Engineering GatorTRAX

Mechanical Engineering Module

Advanced Level

Designed in accordance with Tau Beta Pi MindSET standards

*By **American Society of Mechanical Engineers, University of Florida Chapter, 2009***

CANDY PREDICTION

When looking to predict the number of candies in the container, many components must be taken into consideration. Therefore, we are here today to teach you things that will help you become better at predicting.

Try and predict how many candies are in the container

Now are you here to make an accurate or precise prediction?

VOLUME

Understanding volume is probably the first step to making a better prediction. Volume is defined as the amount of three dimensional space that an object takes up. It can be measured and predicted as well. Objects that look bigger have larger volumes and vice versa, so anyone can see that a candy has a much smaller volume than the container. One thing that might not be as obvious is that the volumes of the candies all together can give you a good estimate of the volume of the container.

Why isn't the sum of the volumes of the candies equal to the volume of the container?

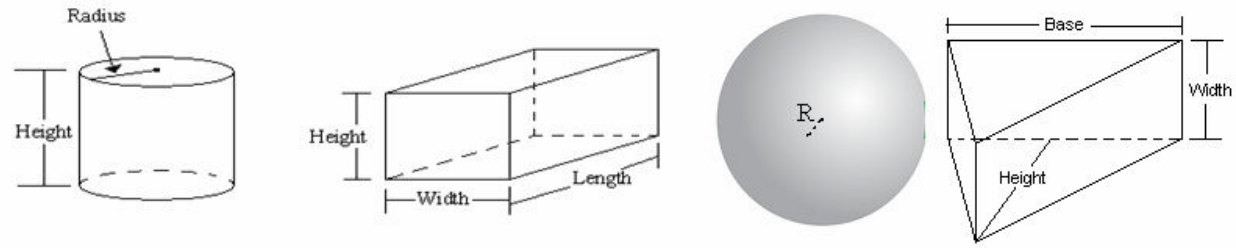
Here are some equations for the volumes of different shapes

Cylinder: $3.14 \times \text{Radius}^2 \times \text{Height}$

Rectangular Prism: Length x Width x Height

Sphere: $4/3 \times 3.14 \times \text{Radius}^3$

Triangular Prism: 1/2 x Base x Height x Width



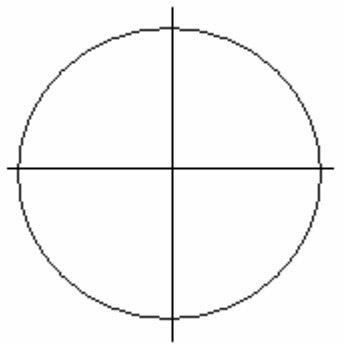
Since all the candies are of a similar shape and size, we can assume that they all have the same volume. Therefore, we can say that the volume that all the candies take up is equal to the volume of a candy times the number of candies. Now, we have an equation brewing! If we were to call the number of candies N, what would be the equation for it?

