Project 2.1.4

—Super Cool Paper Rockets—

Principles Of Engineering, 6°
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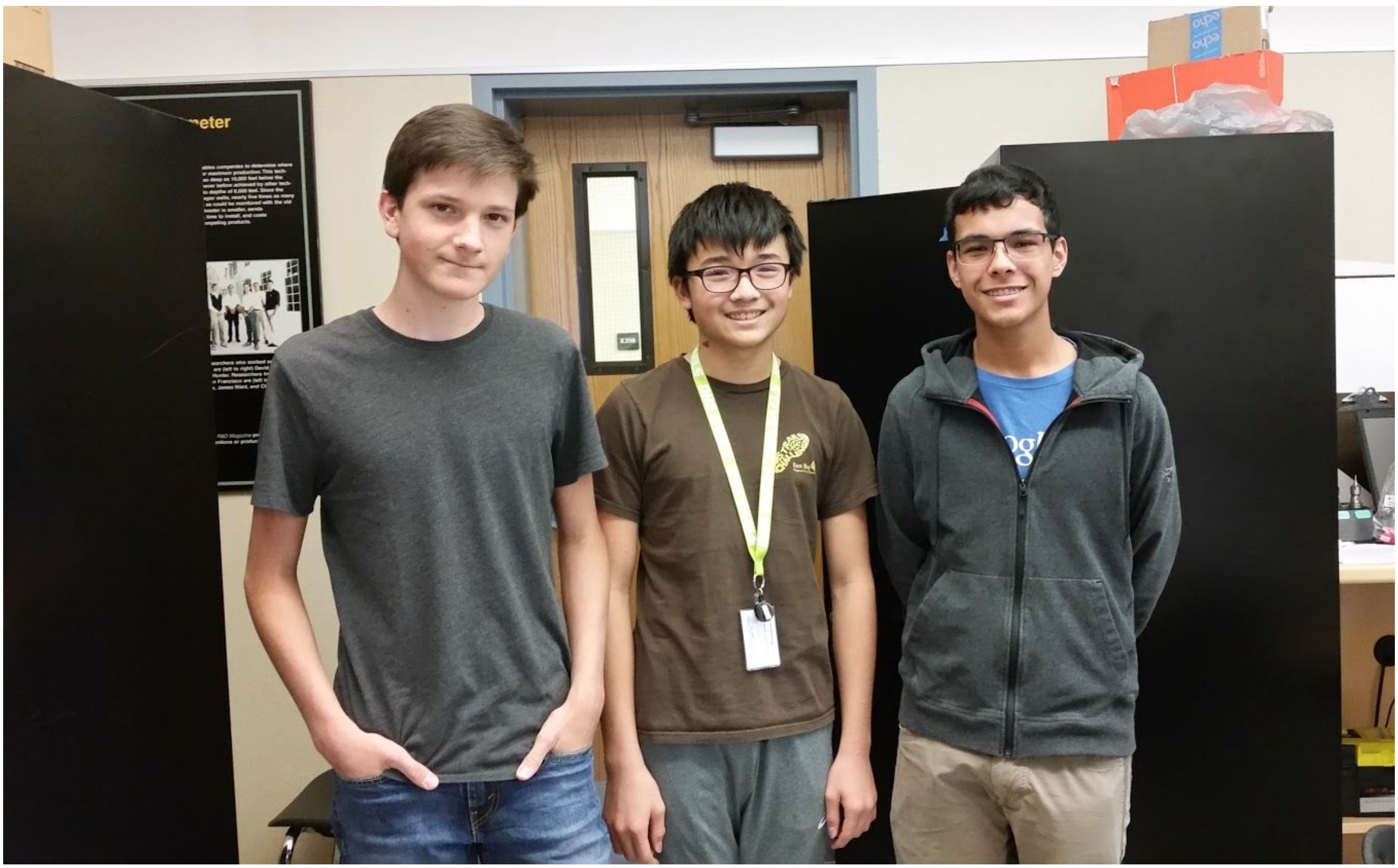
Team Members: Wesley Wong, Noah Boursier, Gustavo Silvera



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Design Brief

Customer	Nitro Planes
Designers	Wesley Wong, Gustavo Silvera, Noah Boursier
Design Problem	We are being tasked to design and test model rockets to serve as children's toys that will go as far as possible when launched from a pressurised launcher.
Constraints	● Must be only paper and tape. ● Fits over 3/4” PVC. ● 10” to 15” in length. ● Wingspan < 24” ● Launched at specific psi and Angle. ● You get to choose angle.
Deliverables	● Documentation outlining design procedure ● Individual Deliverables

