FRISBEES AND FLIGHT DISTANCE

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INTRODUCTION

The research question I have decided on is:

> What is the effect of frisbee circumference on flight distance, assuming you throw a frisbee at the optimal 10-20 degree angle?

I've always wondered how these frisbees with a hole in the middle of them fly so much farther than normal, conventional frisbees. I want to investigate whether it's the circumference of the frisbee (since these frisbees are usually bigger than the normal ones) or something else to do with lift.

Finding an answer to the relationship between circumference of an object and the aerodynamic capabilities of said object could have hundreds of uses -- not just in aerospace fields, but also perhaps to protect offshore drilling plants from huge waves.

Hypothesis

The circumference of the frisbee will relate to the distance the frisbee travels parabolically, with an optimal circumference for maximum difference and the distance decreasing exponentially as the circumference becomes bigger and smaller than the optimal value.

METHODOLOGY

Once again, my hypothesis is:

The radius of the frisbee will relate to the distance the frisbee travels parabolically, with an optimal radius for maximum difference and the distance decreasing exponentially as the circumference becomes bigger and smaller than the optimal value.

My manipulated variable will be the radius of the frisbee, which will be measured in centimeters with a ruler. For my range of values, I will be using 12 centimeters to 16 centimeters, with 0.5 cm intervals, for a total of 9 manipulations. I will do each of these manipulations for 5 trials. I picked these values due to the radius for the Frisbee that I have used being 12 cm. It is nearly impossible for me to reduce the radius of the frisbee using power tools accurately, so I will just measure the distance the frisbee goes if the radius increases. I expect a decline in distance if the radius gets bigger, since there has to be a reason that all Frisbees are usually the same size. . I am using an architect's ruler, which has a uncertainty of ± 0.025 centimeters, which will be adequate for my measurement. My validity measure is if the responding variable varies dramatically from the expected value in the trial.

My responding variable is the distance that the frisbee flies, measured in meters. I will be measuring it using a meter stick, which has an uncertainty of ± 0.1 centimeters. To help keep the responding variable safe, I will use a stand for the frisbee to keep the same angle throughout all the trials and use the same pushing motion with my hand to attempt to keep the speed the same. I recognize that the speed of my hand might affect the Frisbee's distance, and will account for variations in hand speed with uncertainty.

My controlled variables are:

- Angle that the frisbee flies; if the angle differs drastically, the distance the frisbee flies differs equally as drastically, since a Frisbee's flying distance is dependent on the amount of air lift beneath it, which is changed by the angle. I will try to keep the angle the same by using a ramp to launch the frisbee from. Since the ramp is unlikely to change angles in the space of a few trials, I will measure the angle of the ramp every four trials with a protractor.
- The wind speed; if the wind differs drastically, the distance the frisbee flies will differ equally as drastically, since a Frisbee's flying distance is dependent on the amount of air lift beneath it, which is changed by the wind speed. I will try to keep the wind speed the same by conducting the experiment on a calm day, and waiting until I can feel no wind to start a trial.

- The hand speed; if the hand speed differs drastically, the distance the frisbee flies will differ equally as drastically, since a Frisbee's flying distance is dependent on the speed at which it is launched. I will try to keep the speed the frisbee is launched at the same by using the same hand motion, and attempting to keep the speed the same. I have no way to verify that I am using close to the exact same speed for each trial, so I will have to eyeball it.

MATERIALS

- A frisbee with radius 12 cm.
- A ruler to check the radius of the frisbee
- A meter stick to check the distance of the frisbee
- A wooden ramp with an incline of approximately 15 degrees, measured with a protractor
- Paper, scissors, and tape
- An assistant to measure where the frisbee touches down

PROCEDURES

1. You will need a wide open space for this experiment. Set the frisbee at the bottom of the ramp and clear space up for the trajectory of the frisbee.
2. With one smooth motion, push the frisbee off the ramp, putting your hand on the top of the frisbee. Make sure your assistant is ready to mark down the exact place where the frisbee touches the ground.
3. Measure the distance the frisbee travels from the ramp to the place it touches down with the meter stick and record the value.
4. Repeat steps 2 and 3 four more times.
5. Use scissors to cut out a hollow circle with that has a border radius of 0.5 inches. Tape this to the outside of the frisbee.
6. Repeat steps 2-4.
7. Repeat steps 5 and 6 7 more times, each time adding a circle to the outside of the frisbee.

SAFETY

As you are throwing objects,you are recommended to wear goggles while doing this experiment. Additionally, makes sure that the area around the Frisbee's flight path is clear of people and objects.

