FIN DESIGN MISSION

Team Members	

Mission: Your team will determine the best fin design for a model rocket. You will compare highest altitude, flight characteristics, and weathercocking. You will report your findings to the class.

Summary:

- Each member of your team will build and fly a model rocket. Your team fleet will include rockets with rectangular, tapered swept, clipped delta, trapezoidal, and elliptical fins. You will also build and fly a tube fin rocket.
- You will determine each rocket's apogee using a sextant and determine the mode (The most frequent value in the data set) and the median (The middle value that separates the higher half from the lower half of the data set) averages.
- You will also determine the average velocity of the model rockets.
- You will take note of each rocket's flight and take note of pitch, roll, and weathercocking.
- During post flight activities, you will analyze the data to determine the best fin design to achieve the highest altitude with the best flight characteristics.

Materials:

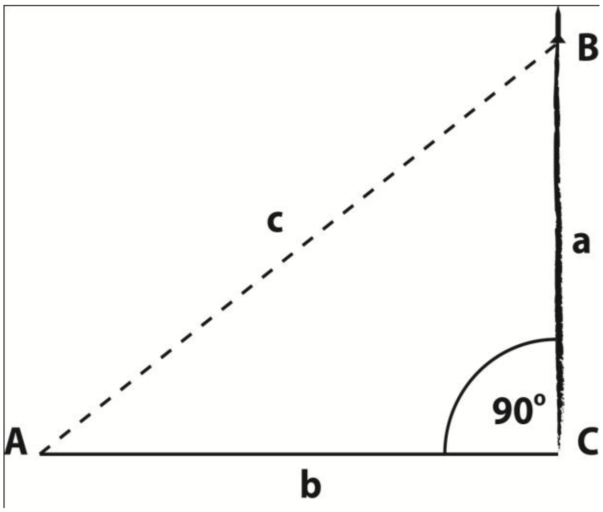
1. A completed model rocket for each member. All rockets must have the same weight in grams.
2. Copies of the Engineer Checklist and Flight Log for each rocket.
3. Altitude and Velocity Worksheets
4. Fin template sheet
5. 2 trackers with Estes Altitracs at two separate locations
6. 2 timers with stopwatches
7. Class launch equipment.

Sequence of Events:

1. Each team member will build a model rocket to the teacher's specifications. Each member will use a different fin template for their models.
2. Adjust their weights in grams to be equal. Determine how to do this as a team.
3. Request a launch date from the teacher.
4. On prep day, prep each rocket using an Engineer Checklist for each rocket. Load each rocket with an A8-3 rocket motor.
5. From the other teams in the class assign them to the following duties:
    a. 1 team: tracking stations and to serve as timers.
    b. 1 team: pad engineers.
    c. 1 team: meteorology (This team will also serve as observers and report on pitch, roll, and weathercocking during flight.)
6. Your team will operate the control center and record any collected data.
7. Launch each of your rockets on the same day, if possible. Gather required information from trackers, timers, and meteorologists and enter the data onto the flight log
8. After all of your rockets have been launched, fill out the Altitude and Velocity Worksheet and complete all calculations.
9. Give a report to the class on your findings.
10. Submit all paperwork to the teacher.

Calculating Altitude with a Sextant

To determine the apogee of a rocket's flight, we collect two types of data: distances and angles. This data is used to create a triangle with is a model of the lines that would join the tracker and the rocket, the rocket and a point directly below the ground, and the point on the ground and the tracker.



In this diagram, A represents the tracking station, B is the rocket at maximum altitude, and C is the launch pad. The angle formed by the lines at C is then a right angle or 90 degrees. Since there are 180 degrees in the angles of a triangle, if we know angle A, we can find angle B, since B = 180 degrees – (A+C), or B = 90 degrees – A. (In trigonometry, a capital letter represents an angle, a small letter represents a side. The small letter "a" will always be used to represent the side opposite angle A, "b" the side opposite B, etc. Two capital letters together represent a distance. Thus BC represents the distance from angle B to angle C, or side "a".

If the rocket flight is vertical, we can call C a right angle (90 degrees). In that case, B is equal to 90 degrees – A. So we must measure angle A during the flight of the rocket using a sextant. A sextant is a measuring device that gives us the angle of an object in degrees from the ground. Students use a sextant called an Estes Altitrak, which is designed to track model rockets.

We need to know the distance of the tracker using the sextant, which we call the tracking station, from the launch pad, which is where the rocket will begin its flight. The recommended distance is twice the distance of how high we expect the rocket to fly, but if that is not possible, it should be as far away as possible for accuracy. We use a measuring wheel to measure that distance. The distance can be in feet or meters.