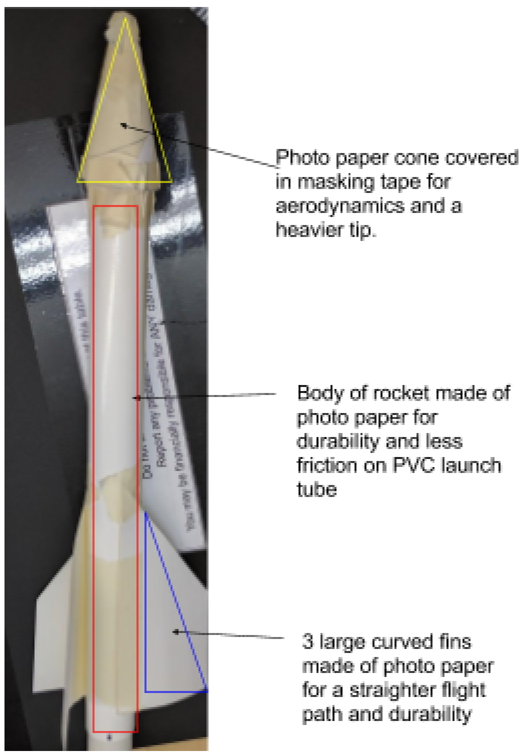
DATA

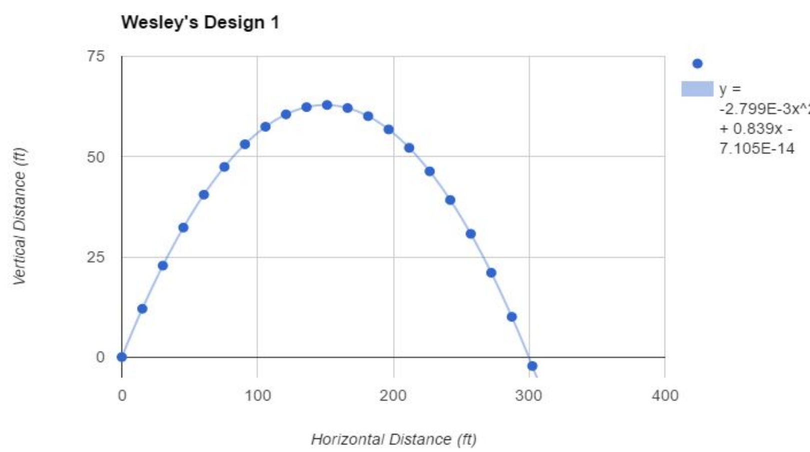
LAUNCH I					
Rocket Name	Degree Launched	Distance	Time in Air	PSI	Initial Velocity
Knome II	40°	26 yards	2.56s	60psi	52.02 fps
Satan III	40°	100 yards	5.16s	60psi	98.73 fps
Spearhead	40°	16 yards	3.09s	60psi	41.88 fps
LAUNCH II					
Rocket Name	Degree Launched	Distance	Time in Air	PSI	Initial Velocity
Cool Beans	40°	150 yards	8.02s	70psi	112.57 fps
Javelin	40°	135 yards	9.2s	70psi	108.15 fps
Wonginator	40°	160 yards	7.31s	70psi	120.92 fps

WESLEY’S FIRST DESIGN

V0 = 98.7 ft/s^2 Angle = 40 degrees

The purpose of this design was to make a more durable yet light rocket that could fly far distances. I used photography paper because of its strength and durability. Also, for the pressure cap, I weaved masking tape to improve the durability of the pressure cap while keeping a nice airtight seal. The reason I chose to use masking tape was because it was easier to cut it into the shape and size needed to attach the various components to my rocket. Also, it is lighter than duct tape and stronger than normal clear tape. To stabilize my rocket, I added 3 stabilizer fins in 120 degree increments around the base of the rocket. To make the flight path straighter, I also curved the fins. This allowed the rocket to fly straight during my trials. It flew a total of **100 yds on 60 psi and 40 degrees.** I launched it at an angle of 40 degrees, and it went high enough into the air to catch on to some wind, which also carried it farther. The curved fins and the size of the fins may have contributed to some drag and as a result would hinder how far my rocket would go.



