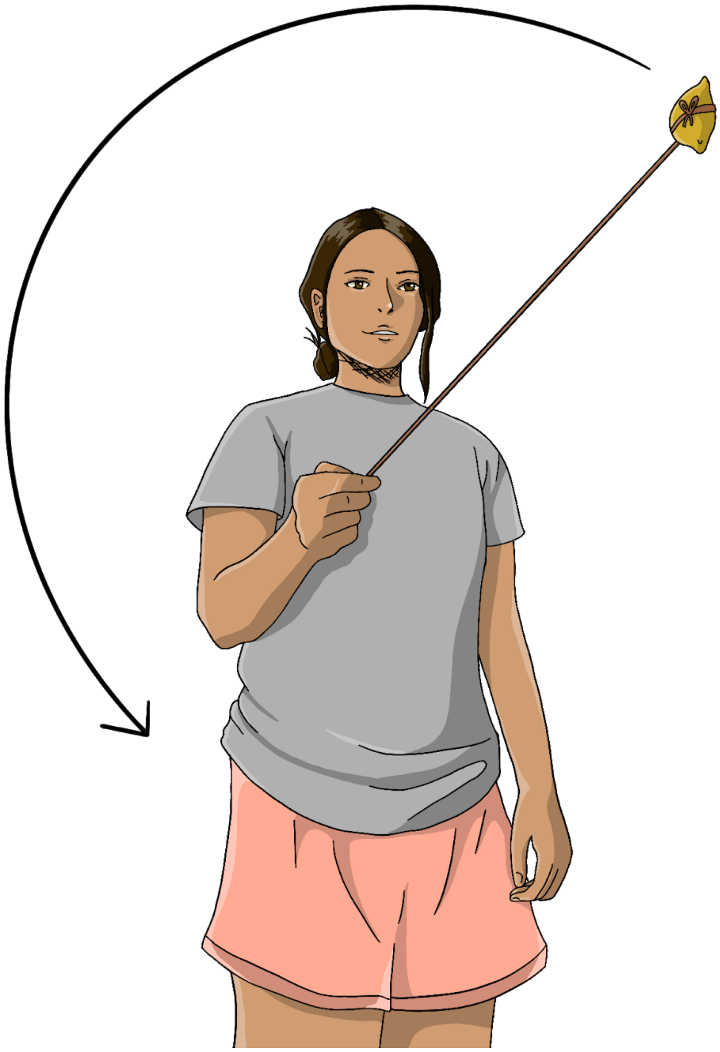

Lab Summary

In this lab, I am shown throwing a lemon with a string tied to it around in a circle. From the experiment, I collected the radius and velocity data and the weight of the lemon. For this experiment, I need to determine at what velocity will tension equal zero at the top of the circle. My experiment already measured the velocity of this; however, I need to compare this with the predicted velocity that I will find. I will use the forces, mass, and radius of the circle to calculate the predicted velocity of the top and bottom of the circle. Using the predicted highest and lowest velocities, I can average them, which will give me the average predicted velocity. I will use this velocity and compare it to the real, measured velocity.

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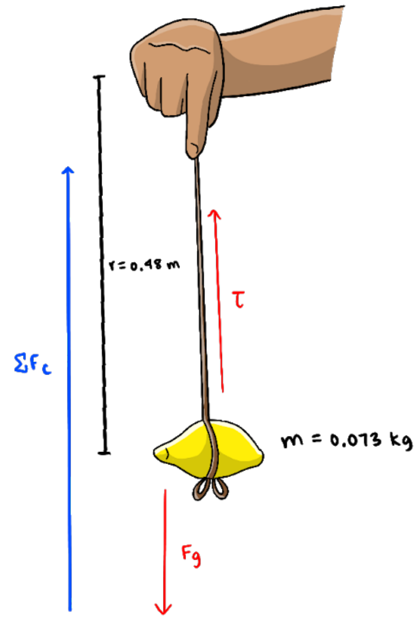