DATA COLLECTION

Table I

Radius (± 0.025 cm)	Distance (± 0.1 cm)	Radius (± 0.025 cm)	Distance (± 0.1 cm)
12.00	263	14.00	365
	269		367
	259		368
	274		361
	246		366
12.50	294	14.50	358
	286		356
	297		359
	296		354
	303		355
13.00	328	15.00	349
	334		351
	367		347
	326		348
	330		349
13.50	352	15.50	340
	356		341
	347		338
	379		339
	353		339

The Effect of Radius of Frisbee on Distance

Table II

Radius (± 0.025 cm)	Distance (± 0.1 cm)	Radius (± 0.025 cm)	Distance (± 0.1 cm)
12.00	262	14.00	365
12.50	295	14.50	356
13.00	337	15.00	349
13.50	357	15.50	339

Average Effect of Radius of Frisbee on Distance

Sample Calculation for Average Distance

The sample we will use is the average distance the frisbee traveled when the frisbee radius was 13.00 centimeters.

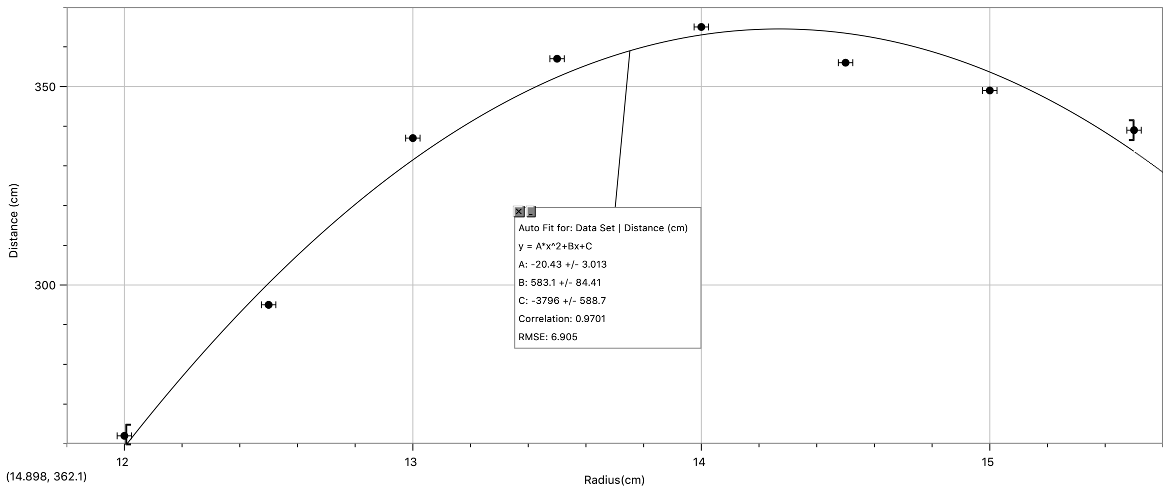
1. Identify any outliers.

   From this sample size, I can see that 3.67 is an outlier in this sample, so I will not consider that value while calculating the average.