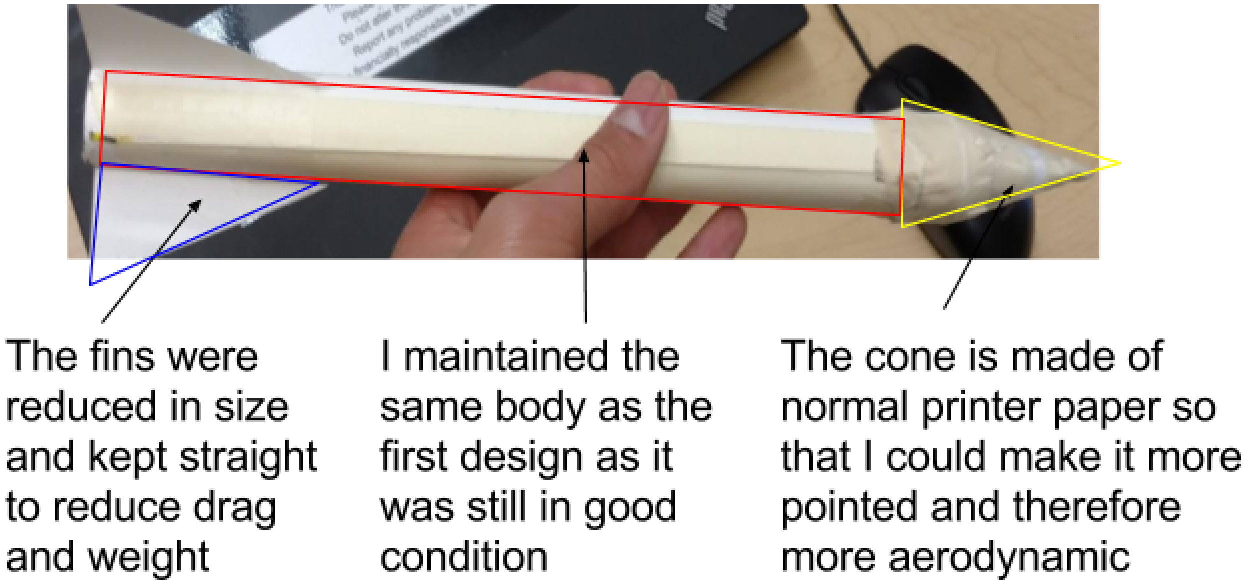


First Design Data

Time	X	Y
0	0	0
0.2	15.12171731	12.04862742
0.4	30.24343461	22.81725483
0.6	45.36515192	32.30588225
0.8	60.48686923	40.51450966
1	75.60858654	47.44313708
1.2	90.73030384	53.09176449
1.4	105.8520212	57.46039191
1.6	120.9737385	60.54901932
1.8	136.0954558	62.35764674
2	151.2171731	62.88627415
2.2	166.3388904	62.13490157
2.4	181.4606077	60.10352898
2.6	196.582325	56.7921564
2.8	211.7040423	52.20078381

3	226.8257596	46.32941123
3.2	241.9474769	39.17803864
3.4	257.0691942	30.74666606
3.6	272.1909115	21.03529347
3.8	287.3126288	10.04392089
4	302.4343461	-2.227451696

WESLEY'S SECOND DESIGN



V0 = 124.3 Ft/s^2
Angle = 40 degrees

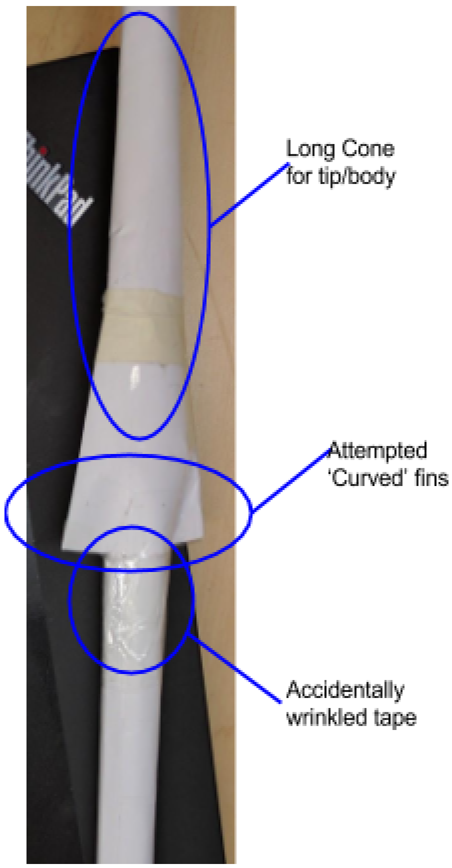
The base tube of this second iteration is the same from my first rocket. The goal was to increase the distance traveled by the rocket by making it more streamlined and have less drag while still maintaining a straight flight path. To do this, I created a new cone of printer paper, as it allowed for a pointier nose, increasing aerodynamics. Also, I made the fins smaller and straight instead of curved, allowing my rocket to be more front heavy and providing the stability needed without adding excessive weight. During testing, this rocket performed extremely well, going to distances of **160 yds on 70 psi.** In addition,
the flight path was straight even without curved fins and the cone held up relatively well.