Identifying the variables

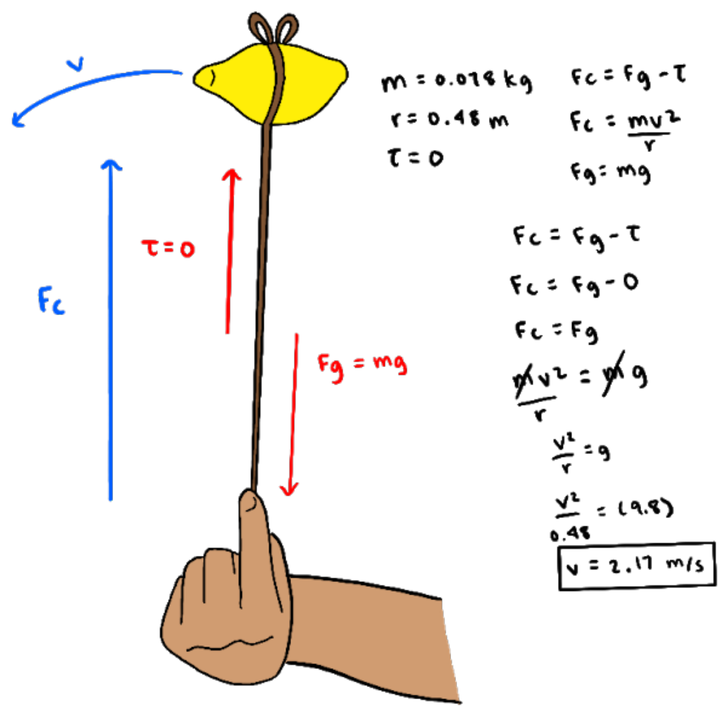
In this experiment, I am holding a lemon, which represents the mass (M), with a measurement of 0.078 kg. The length from the middle of the lemon to the center point of the circle I'm throwing the lemon in represents the radius, with a measurement of 0.48

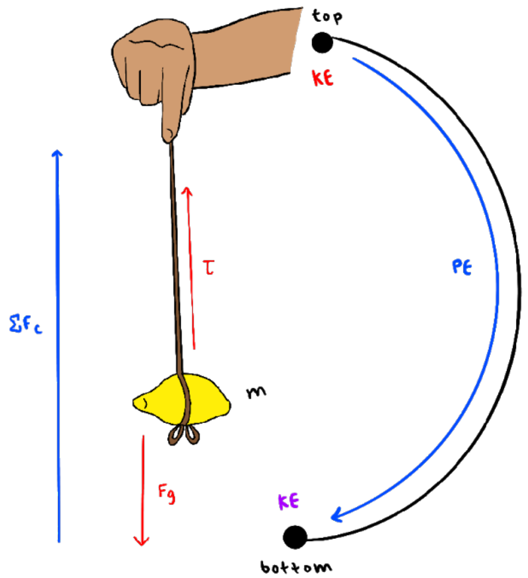
Identifying the forces

There are 2 forces that are acting on the system, the force of gravity (Fg) and the tension (T). The centripetal force (Fc), the sum of the forces, represents the combined force of Fg and T.

Finding the top velocity

To solve for the top velocity, I first need to identify the forces acting on the system. The force of gravity is pulling the lemon down, while the tension is pulling the lemon up; however, the tension must equal zero (which is given). Since the centripetal force (the sum of the forces) equals the force of gravity minus tension, if tension is zero, the centripetal force will equal the force of gravity. Based on the equations Fc = mv^2/r and Fg=mg, I can replace them into the equation to get mv^2/r = mg, and I can solve for v at the top of the circle(velocity). The velocity at the top of the circle was 2.17 m/s.





