Height of the Rocket determined by the Water Pressure

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Background:

What am I able to do to make this go higher? That is a question I am constantly thinking of when it comes to things going up. By doing my research around a water rocket where I am able to alter the height of the rocket by changing the amount of water within the rocket I am able to come to a conclusion on the effects .

What are the backgrounds and origin of rockets? I decided to investigate the origin of the rocket to gain further knowledge. The first rockets made were created by the Song Chinese dynasty and were used against the mongols. These were the earliest rockets and served to shoot arrows at further distances. A rocket by definition according to oxford languages is “a cylindrical projectile that can be propelled to a great height or distance by the combustion of its contents, used typically as a firework or signal”[1]. Which means that rockets can have many different forms such as the rockets that we have manufactured and perfected to take man to the moon. But that as well includes something as little as a water rocket.

A water rocket works as you pump air into the rocket. The air is seeking to expand as you pump more into it. However the rocket can only take in so much air due to the water taking up volume within the rocket. As the air has no place to exit the bottle and the only access point is the

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bottom. The air is constantly pushing the water down as it tries to escape, increasing the overall pressure within the rocket. Once the pressure in the rocket no longer can spread it begins to push the water as the air tries to escape. This makes the rocket expel the water out as it comes out the rocket at a speed that propels the rocket upward.

The purpose of this investigation will focus on how the amount of water determines the height of the launch. The independent variable for this investigation is the amount of water that goes in the rocket. The dependent variable is the height of the rocket. The controlled variable is the size of the rocket.

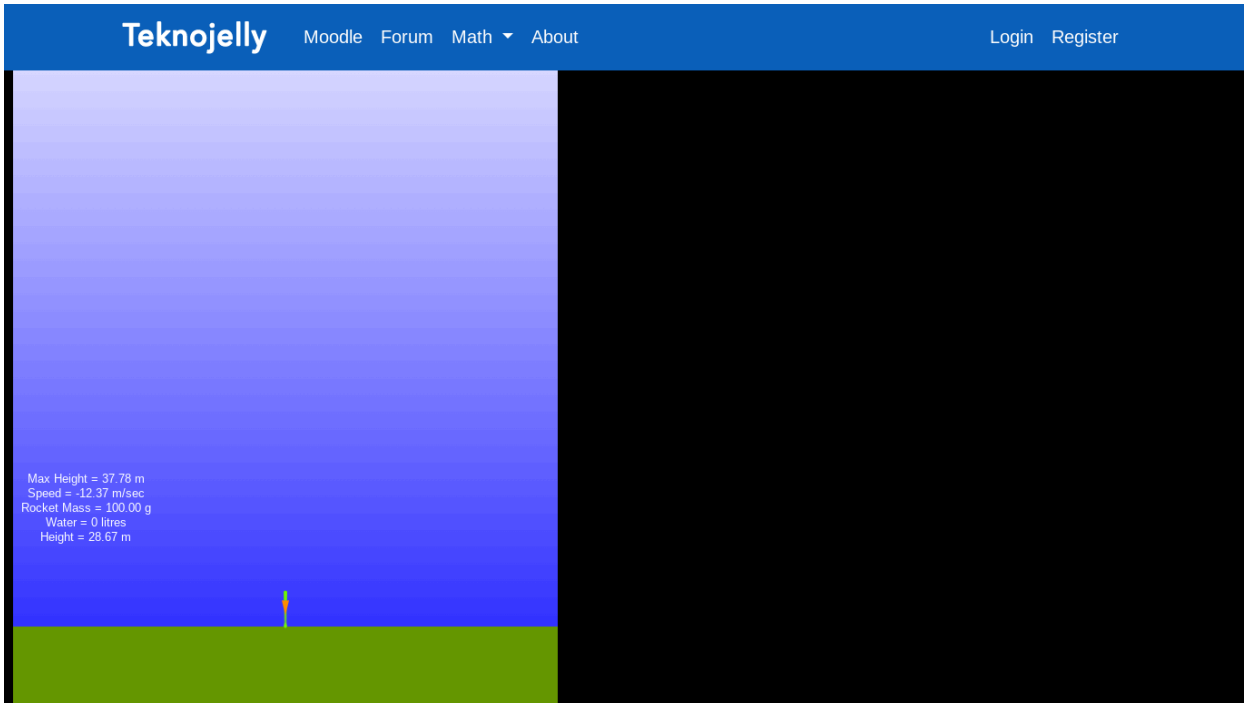
Hypothesis:

I believe that rocket height will increase as there is more water in the rocket due to the reason that there is less room for the air to expand making the rocket launch faster and higher.

Materials:

I initially intended to acquire my data using a rocket I bought online, although due to unfortunate weather conditions I had to resort to using an online simulator by teknojelly . The volume of the container for the rocket was 2.144 liters. I changed the volume of water within the container while keeping everything else the same.

Diagram:



Method:

I began my experiment by finding a simulator which provided different points of the graph. My process to acquire my data I first decided the volume of the rocket I wanted to use. I decided to use a 2.144 L container for all my trials. For the amount of water used I began by using .042 liters which was 2.5% of the container. I then would launch the rocket while gaining data of the maximum

height. I would increase the percent by 2.5% all the way up to 60% repeating the trials. By doing 5 trials by variable it allowed me to gain more accurate data.

Risk Factor:

The only form of harm that was present was when trying to get my original data with the physical rocket as there was a risk of somebody getting hit on the head.

Data and analysis

DATA FILE

Data table 1: Raw data of 5 trials for 24 variations

%of water/ml	x	trial 1	trial 2	trial 3	trial 4	trial 5
2%(42.88) ml	1	1.69	2.71	1.23	3.03	2.65
5%(107.2) ml	2	8.56	3.92	3.68	4.02	8.42
7%(150.8) ml	3	7.78	12.31	7.01	11.38	10.01
10%(214.4)ml	4	9.18	10.26	10.44	10.62	10.51
12%(257.28)ml	5	15.98	16.32	16.84	12.04	13.26
15%(321.6)ml	6	13.28	17.62	12.57	13.78	18.26
17%(364.48)ml	7	19.93	20.92	21.43	19.99	17.63
20%(428.8)ml	8	20.69	21.03	19.23	21.10	18.41
22%(471.68)ml	9	20.21	24.74	20.19	21.97	17.73
25%(536)ml 10	10	23.62	19.92	24.64	24.42	25.19
27%(578.88)ml	11	21.62	21.65	26.78	25.65	24.18
30%(643.2)ml	12	28.59	28.07	22.79	23.75	22.27
32%(686.08)ml	13	26.23	28.92	26.98	25.19	29.73
35%(750.45)ml	14	25.68	25.42	26.93	22.63	22.78
37%(793.28)ml	15	25.93	26.19	24.52	29.82	30.70
40%(857.6)ml	16	29.90	27.46	25.97	31.40	29.00
42%(900.48)ml	17	27.36	29.19	31.88	32.54	31.34
45%(964.8)ml	18	31.18	34.34	31.65	28.65	33.39
47%(1007.68ml	19	30.01	28.63	28.76	29.89	31.26
50%(1072)ml	20	30.78	34.29	31.68	30.44	35.69
52%(1114.88ml	21	32.56	34.68	34.11	29.48	32.56
55%(1179.2)ml	22	31.73	36.43	31.17	36.46	30.07
57%(1222.08ml	23	34.08	31.19	32.65	33.43	38.40
60%(1286.4)ml	24	32.06	35.78	34.58	31.78	34.28

In the data table I recorded my raw data where I did 5 trials for each variable of the launch. In the first variable I began with 2% of the rocket filled with water and gradually increased it by 2-3%. I repeated