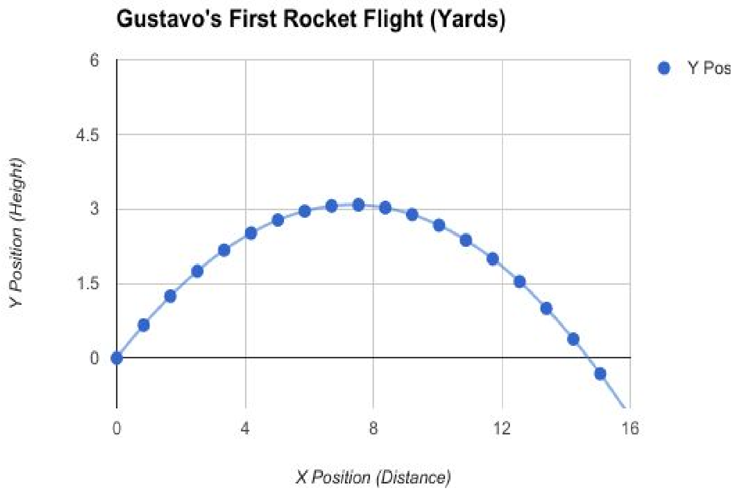
Time	X	Y
0	0.00000	
0.2	19.04386	15.33969998
0.4	38.08773	29.39939995
0.6	57.13159	42.17909993
0.8	76.17546	53.67879991
1	95.21932	63.89849988
1.2	114.26319	72.83819986
1.4	133.30705	80.49789984
1.6	152.35092	86.87759981
1.8	171.39478	91.97729979
2	190.43865	95.79699977
2.2	209.48251	98.33669974
2.4	228.52638	99.59639972
2.6	247.57024	99.5760997
2.8	266.61411	98.27579968
3	285.65797	95.69549965
3.2	304.70184	91.83519963
3.4	323.74570	86.69489961
3.6	342.78957	80.27459958
3.8	361.83343	72.57429956
4	380.87730	63.59399954
4.2	399.92116	53.33369951
4.4	418.96503	41.79339949

4.6	438.00889	28.97309947
4.8	457.05276	14.87279944
5	476.09662	-0.5075005798

GUSTAVO'S ROCKET DESIGNS

Spearhead (1st)



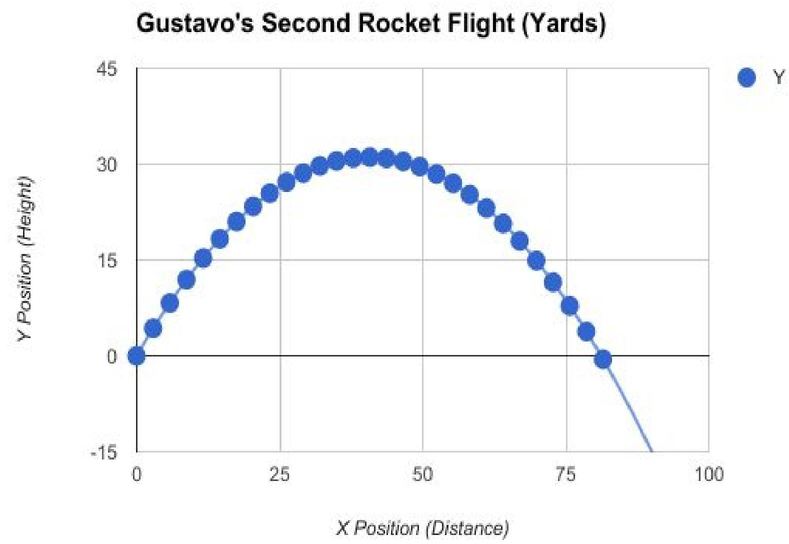


Initial Velocity: sqrt((-gx)/(sin(2Θ))) = sqrt((32*48)/(sin(2*40))) = **39.5 F/s**
Launch Angle: **40° @ 60 psi**
Distance: approx **16 yards**
Time in Air: **3.09 seconds**

The Spearhead, or Dagger, was an initial prototype rocket with an ultimate purpose of experimenting with curves on the projectile, which would theoretically assist with aerodynamics. With this design, the most difficult feature by far was the implementation of the curves with the side wings and cone-like tip. With paper being our primary material, adding perfect curves would be nearly impossible, which was believe the largest factor in having the rocket swerve a bit while in the air, and barely going past 16 yards. Another factor that could have affected the flight of the rocket would be the fact that the tape was not smoother out on the rocket, and it was not at all even, but rather it was quite wrinkly and rugged, which could allow for turbulent air to interfere with a straight path. According to close viewers, the performance of the Spearhead was particularly odd, apparently it curved heavily while flying and these quick shifts of direction caused the rocket to dive nose down into the earth, shortening the flight by a landslide.