2. Calculate the average.

$$\frac{328+334+326+330}{4} = \boxed{337}$$

Graph I

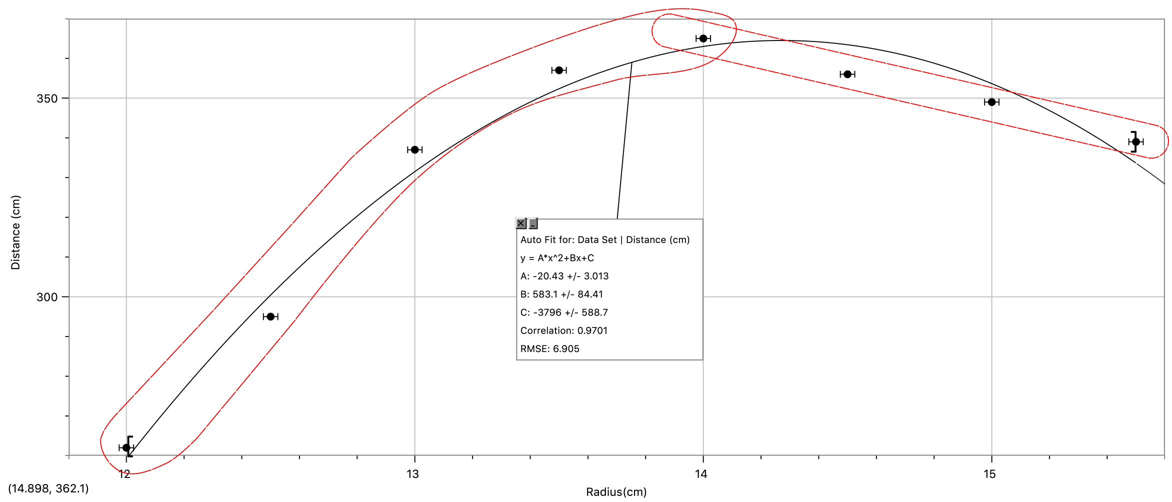


Frisbee Distance vs. Frisbee Radius

I used a quadratic curve of best fit since it seemed that a linear fit would not be adequate for measuring the correlation between distance and radius. My quadratic curve of best fit is

$$y = -20.43x^2 + 583.1x - 3796$$

However, on closer inspection, it appears that the graph is divided into two parts. The points from 12 cm to 14 cm are arrayed in an increasing logarithmic curve, whereas the points from 14 cm to 15.5 cm are arrayed decreasing linearly.



Therefore, it is most optimal to simply linearize the points from 12 cm to 14 cm and leave the rest of the points be.

Table III

Radius (± 0.025 cm)	Distance^2 (cm)
12.00	68644 ± 41.1864
12.50	87025 ± 52.215
13.00	113569 ± 68.1414
13.50	127449 ± 76.4694
14.00	133225 ± 79.935

The Effect of Radius of Frisbee on Distance^2

Sample Calculation for Distance^2

1. Square the distance.

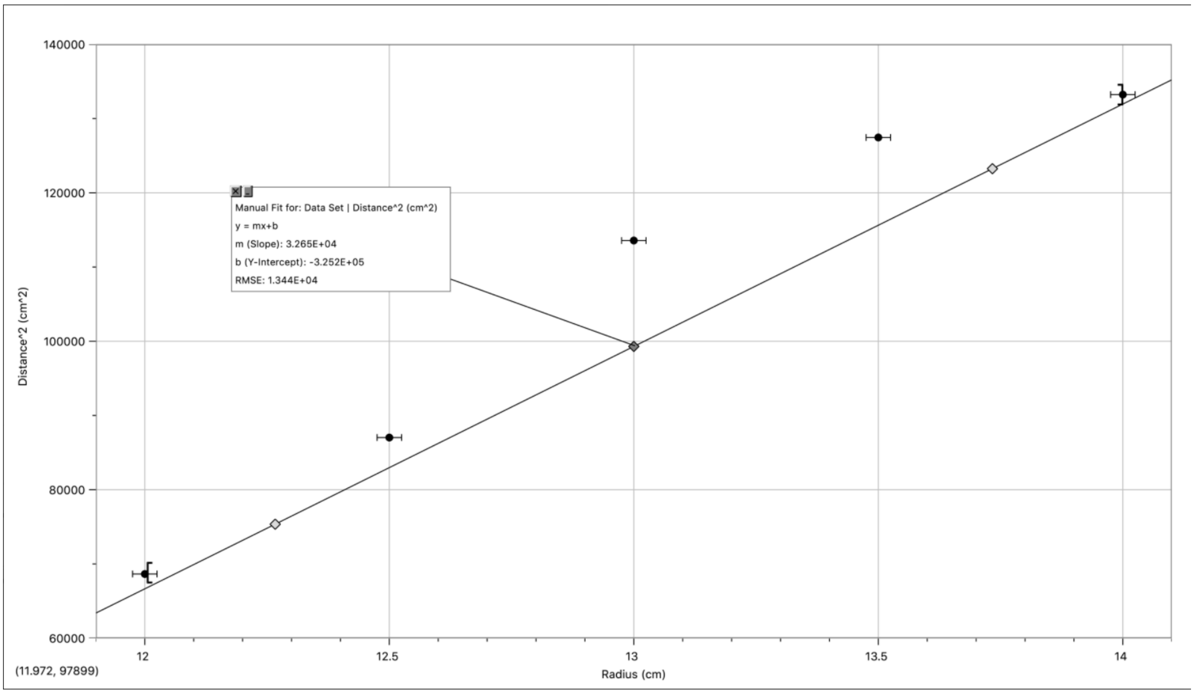
$$262^2 = \boxed{68644}$$

2. Calculate the relative uncertainty by adding the relative uncertainties together and then calculate the real uncertainty by multiplying the calculated relative uncertainty by the square of the distance.