When the rocket launches, the tracker follows the rocket up with the sextant by aiming at the rocket's nose. At the highest point of the flight, the tracker releases the trigger of the AltiTrak which locks the measuring arm over a number that represents angle A in degrees. By using the Table of Tangents, the tangent of angle A can be determined.

To find the distance from C (the launch pad) to B (the highest point of the rocket's flight), we take the tangent of angle A and multiply it by the distance from the tracker to the launch pad (side AC).

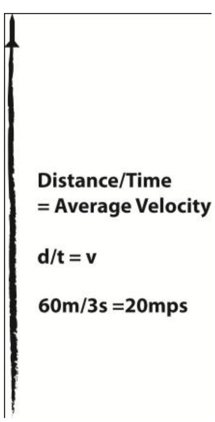
Tan A X AC = BC

To convert meters to feet - multiply by 3.2808, To convert feet to meters - divide by 3.2808

Tangent Table

Degree	Tangent	Degree	Tangent	Degree	Tangent	Degree	Tangent
1	0.0175	21	0.3838	41	0.8692	61	1.8037
2	0.0349	22	0.4040	42	0.9003	62	1.8804
3	0.0524	23	0.4244	43	0.9324	63	1.9622
4	0.0699	24	0.4452	44	0.9656	64	2.0499
5	0.0875	25	0.4663	45	1.0000	65	2.1440
6	0.1051	26	0.4877	46	1.0354	66	2.2455
7	0.1228	27	0.5095	47	1.0722	67	2.3553
8	0.1405	28	0.5317	48	1.1105	68	2.4745
9	0.1584	29	0.5543	49	1.1502	69	2.6044
10	0.1763	30	0.5773	50	1.1916	70	2.7467
11	0.1944	31	0.6008	51	1.2347	71	2.9033
12	0.2125	32	0.6248	52	1.2798	72	3.0767
13	0.2309	33	0.6493	53	1.3269	73	3.2698
14	0.2493	34	0.6744	54	1.3762	74	3.4862
15	0.2679	35	0.7001	55	1.4279	75	3.7306
16	0.2867	36	0.7265	56	1.4823	76	4.0091
17	0.3057	37	0.7535	57	1.5396	77	4.3295
18	0.3249	38	0.7812	58	1.6001	78	4.7023
19	0.3443	39	0.8097	59	1.6640	79	5.1418
20	0.3639	40	0.8390	60	1.7317	80	5.6679

ID06: Investigating Average Velocity



Model rockets travel at different rates of speed throughout the flight. During the first moments of flight, the rocket is accelerating. As it consumes its fuel, the rocket becomes lighter and speeds up until it reaches what is known as maximum velocity, or the fastest speed that it will go and now longer accelerate. Once the fuel is consumed, the rocket continues to fly because of the stored, or kinetic energy. This is known as the coast phase as the rocket is using up its kinetic energy and begins to decelerate, or slow down. The flight ends when the rocket deploys its recovery system. We know when this event occurs because we hear a popping sound as the deployment charge ignites and pushes out the recovery system.

In order to calculate the average velocity, we can time the flight from launch to apogee with a stopwatch. Once the trackers report the altitude of the flight, we can take that number and divide it by the time of flight from launch to apogee. The result is the average velocity in either feet per second (fps) or meters per second (mps).

ENGINEER CHECKLIST

ROCKET SERIAL # ___________________

BUILDER: ____

PRE-FLIGHT SAFETY CHECK

GO	NO GO	
		All glue and paint on model is completely dry
		Model is complete and all parts are present
		Nose cone fits properly and is not tight
		Nose cone is securely attached to the airframe
		Shock cord is secure
		Airframe is straight with no bends or warps
		Fins are present, securely attached and properly aligned
		Fins are undamaged
		Launch lug is securely attached to the airframe
		Motor mount is secure and operational
		ROCKET IS READY FOR FLIGHT!

PRE-FLIGHT PREPARATION

		ROCKET WEIGHT EMPTY: _______ grams
		Wadding installed
		Recovery system installed
		Rocket motor nomenclature: ____________
		Rocket motor undamaged
		Rocket motor installed
		Igniter and igniter plug installed
		Payload description: ____
		Payload installed
		ROCKET WEIGHT LOADED: ________ grams

POST-FLIGHT INSPECTION

		Rocket successfully recovered
		Rocket nose, airframe, and fins are intact and undamaged
		Recovery system is reusable
		ROCKET POST-FLIGHT WEIGHT : ________ grams
		(Including engine casing & recovery system)