__N__ = _____ / _____

Pi

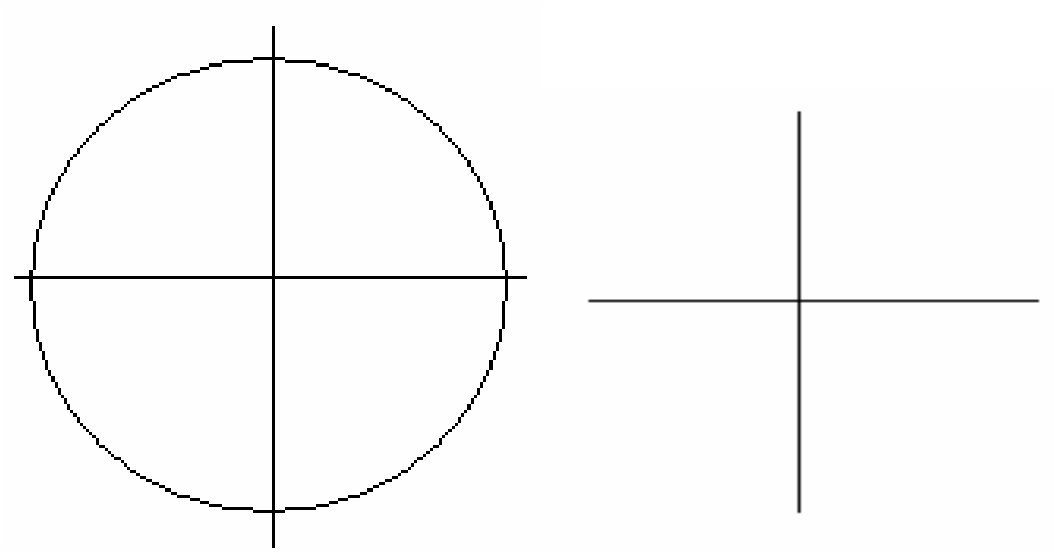
The value of π that is commonly used is 3.14, but what does this really represent? Π is a constant that is used widely to relate a circles circumference to its radius. That is the reason why you would use it to find the circumference of a circle (2πR). The idea behind π is used with angles in the radians scale as well. For instance, the angle many of you know as 90 degrees is also π/2 radians. Multiplying this by 4, we get 360 degrees = 2π. Do you see a connection?

The equation for the circumference is really just 360 degrees times its radius. Try to put the values of angles in radians on this circle. Remember that: $\frac{degrees\ x\ 2\pi}{360}$ = Radians



You have really just completed a unit circle. This is actually called a polar coordinate plane!

Many of you may be very familiar with the Cartesian plane which has an X-axis and Y-axis, but polar coordinates make up a whole different type of plane with different properties. Where the Cartesian plane needs an X and Y value to plot a point, the polar plane needs a radial coordinate and an angular coordinate. For instance, if you want a point on the y-axis that is a distance one from the origin (center), you would just use (0, 1) for a Cartesian plane. For a Polar plane, you would just use (1, $\pi/2$) with 1 being the distance from the origin and $\pi/2$ as the angle. Here is a practice to help you understand.



Plot these points on both graphs and give coordinates.

Cartesian		Polar	
X	Y	R	Angle (radians)
0	1	1	$\pi/2$
1	0		
-1	0		
0	-1		

GET THOSE DIMENSIONS

Now you have the equations, get out there get those dimensions! Remember to try and get very accurate with your measurements, because this will give you a very accurate value for number of candies in the end. Also, try to make out the shapes that you will be working with.

Shape	Measurements Taken

Dimensions in hand, you can now solve for your total volume. Take the volumes you get and add them together. Give it a try.

Shape	Equation for volume	Volume
		+ _____

With these dimensions, it is time to make some calculations. Solve for the number of candies.

__N__ = _____ / _____ =

Another factor that may come into play is the air in the container. Try to find the amount of air in the container, subtract it from the total volume, and redo your calculations.

Finally, it's time to make a prediction! Be sure to recheck your calculations and get as much advice as you can.

PERCENT ERROR

Percent error is something that might show the effectiveness of using mathematical methods to solve everyday problems. It is defined as the difference between an exact value and a predicted one. The equation for it is such follows. Try to figure out your error.

With $V_{predicted}$ as the value you came up with when you first predicted, and V_{actual} as the true value

$$\text{Percent error} = \frac{V_{predicted} - V_{actual}}{V_{actual}} \times 100\% = \frac{\quad}{\quad} \times 100\% =$$

If your value came out to a negative value in your calculator, do not worry. It is because your predicted value was less than the actual value. Simply make your percentage positive.

Now that you have a hold on this, get the percent error for the value you predicted using the concept of volumes.

$$\text{Percent error} = \frac{V_{predicted} - V_{actual}}{V_{actual}} \times 100\% = \frac{\quad}{\quad} \times 100\% =$$

For which did you have less error?

PENNY LAUNCHER

It is now time to apply the concept of percent error to something that is just as fun.

Penny Launchers!

The setup is simple. You can only use rubber bands, popsticle sticks, and tape. The rules and regulations are just as simple:

- Size restriction: 12 x 12 x 12
- Must activate by a release

So the competition this time will stress both accuracy and precision. You and your group will be looking to create a launcher that will make pennies land in the right position, consistently.