Time	X Position	Y Position
0	0	0
0.05	0.8370950652	0.6624190162
0.1	1.67419013	1.244838032
0.15	2.511285196	1.747257049
0.2	3.348380261	2.169676065
0.25	4.185475326	2.512095081
0.3	5.022570391	2.774514097
0.35	5.859665457	2.956933114
0.4	6.696760522	3.05935213
0.45	7.533855587	3.081771146
0.5	8.370950652	3.024190162
0.55	9.208045717	2.886609179
0.6	10.04514078	2.669028195
0.65	10.88223585	2.371447211
0.7	11.71933091	1.993866227
0.75	12.55642598	1.536285244
0.8	13.39352104	0.9987042598
0.85	14.23061611	0.381123276
0.9	15.06771117	-0.3164577077

Cool Beans (2nd)



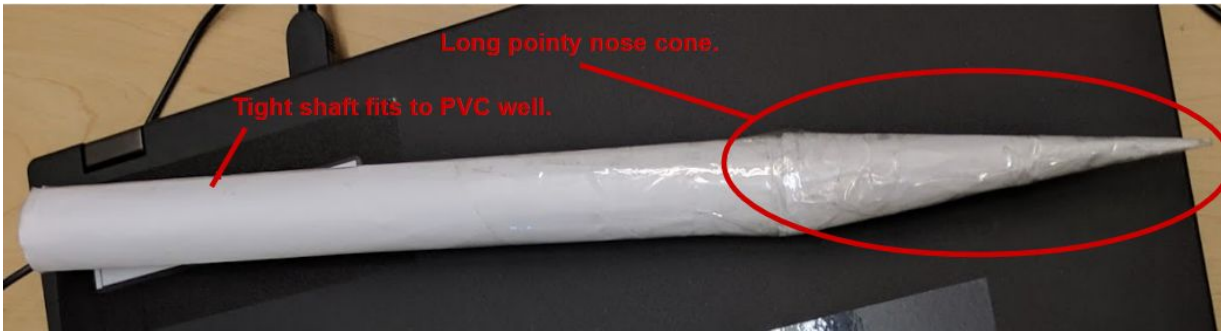
Initial Velocity: sqrt((-gx)/(sin(2Θ))) = sqrt((32*450)/(sin(2*40))) = **120.92 F/s**
Launch Angle: **40° @ 70 psi**
Distance: Approx. **150 yards**
Time in Air: **8.79 Seconds**

Cool Beans attempted to solve the multiple issues with the initial prototype, The Spearhead. By increasing weight at the front, adding find, and not attempting to implement a ridiculously tedious abundance of perfect curves, Cool Beans far surpassed it's predecessor. Rather than focusing on making curves, on paper, which was the downfall of The Spearhead, with Cool Beans, I decided on improving the smoothness and limiting the amount of wrinkles and unevenness, which would obviously hinder the rocket from going in a straight, unaffected path. According to an investigatory field trip to the patriots jet center, I was able to understand how and why fins would assist with aerodynamics. Because of this I decided on putting four fins at the end of the rocket, which would allow for increased stability and provide the rocket with a straight path to follow. Based off comments from the viewers, and my own personal experience, the performance I saw, this rocket had a far more direct flight and was as if it was not affected by the wind or anything else in any way. The straightness of the path allowed the rocket to reach further than the end of a football field, and approximately 50 yards more. With this design I proved that with a better placement of weight, a smoother overall build, and fins, the projectile was able to fly substantially better than if it did not have these features.