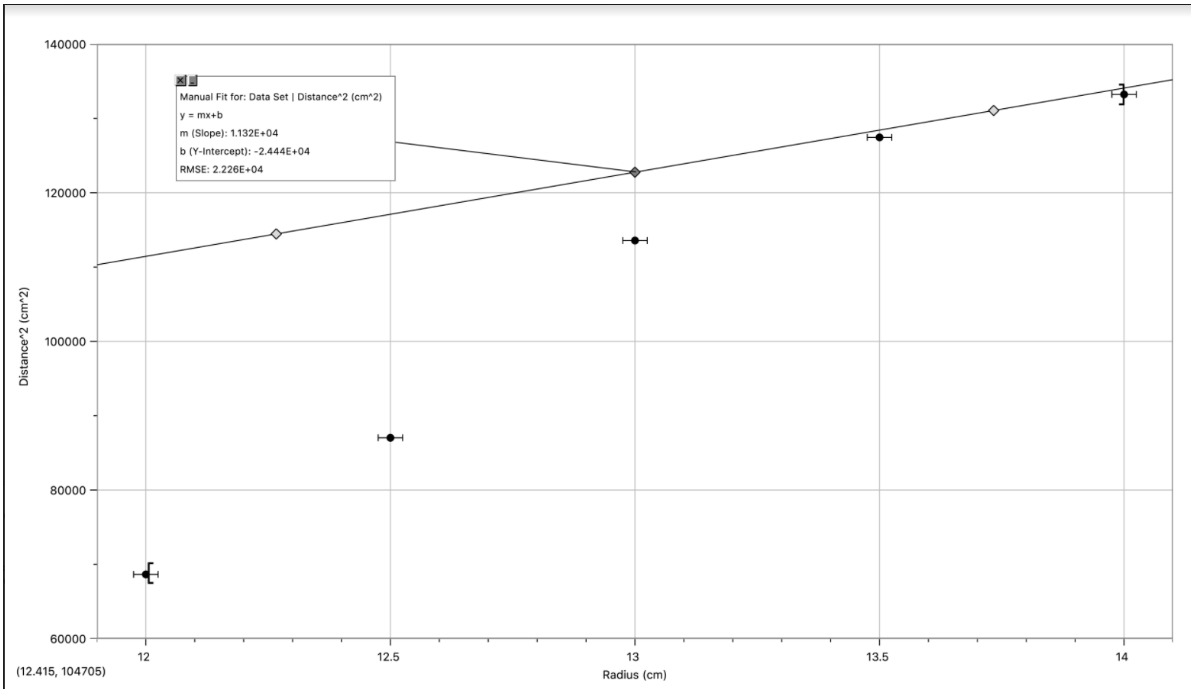
$$\left[\left[\frac{0.1}{262}\right] \cdot 100\right]^2 = 0.06\ \%$$