LAUNCH LOG

Rocket Name: ______________________________________

Serial # ______________________

Builder:____

LAUNCH INFORMATION	**FLIGHT DATA**	
Date:	**Liftoff**	**Recovery**
Launch Time:	Successful:	Recovery System Deployment
Location:	***Misfire***	***Stage 1***
Launch Pad Elevation:	Stage 1:	Before Apogee:
	Stage 2:	At Apogee:
ROCKET DATA	**Pitch & Roll**	During Descent:
Fin Design:	***Thrust Phase***	Partial Deployment:
Fin #	No Pitch/Roll:	Failed to Deploy:
Engine	Pitched:	***Stage 2***
Stage 1:	Rolled:	Before Apogee:
Stage 2:	Tumbled:	At Apogee:
	Weathercock:	During Descent:
Recovery System	***Coast Phase***	Partial Deployment:
Stage 1:	Straight Trajectory:	Failed to Deploy:
Parachute -	Weathercock:	
Diameter:	Tumbled:	Recovery System Performance
Spill Hole Diameter:		***Stage 1***
Streamer -	**ALTITUDE**	Stable Descent:
Size:	***Tracking Station***	Oscillation:
Material:	Track. 1 Distance from pad:	Spinning:
Stage 2:	Track.2 Distance from pad:	***Stage 2***
Parachute -	Track.3 Distance from pad:	Stable Descent:
Diameter:	Tracker 1 Degrees:	Oscillation:
Spill Hole Diameter:	Tracker 2 Degrees:	Spinning:
Streamer -	Tracker 3 Degrees:	
Size:		**Landing**
Material:	***Marker Streamer***	Soft:
	Timer 1:	Hard:
Mass	Timer 2:	Crash:
Empty:		Distance from Pad:
Loaded:	***Electronic Altimeter***	Direction from Pad:
Post:	Reading:	
	FLIGHT TIMES	**Post Flight Inspection**
METEOROLOGY	***To Apogee***	***Damage***
Temperature:	Timer 1:	Nose:
Humidity:	Timer 2:	Airframe:
Barometer:	***Apogee to Landing***	Fins:
Wind Speed:	Timer 1:	Shock Cord:
Wind Direction:	Timer 2:	Recovery System:
Conditions:	***Total Time of Flight***	Can be reflown?
Cloud Type:	Timer 1:	
	Timer 2:	

FIN DRAG ALTITUDE WORKSHEET			
Use the raw data collected on the flight log of each rocket to fill out the form			
Rocket 1 : Rectagular Fins			
Apogee in Degrees Tracker 1		Apogee in Degrees Tracker 2	
Tangent A		Tangent A	
Distance from Launch Pad (AC)		Distance from Launch Pad (AC)	
Tan A x AC = BC		Tan A x AC = BC (altitude)	
		Average Altitude:	
Rocket 2 : Clipped Delta Fins			
Apogee in Degrees Tracker 1		Apogee in Degrees Tracker 2	
Tangent A		Tangent A	
Distance from Launch Pad (AC)		Distance from Launch Pad (AC)	
Tan A x AC = BC		Tan A x AC = BC (altitude)	
		Average Altitude:	
Rocket 3 : Tapered Swept Fins			
Apogee in Degrees Tracker 1		Apogee in Degrees Tracker 2	
Tangent A		Tangent A	
Distance from Launch Pad (AC)		Distance from Launch Pad (AC)	
Tan A x AC = BC		Tan A x AC = BC (altitude)	
		Average Altitude:	
Rocket 4 : Trapezoidal Fins			
Apogee in Degrees Tracker 1		Apogee in Degrees Tracker 2	
Tangent A		Tangent A	
Distance from Launch Pad (AC)		Distance from Launch Pad (AC)	
Tan A x AC = BC		Tan A x AC = BC (altitude)	
		Average Altitude:	
Rocket 5: Elliptical Fins			
Apogee in Degrees Tracker 1		Apogee in Degrees Tracker 2	
Tangent A		Tangent A	
Distance from Launch Pad (AC)		Distance from Launch Pad (AC)	
Tan A x AC = BC		Tan A x AC = BC (altitude)	
		Average Altitude:	
Rocket 6: Tube Fins			
Apogee in Degrees Tracker 1		Apogee in Degrees Tracker 2	
Tangent A		Tangent A	
Distance from Launch Pad (AC)		Distance from Launch Pad (AC)	
Tan A x AC = BC		Tan A x AC = BC (altitude)	
		Average Altitude:	
Results			
Rocket with highest altitude:		**Rocket with best flight:**	