Time	X Position	Y Position
0	0	0
0.1	2.911428511	4.300946011
0.2	5.822857021	8.281892022
0.3	8.734285532	11.94283803
0.4	11.64571404	15.28378404
0.5	14.55714255	18.30473006
0.6	17.46857106	21.00567607
0.7	20.37999957	23.38662208
0.8	23.29142808	25.44756809
0.9	26.20285659	27.1885141
1	29.11428511	28.60946011
1.1	32.02571362	29.71040612
1.2	34.93714213	30.49135213
1.3	37.84857064	30.95229815
1.4	40.75999915	31.09324416
1.5	43.67142766	30.91419017
1.6	46.58285617	30.41513618
1.7	49.49428468	29.59608219
1.8	52.40571319	28.4570282
1.9	55.3171417	26.99797421
2	58.22857021	25.21892022
2.1	61.13999872	23.11986624
2.2	64.05142723	20.70081225
2.3	66.96285574	17.96175826
2.4	69.87428425	14.90270427
2.5	72.78571276	11.52365028
2.6	75.69714127	7.824596292
2.7	78.60856978	3.805542303
2.8	81.51999829	-0.5335116857

NOAH'S DESIGNS

Knome II Rocket

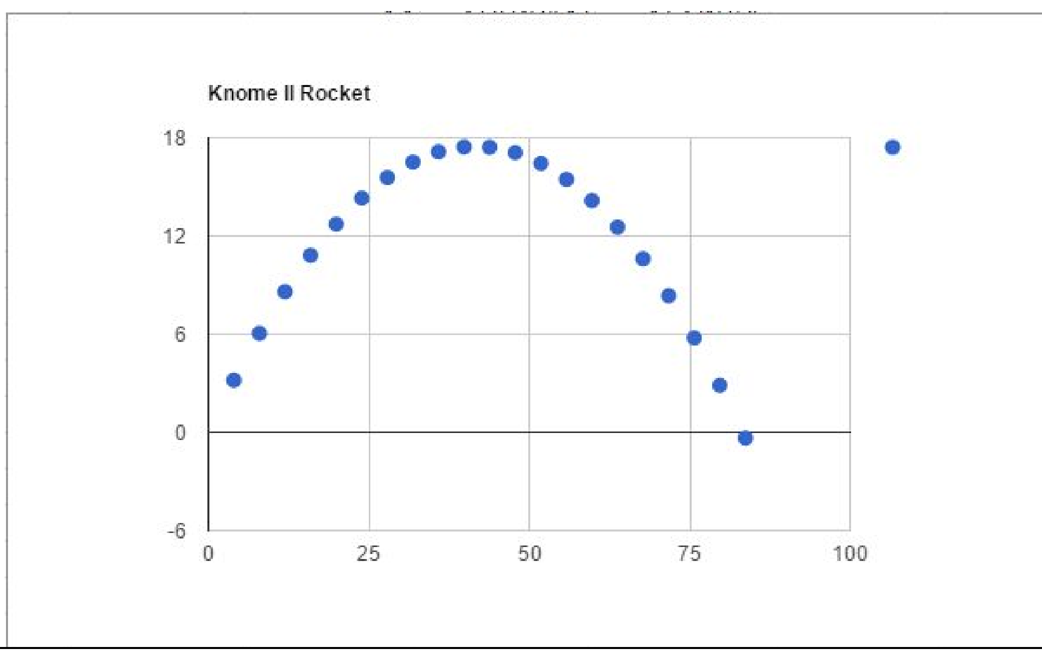


Launch Data:

- Launched at 60 psi
- 40 Degrees
- Traveled 26 Yards
- Initial Velocity: 52.02 Fps
- 2.56 seconds in air.