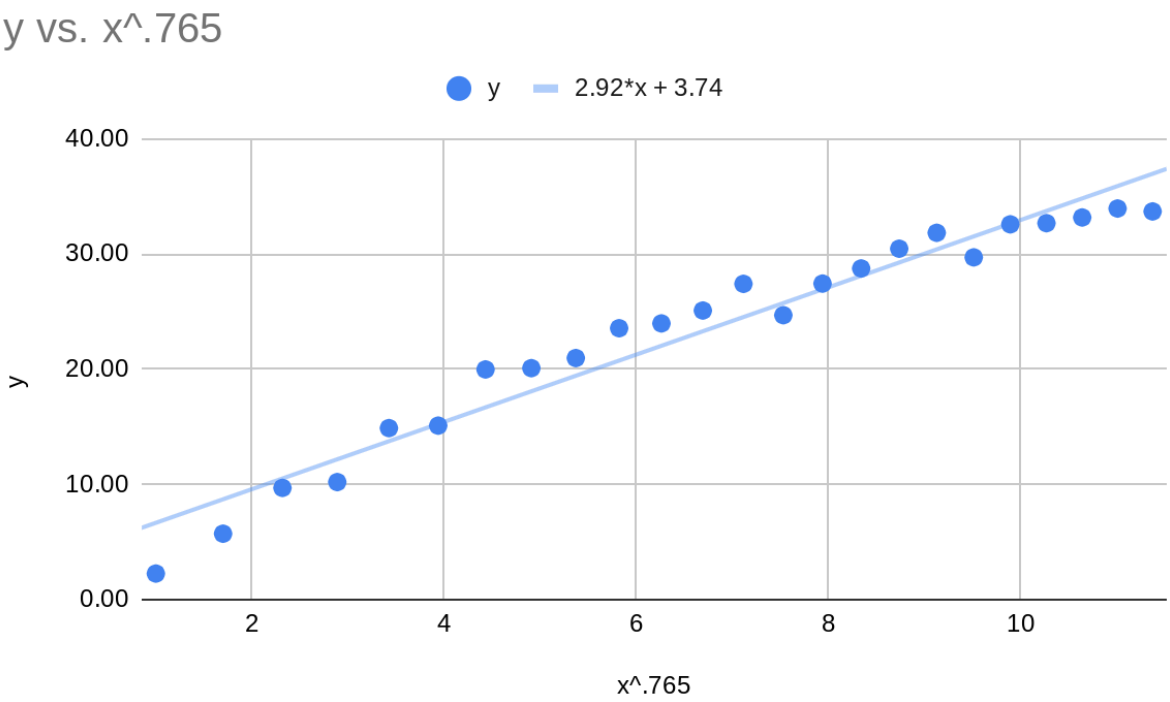
this process for 24 variables. This would give me more data points which would give me more analysis.

Data table 2:

%of water/ml	x	trial 1	trial 2	trial 3	trial 4	trial 5	avg	uncty
2.5%(42.88) ml	1	1.69	2.71	1.23	3.03	2.65	2.26	0.90
5%(107.2) ml	2	8.56	3.92	3.68	4.02	8.42	5.72	2.44
7%(150.8) ml	3	7.78	12.31	7.01	11.38	10.01	9.70	2.65
10%(214.4)ml	4	9.18	10.26	10.44	10.62	10.51	10.20	0.72
12%(257.28)ml	5	15.98	16.32	16.84	12.04	13.26	14.89	2.40
15%(321.6)ml	6	13.28	17.62	12.57	13.78	18.26	15.10	2.85
17%(364.48)ml	7	19.93	20.92	21.43	19.99	17.63	19.98	1.90
20%(428.8)ml	8	20.69	21.03	19.23	21.10	18.41	20.09	1.35
22%(471.68)ml	9	20.21	24.74	20.19	21.97	17.73	20.97	3.51
25%(536)ml	10	23.62	19.92	24.64	24.42	25.19	23.56	2.64
27%(578.88)ml	11	21.62	21.65	26.78	25.65	24.18	23.98	2.58
30%(643.2)ml	12	28.59	28.07	22.79	23.75	22.27	25.09	3.16
32%(686.08)ml	13	26.23	28.92	26.98	25.19	29.73	27.41	2.27
35%(750.45)ml	14	25.68	25.42	26.93	22.63	22.78	24.69	2.15
37%(793.28)ml	15	25.93	26.19	24.52	29.82	30.70	27.43	3.09
40%(857.6)ml	16	29.90	27.46	25.97	31.40	29.00	28.75	2.72
42%(900.48)ml	17	27.36	29.19	31.88	32.54	31.34	30.46	2.59
45%(964.8)ml	18	31.18	34.34	31.65	28.65	33.39	31.84	2.85
47%(1007.68ml	19	30.01	28.63	28.76	29.89	31.26	29.71	1.32
50%(1072)ml	20	30.78	34.29	31.68	30.44	35.69	32.58	2.63
52%(1114.88ml	21	32.56	34.68	34.11	29.48	32.56	32.68	2.60
55%(1179.2)ml	22	31.73	36.43	31.17	36.46	30.07	33.17	3.20
57%(1222.08ml	23	34.08	31.19	32.65	33.43	38.40	33.95	3.61
60%(1286.4)ml	24	32.06	35.78	34.58	31.78	34.28	33.70	2.00