VELOCITY

Defined as the rate of change of position, velocity is a type of vector that has both a magnitude and a direction. Mainly, the things you see moving everyday have velocity. Items that move fast like cars have much larger velocities compared to snails which move very slow, having low velocity. Measuring the velocity of an object involves two things. One is a change in position also called a displacement, for instance here to your house. The second is the change in the time that the transition occurred (time it took you to get home). Here is a table to help this all become a little clearer.

Change in position (displacement)	Change in time (time it took)	Velocity
Here to Miami (350 miles)	5 hours	$\frac{350 \text{ miles}}{5 \text{ hours}} = 70$ Miles per hour
From one side of a 12 inch ruler to the other side	2 seconds	$\frac{12 \text{ inches}}{2 \text{ seconds}} = 6$ inches per second
From one end of a football field to the other (100 Yards)	10 seconds	
From floor to the ceiling (14 feet)	2 seconds	
Here to Miami and Back to the same position	10 hours	

Now, it is very easy to confuse the concept of velocity with speed, which is defined as the distance traveled per unit time. The last problem in the table may still confuse you, but this is fine.

The trick is to focus on the change in position. With displacement, you could obtain a negative number, but when you deal with distance you cannot. Therefore, you can have a negative velocity but not a negative speed. Another thing you need to understand is that velocity only cares about the position you are at in the beginning of the time and at the end of it. Displacement is defined as the final position minus the initial position. So in the case of your trip to Miami and back, velocity can care less about what you did along the way. Speed, on the other hand, does take into consideration what you do along the way, so your speed would be calculated thusly:

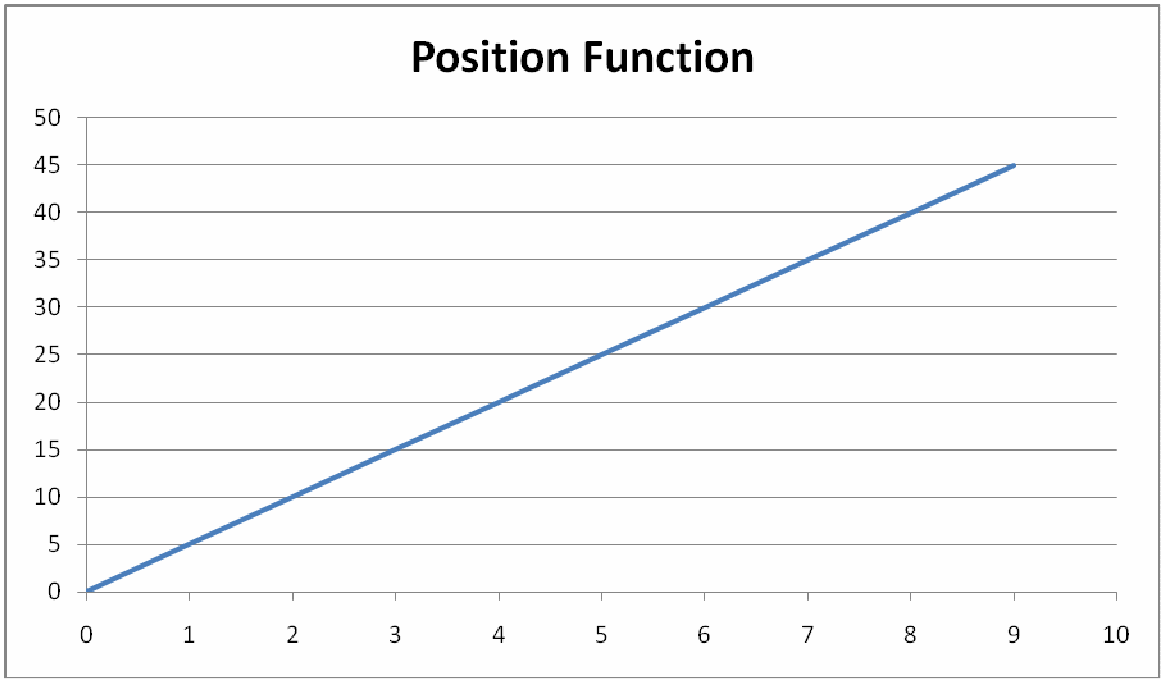
$$\frac{\text{Distance traveled to Miami + Distance traveled back}}{\text{Time it took}} = \frac{350 + 350}{10 \text{ hours}} = 70 \text{ Miles per hour}$$

Now, how can this concept help you build a better launcher?