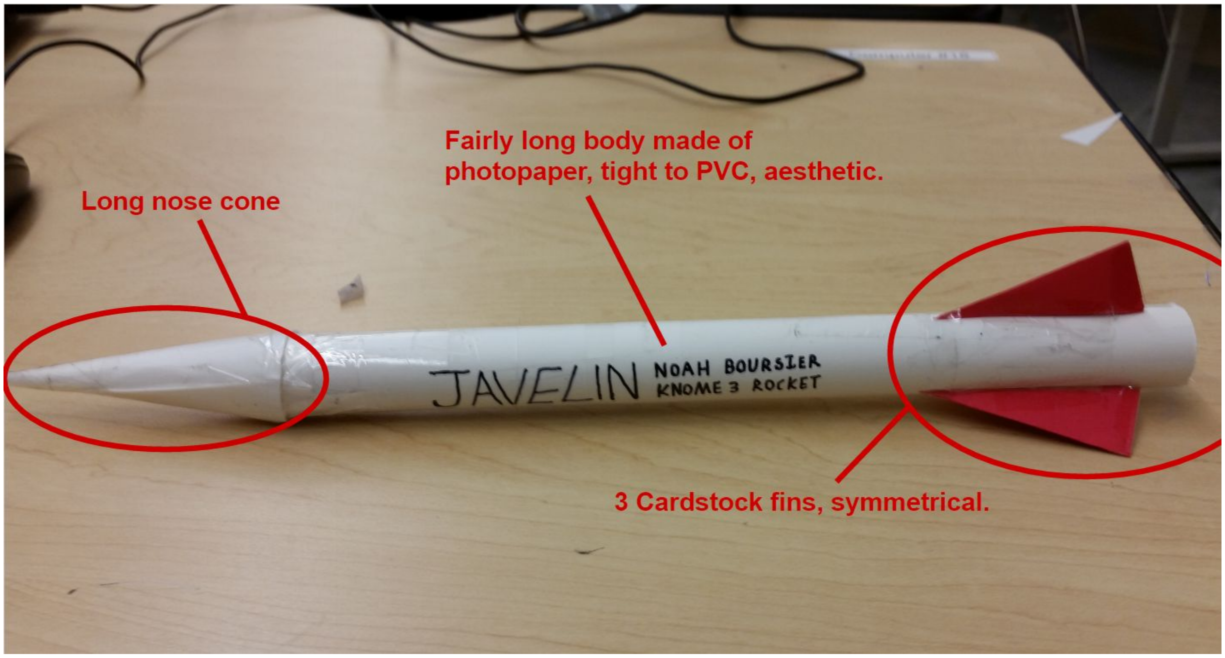
The Knome II rocket was built to test the usefulness of fins by not having them.The idea was to compare its flight to that of a rocket with fins, the Satan II rocket, for example. During its flight it flew straight for about 20 yards on course, then suddenly caught some wind and went head long into the ground. Other design features of the Knome II include a tight shaft for pressure build up, a cone pressure cap, and a long nose cone. The Knome II has the majority of the mass in the nose cone, in an attempt to shift the center of mass to about the front third of the rocket, this would, in theory, help the rocket fly straight as the tip would have greater momentum/inertia than that of the body and lead it through the air.

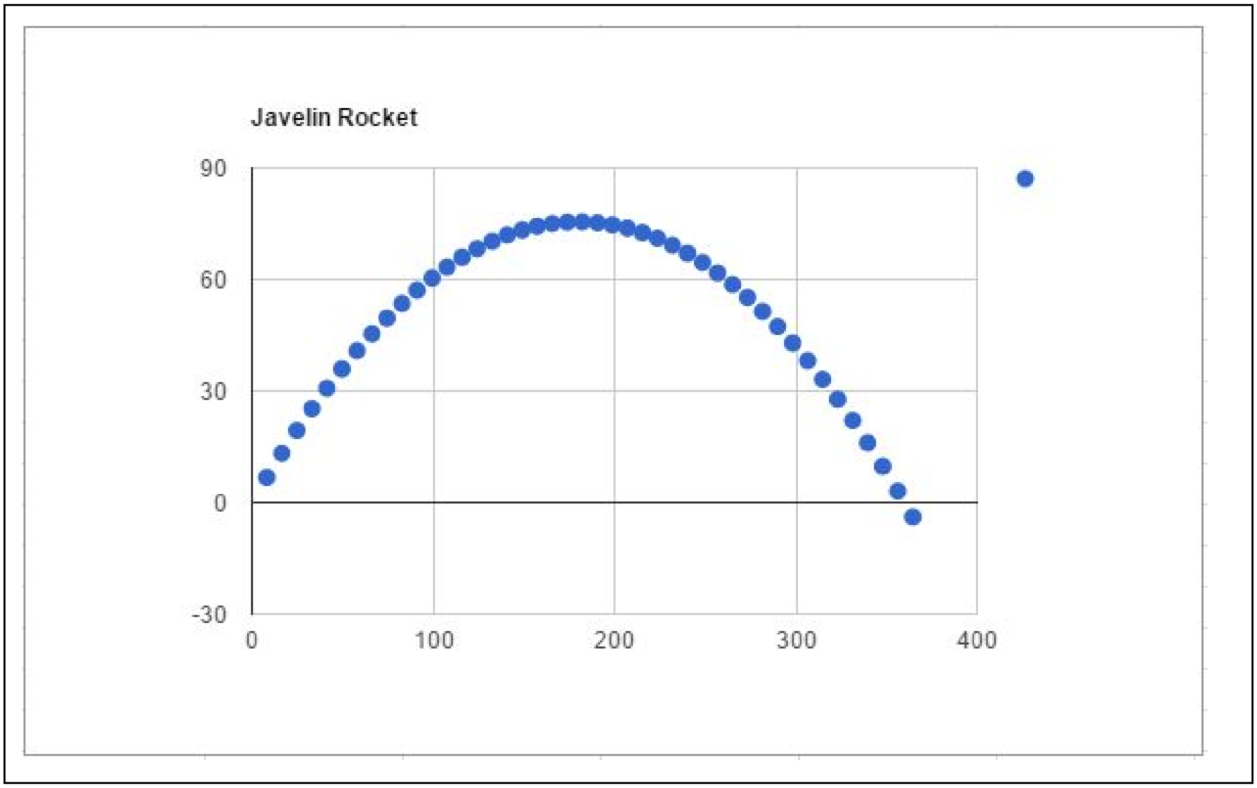
Flight Graph:



Time	X	Y
0	0	0
0.1	3.984963193	3.183781146
0.2	7.969926386	6.047562291
0.3	11.95488958	8.591343437
0.4	15.93985277	10.81512458
0.5	19.92481597	12.71890573
0.6	23.90977916	14.30268687
0.7	27.89474235	15.56646802
0.8	31.87970554	16.51024916
0.9	35.86466874	17.13403031
1	39.84963193	17.43781146
1.1	43.83459512	17.4215926
1.2	47.81955832	17.08537375
1.3	51.80452151	16.42915489
1.4	55.7894847	15.45293604
1.5	59.7744479	14.15671718
1.6	63.75941109	12.54049833
1.7	67.74437428	10.60427948
1.8	71.72933748	8.348060621
1.9	75.71430067	5.771841766
2	79.69926386	2.875622912
2.1	83.68422706	-0.3405959426

Initial Velocity: 52.02 Fps / Angle: 40 Degrees

Javelin (Gnome III) Rocket

Launch Data: - Launched at 70 psi - 40 Degrees - Traveled 135 Yards - Initial Velocity: 108.15 Fps - 9.2 seconds in air.
The Javelin was a rocket designed with distance and elegance in mind, combining the best aspects of previous rockets. The Javelin has three fins, the optimum amount for symmetry, turbulence negation and minimal drag. It has a long and pointy yet sturdy nose cone made with aerodynamics in mind. The only things that I would've changed about the rocket if given another launch would be its length, which should be shorter for less turbulence and drag, I would also make it a bit less tight on the PVC launcher so that it doesn't have as much friction coming off. The original idea was that if it is tight it will build up more pressure, but I realized that the tight grip it has on the PVC will be maintained the entire time that the rocket is being released from the PVC, which means it could be creating unnecessary friction which slows the rocket down. During the Javelin's flight it made third in the class at 135 yards, almost reaching the far end of the track on the football field. The Javelin flew straight and true, with minimal wobble.
Flight Graph:


Javelin Rocket
90
60
30
0
-30
0
100
200
300
400

Time	X	Y
0	0	0
0.1	8.284770652	6.791747999
0.2	16.5695413	13.263496
0.3	24.85431196	19.415244
0.4	33.13908261	25.246992
0.5	41.42385326	30.75873999
0.6	49.70862391	35.95048799
0.7	57.99339457	40.82223599
0.8	66.27816522	45.37398399
0.9	74.56293587	49.60573199
1	82.84770652	53.51747999
1.1	91.13247718	57.10922799
1.2	99.41724783	60.38097599
1.3	107.7020185	63.33272398
1.4	115.9867891	65.96447198
1.5	124.2715598	68.27621998
1.6	132.5563304	70.26796798
1.7	140.8411011	71.93971598
1.8	149.1258717	73.29146398
1.9	157.4106424	74.32321198
2	165.695413	75.03495998
2.1	173.9801837	75.42670797
2.2	182.2649544	75.49845597
2.3	190.549725	75.25020397
2.4	198.8344957	74.68195197
2.5	207.1192663	73.79369997
2.6	215.404037	72.58544797
2.7	223.6888076	71.05719597
2.8	231.9735783	69.20894397
2.9	240.2583489	67.04069196
3	248.5431196	64.55243996
3.1	256.8278902	61.74418796
3.2	265.1126609	58.61593596
3.3	273.3974315	55.16768396
3.4	281.6822022	51.39943196
3.5	289.9669728	47.31117996
3.6	298.2517435	42.90292796
3.7	306.5365141	38.17467595
3.8	314.8212848	33.12642395
3.9	323.1060554	27.75817195
4	331.3908261	22.06991995
4.1	339.6755967	16.06166795
4.2	347.9603674	9.733415948
4.3	356.2451381	3.085163947
4.4	364.5299087	-3.883088055

Initial Velocity: 108.15 Fps / Angle: 40 Degrees