FIN DRAG VELOCITY WORKSHEET

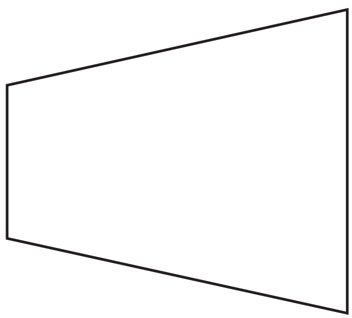
Use the raw data collected on the flight log of each rocket to fill out the form

Rocket 1 : Rectangular Fins			
Launch to Apogee Timer 1:		Time to Apogee Timer 2:	
Average Ascent Velocity:		Average Ascent Velocity:	
Apogee to Ground Timer 3:		Apogee to Ground Timer 4:	
Average Descent Velocity:		Average Descent Velocity:	
Average Ascent Velocity:		**Average Descent Velocity:**	
Rocket 2 : Clipped Delta Fins			
Launch to Apogee Timer 1:		Time to Apogee Timer 2:	
Average Ascent Velocity:		Average Ascent Velocity:	
Apogee to Ground Timer 3:		Apogee to Ground Timer 4:	
Average Descent Velocity:		Average Descent Velocity:	
Average Ascent Velocity:		**Average Descent Velocity:**	
Rocket 3 : Tapered Swept Fins			
Launch to Apogee Timer 1:		Time to Apogee Timer 2:	
Average Ascent Velocity:		Average Ascent Velocity:	
Apogee to Ground Timer 3:		Apogee to Ground Timer 4:	
Average Descent Velocity:		Average Descent Velocity:	
Average Ascent Velocity:		**Average Descent Velocity:**	
Rocket 4 : Trapezoidal Fins			
Launch to Apogee Timer 1:		Time to Apogee Timer 2:	
Average Ascent Velocity:		Average Ascent Velocity:	
Apogee to Ground Timer 3:		Apogee to Ground Timer 4:	
Average Descent Velocity:		Average Descent Velocity:	
Average Ascent Velocity:		**Average Descent Velocity:**	
Rocket 5 : Elliptical Fins			
Launch to Apogee Timer 1:		Time to Apogee Timer 2:	
Average Ascent Velocity:		Average Ascent Velocity:	
Apogee to Ground Timer 3:		Apogee to Ground Timer 4:	
Average Descent Velocity:		Average Descent Velocity:	
Average Ascent Velocity:		**Average Descent Velocity:**	
Rocket 6: Tube Fins			
Launch to Apogee Timer 1:		Time to Apogee Timer 2:	
Average Ascent Velocity:		Average Ascent Velocity:	
Apogee to Ground Timer 3:		Apogee to Ground Timer 4:	
Average Descent Velocity:		Average Descent Velocity:	
Average Ascent Velocity:		**Average Descent Velocity:**	

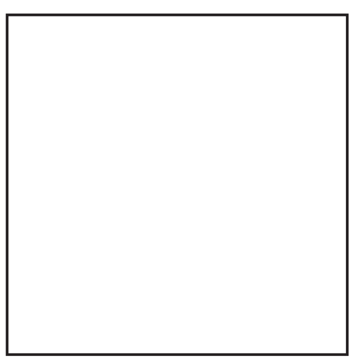
Results

Rocket with highest ascent velocity:

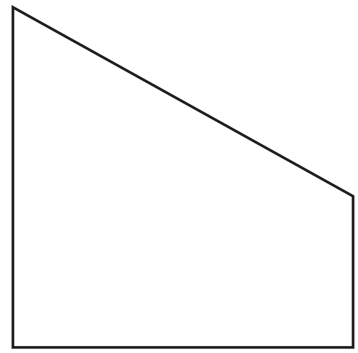
FIN TEMPLATES



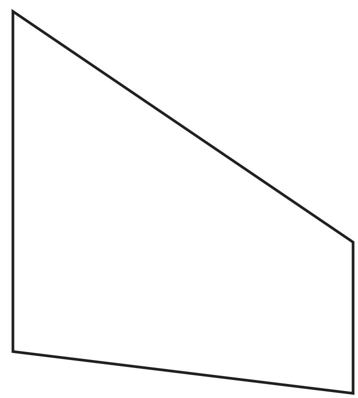
trapezoidal



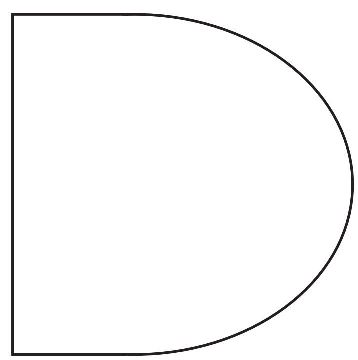
rectangular



clipped delta



tapered swept



elliptical