$$0.06\% \ \cdot 68644 = \boxed{41.186}$$

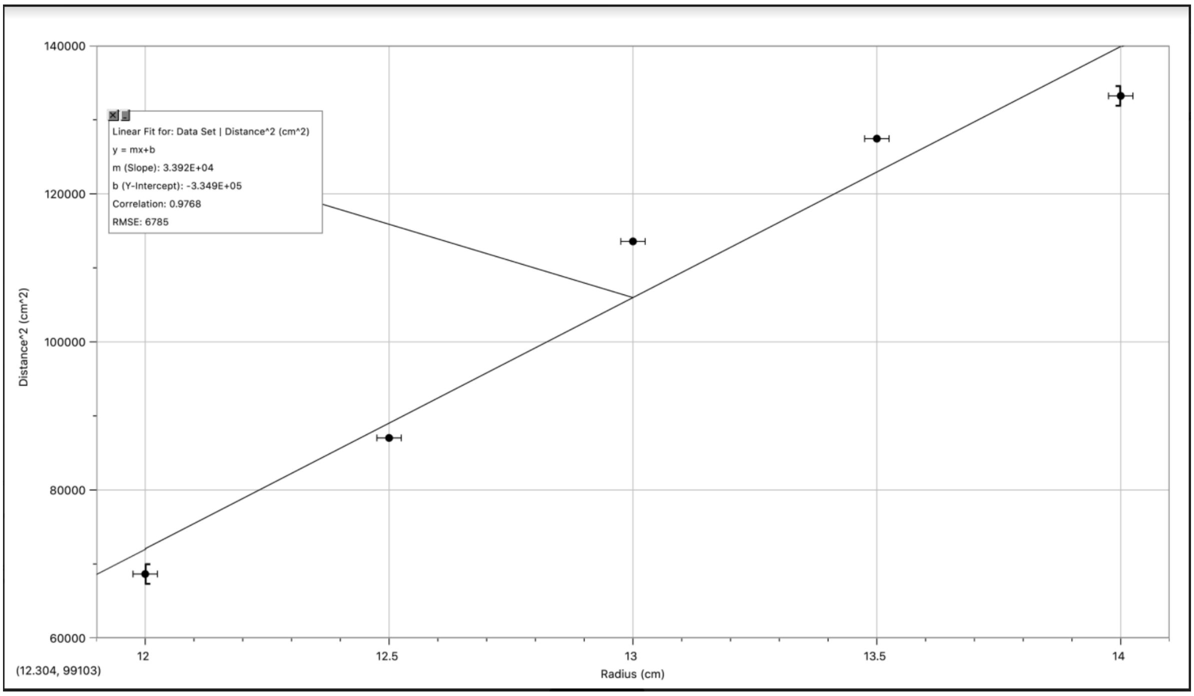
Graph II



Manual Fit for: Data Set | Distance^2 (cm^2)
y = mx+b
m (Slope): 3.265E+04
b (Y-Intercept): -3.252E+05
RMSE: 1.344E+04
Distance^2 (cm^2)
Radius (cm)
(11.972, 97899)
140000
120000
100000
80000
60000
12
12.5
13
13.5
14



Manual Fit for: Data Set | Distance^2 (cm^2)
y = mx+b
m (Slope): 1.132E+04
b (Y-Intercept): -2.444E+04
RMSE: 2.226E+04
Distance^2 (cm^2)
Radius (cm)
(12.415, 104705)
140000
120000
100000
80000
60000
12
12.5
13
13.5
14



Frisbee Distance² vs Frisbee Radius less than 14 cm

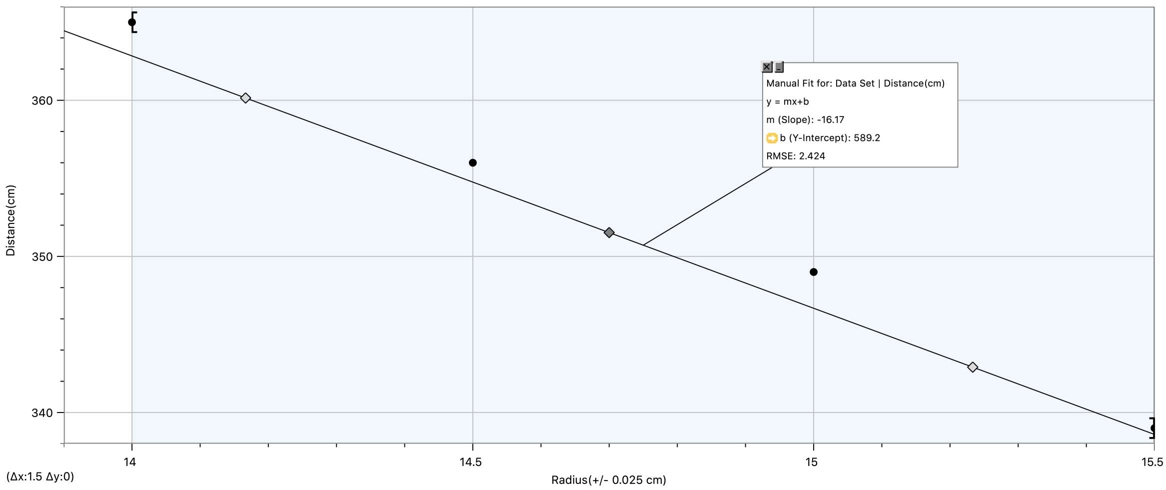
The line of best fit for these 5 points that I calculated was