$m = 0.078$ kg $KE = 1/2mv^2$

$r = 0.48$ m $PE = mgh$

$V_1 = 2.17$ m/s $h = 2r$

$KE + PE = KE$

① $KE = 1/2mv^2$

$KE = 1/2(0.078)(2.17)^2$

$KE = 0.184$ J

② $PE = mgh$

$PE = mg2r$

$PE = 0.078(9.8)2(0.48)$

$PE = 0.734$ J

③ $KE + PE = KE$

$0.184 + 0.734 = KE$

$KE = 0.918$ J

④ $KE = 1/2mv^2$

$0.918 = 1/2(0.078)v^2$

$v^2 = 23.54$

$v = 4.85$ m/s

$$\text{average} = \frac{V_{top} + V_{bottom}}{2}$$

$$= \frac{2.17 + 4.85}{2}$$

average velocity = 3.51 m/s

Finding the bottom velocity

At the bottom of the circle, I will have to use energy equations instead of force equations because the tension doesn't equal zero. To find the bottom velocity, I need to find the total amount of kinetic energy when the lemon is at the bottom of the circle. To do this, I have to first find the kinetic energy at the top of the circle. I can use the equation KE = 1/2mv^2 and input the mass and velocity (I got from the last step) to solve for kinetic energy (KE) (which was o.184 J). The remaining energy comes from potential energy (PE) as the lemon is falling to the bottom. I can find PE by using the equation PE=mgh (h=height which is the diameter) and get 0.734 J for PE. Adding up the top kinetic energy and the potential energy will give me the total kinetic energy at the bottom

Finding the average velocity

To find the average velocity of the lemon, I have to take the average of the top/lowest velocity and the bottom/highest velocity (which are the ones I solved for). The average velocity was 3.51 m/s.

Finding the predicted period

Using the average velocity, I can now find the period of rotation of the lemon by using conversion methods. To convert the meters per second into rotations per minute, I first need to change meters per second into meters per minute (since I want to end up with rotations per minute) by multiplying the velocity by 60. Then to convert it into rotations, I have to divide the meters per minute velocity by 2pir (or multiply by 1/2pir). This gave me 69.8 rotations per minute.

average velocity = 3.51 m/s

$$\frac{3.51\text{ m}}{\text{sec}} \cdot \frac{60}{1} = \frac{210.6\text{ m}}{1\text{ min}} \cdot \frac{1}{2\pi r} =$$

$$\frac{210.6\text{ m}}{2\pi(0.48)} = \frac{69.8\text{ rot}}{\text{min}} \rightarrow \boxed{69.8\text{ rot/min}}$$

Finding actual velocity

Using the opposite methods as the last step, I can use the measured rotations per minute to find the measured average velocity. In the experiment, I measured the period to be 67.5 rot/min. I can then multiply that value by 2pir so it can be converted back into meters. Since this gives me meters per minute, I have to divide the velocity by 60, so it will give me meters per second. The measured velocity was 3.39 m/s.

measured rotations per minute = 1.125 rot/min

$$\frac{67.5 \text{ rot}}{\text{min.}} \cdot \frac{2\pi r}{1} = \frac{67.5(2\pi)(.48)}{\text{min}} = \frac{203.57 \text{ m}}{\text{min}}$$

$$\frac{203.57 \text{ m}}{1 \text{ min}} \rightarrow \frac{203.57 \text{ m}}{60 \text{ sec}} = 3.39 \text{ m/s}$$

Finding percent error

To calculate the percent error, I need to subtract the predicted value from the real or measured value, divide the answer by the measured value, and then multiply the answer by 100. Using the predicted and measured velocity, I found the percent error to be 3.4%. Using the predicted and measured period (rotations per minute), I found that percent error was 3.4% too.

$$\frac{|\text{measured value} - \text{predicted}|}{\text{measured value}}$$

$$100 \cdot \frac{|3.51 - 3.39|}{3.51} = \boxed{3.4\% \text{ velocity error}}$$

$$100 \cdot \frac{|67.5 - 69.8|}{67.5} = \boxed{3.4\% \text{ period error}}$$

Percent error analysis

With a percent error of 3.4, I can say that my experiment was successful. This small error shows that I was able to closely imitate the lab if it were in a perfect world, with no air resistance or other factors affecting the spinning lemon. This also shows that I spun the lemon with the right amount of force and velocity so that the tension at the top could be close to zero.

Conclusions

Overall, I think I did a great job in this lab. I was able to spin the lemon so that the tension of the string at the top of the circle would equal zero. I learned how to calculate the average velocity using the highest and lowest values, which I also learned to solve for, and see if my actual experiment matched the predicted values. I thought this experiment was simple and fun, and I think it helped me to better understand centripetal force.