From the data acquired from the rocket then was used to find and calculate the average height of the rocket. For example to find the first variable I did $\frac{1.69m+2.71m+1.23m+3.03m+2.65m}{5} = 2.62m$ which was the average for the first variable.

To find the uncertainty is $\frac{max-min}{2} = uncty$. Such as the uncertainty for the first variable looked like $\frac{3.03-1.23}{2} = 0.9.$ The process is then repeated until we get all the averages and uncertainties.



The more water pumped inside the correct the higher the rocket will travel upwards. Due to finding the height of the rocket i used the equation $S = ut + \frac{1}{2}at^2$. As we are trying to find the

final height of the rocket this calculation allows us to find the final height of the rocket. We will have to use the equation $P_1 \cdot V_1 = P_2 \cdot V_2$ which helps us find the pressure within the rocket before and after and while the volume inside stays the same. $PV = nRT$ The reason for this calculation is due to us finding the amount of air required to be pumped before it launches.

Evaluation:

As shown in the data I acquired it appears that the rocket with more water traveled higher due to the lower volume for the air making it want to leave the rocket sooner making the rocket launch propel itself higher.

My hypothesis did turn out to be correct to some extent. When acquiring my data physically my rocket traveled higher the less water was within the rocket. However when i was doing the online option for the simulation the rocket traveled higher when there was water in the rocket.

If i were to do this experiment once again something I would do differently would have to be getting the data with a physical rocket which was the way i initially intended to acquire my data. However, that was not the case as the weather did not allow me to do that.

The simulation I used was not alway precies and at times it would glitch meaning i had to restart the simulation and change the settings for it.

Related Links:

https://www.freedrinkingwater.com/blogs/water-health/8-water-pressure#:~:text=Water%20pressure%20is%20the%20measure,water%20falls%20down%20the%20waterfall.- This link mentions how water pressure works
https://openstax.org/books/chemistry-2e/pages/9-2-relating-pressure-volume-amount-and-temperature-the-ideal-gas-law#:~:text=Decreasing%20the%20volume%20of%20a,same%20factor%2C%20and%20vice%20versa.- This Source mentions the affect of volume and other aspect that affect volume.
https://www.grc.nasa.gov/www/k-12/rocket/BottleRocket/about.htm- Water rockets and what are they
https://www.voorhees.k12.nj.us/cms/lib/NJ01000237/Centricity/ModuleInstance/6483/Rocket_Stability_Determination.pdf- the involvement of pressure on the rocket
https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/rocket-aerodynamics/#:~:text=Aerodynamic%20forces%20are%20generated%20and,air%20through%20which%20it%20flies. - the involvement of areodynamics on the rockets.

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Oxford dictionary
https://www.teknojelly.com/math/mathtoolkit/bottle-rocket-simulator/