a density above and beneath this value and repeat the above dropping procedures!

18) Was your prediction correct? Why or why not?
19) What do you think the simulation would represent if the fluid density became very high (something like 1000 kg/m^3 or above).
20) What do you think the simulation would represent if the fluid density became very low, like 0?

<u>The end of winter is soon, but not soon enough!</u>

Now for a challenge! You will now use the real-world simulator (the one with air resistance) to "drop" some objects off of the top of building in Chicago. The end goal is to see how dangerous falling ice is during the winter! It is left for you as an exercise to drop a golf ball, a baseball, a basketball and 12 lb (remember to convert!) bowling ball off of the Sears (Willis) tower, the John Handcock tower, or (and all politics aside here…..) the Trump tower!

To do this activity you will need to find the radii and masses of each ball (an estimation is acceptable when an exact number cannot be found!) and the height of the building you have selected. Note: Google and Wikipedia are your friends!

21) With the information on each ball, predict the order of the balls final velocity.

Once you have found the "real" numbers for each ball, plug in the appropriate values into the simulator and let the ball drop.

From the simulation determine when the “change” to the graph occurs to the KE column, and the note down KE’s final value.

Since KE again represents the amount of energy is present due to motion we can use it to find the final speed of our balls (the velocity it would have just before hitting someone on the street!)

$$KE = \frac{1}{2}mv^2$$

Where KE is the number you get from the bar graph (KE column), m is the mass of the ball, and v, is the speed of the ball. Your last task is to determine the final velocity of these four balls!

22) Which ball had the biggest velocity and which the smallest?
23) Using what was learned from the previous section on how radius, mass, and height change affect the fall of a ball with air resistance, give a reasonable explanation as to why each ball has its relative velocity.
24) Which ball do you think is closest to a piece of ice falling in winter? Why?
25) If we wanted a falling piece of ice to be safer (have less energy when it falls), what could be changed. Think of this in terms of what you are able to change in the simulation!

<u>Question for homework:</u>

1) What were the important quantities for how a ball falls without air?
2) What do the two bar graphs tell us happens without air resistance despite the initial conditions?
3) What is the relationship between the distance a ball falls and the time it takes to fall without air?
4) What does being on a less massive object (the moon) do to gravity, and how does it affect how the ball drops?
5) What does being on a more massive object (the other planet) do to gravity, and how does it affect how the ball drops?
6) What quantities changed the starting value of PE?
7) List the qualitative relationships you discovered in the real simulator with air. For example as the radius increases, the time the ball takes to fall………
8) What happens to the ball’s motion after falling for a long time (as indicated by the KE graph) in the real simulator?
9) What quantities do you think affect the final values of KE (and therefore the final speed of the ball) in the real simulator (Hint: you can always pull up the simulator and give it a try)?
10) The real simulator represents how a ball or sphere travels through the air. If we did not want to use a ball, but a different shape, what line of code would you need to edit? Hint: you want to search for a term in this question!
11) Using the last section of this activity, estimate how dangerous you think a dropping piece of ice would be in downtown Chicago. I am looking for just some good estimates here, nothing exact.
12) What are some advantages to using the simulator of a ball dropping as oppose to simply dropping a real ball?

13) Likewise what are some disadvantages to the simulator versus a real ball?

I would ask that you take some time to answer questions 10 and 11, there are many many advantages and disadvantages that can be talked about, so it should not be a one sentence answer. Rather a short paragraph a piece would be ideal! To help, think about actually making all of the changes we did on the computer, and having to make them in the real world. Alternatively, think about all of the complexities that occur in real life that are not represented in the simulator.