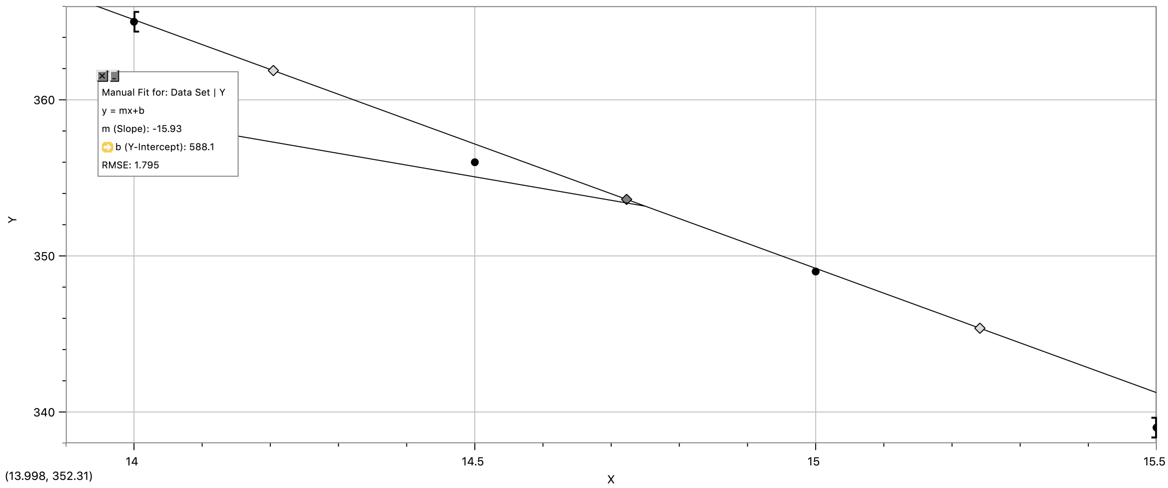
$$y = (3.392 \times 10^4)x - (3.349 \times 10^5)$$

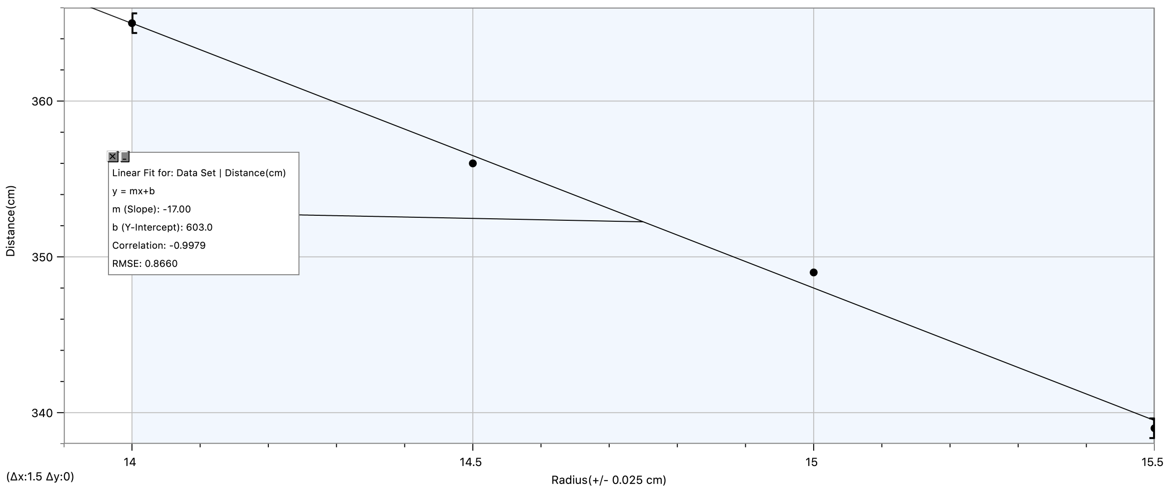
The slope has an uncertainty of about 1.0665×10^4. I calculated this by calculating the difference between the maximum and minimum slopes and dividing by 2.

However, we should take into account the other 3 points on the graph.

Graph III







Frisbee Distance vs Frisbee Radius greater than 14 cm

The line of best fit for these 3 points that I calculated was

$$y = -17x + 603$$

I calculated the uncertainty as 0.12, calculating the difference between the minimum and maximum slope and dividing by 2.

Conclusion

Therefore, in conclusion, the optimal radius of a frisbee for maximum distance is about 14 inches. Before 14 inches, the distance the frisbee travels approximately follows a positive logarithmic curve as the radius increases. After 14 inches, the distance the frisbee travels decreases by approximately 17 centimeters as the radius increases 1 centimeter.

My hypothesis was half right -- the frisbee does follow a negative parabolic arc in terms of distance vs radius until 14 centimeters, but then decreases linearly rather than exponentially after 14 centimeters.

Possible improvements I could make to the procedure include:

- Making a way to keep the speed at which the frisbee launches consistent, like a pulley or motor that moves at a constant speed that can be controlled
- Performing the experiment in a completely controlled environment with no wind to affect the frisbee's flight distance
- Having more manipulations of the data -- e.g. more radii