What would you want to have a large velocity?

Ask some questions

Velocity can also be found by deriving your position function. For example if the position function is y=mx+b, where b is a constant, then your velocity function is y^1= m (first derivative of y). Graphically this is what it looks like:



Here, The y-axis is position in meters and the x-axis is time

Using slope intercept form y=(slope x X) + (y intercept) = mX + B

From this graph, you can see that the slope is 5 and the intercept is 0

So the equation for the line would be:

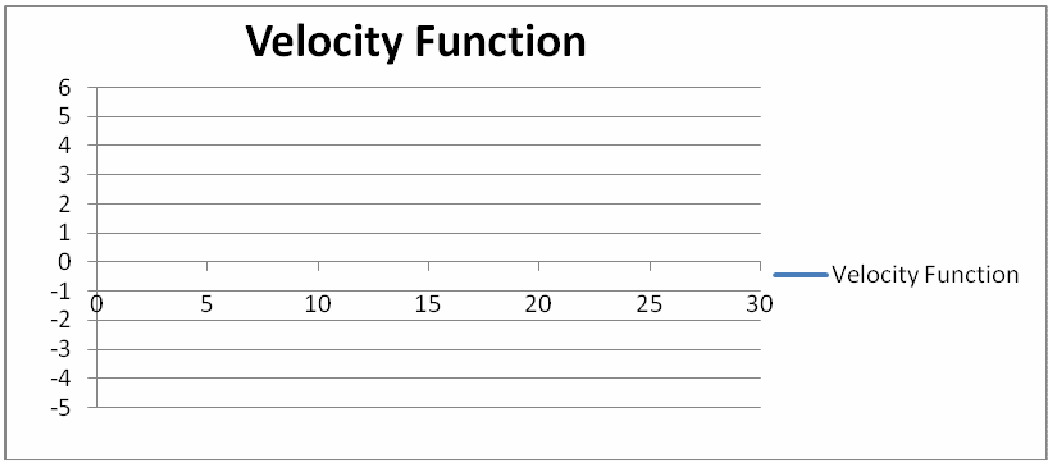
$Y = \square\square\square\square\square\square\square\square\square\square x + \square$

So, the velocity function for this position function would be its derivative

It would be:

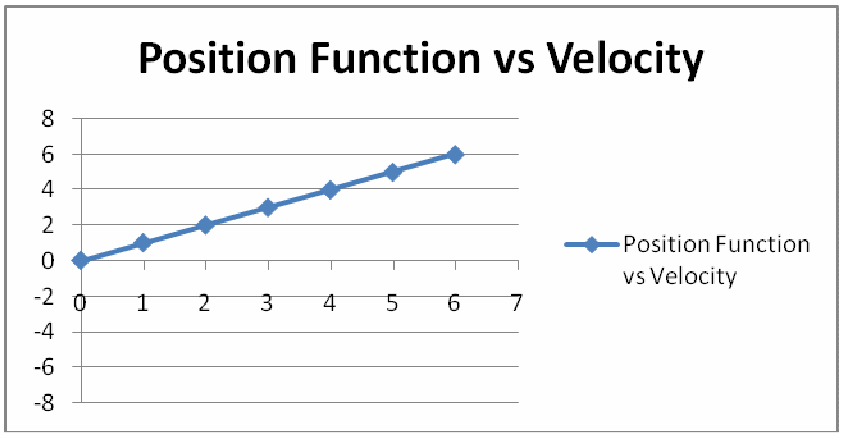
$$Y^1 = \_\_\_\_\_$$

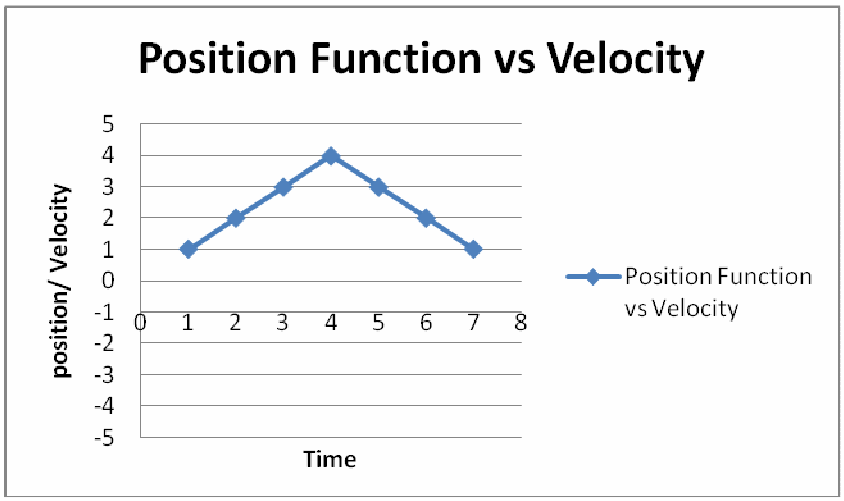
The graph would be:

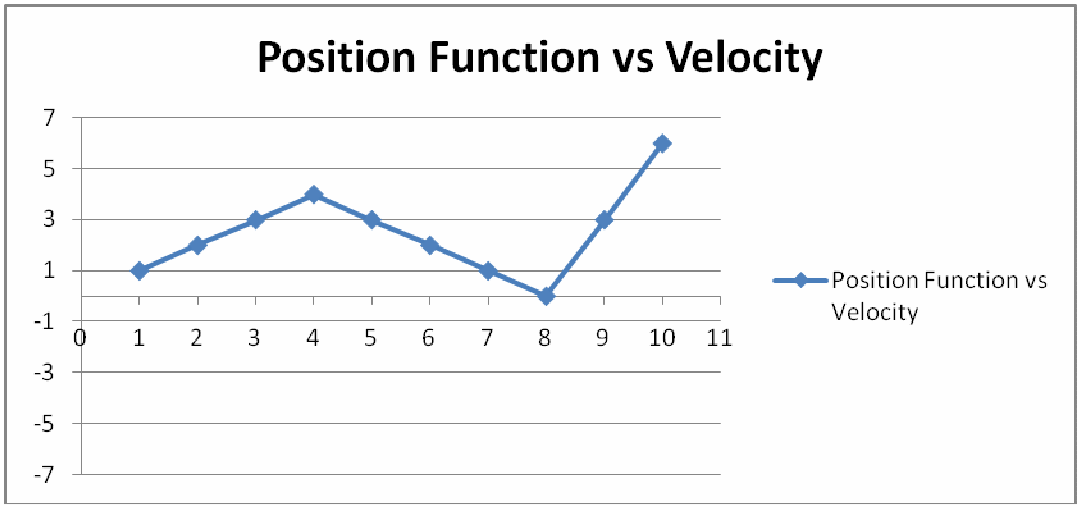


Graphs can describe moving objects.

Try graphing the velocity function of some of these position functions on the same graph. Try to write out their functions as well and discussing what the object is doing.

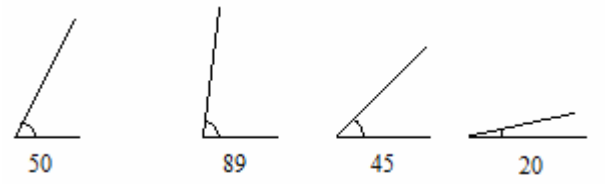






LAUNCH ANGLE

Your penny launcher can be set to shoot in many angles, but which would be the best for getting the furthest horizontally? If you were given a penny launcher that had only one speed setting, what would be the best angle to choose to get furthest?



Pick one, write down, and discuss with others why you think this angle will get you the furthest?