Institution: XXX School, XXX School District,   Street, City, State Zip Code

Public School

Applicant: XXX XXXX, 6th grade Science & Social Studies Teacher, XXX@xxx.org

NAR member - No

Grade Level: 6th

Number of participants: 56 (2019)

Activity Description

The XXX School in CITY, STATE is part of the XXX School District and serves grades Pre-K through six. The 6th grade for 2018/2019 is taught by the normal team of XXX XXXX (English and Language Arts), XXX XXXX (Math), XXX XXXX (Special Education), and myself (Science and Social Studies). In addition, there is a classroom aide, XXX XXXX. Dr. XXX XXXX (NAR, CMASS, MMMSC) has helped develop and run the program. The rocketry unit we've developed has always been first and foremost a means to inspire and teach STEM and has since been expanded to STEAM in 2015. The rocketry unit for 2019 is not scheduled until after the June 1, 2019 Cannon Application deadline and thus this application describes and has pictures from our 2018 rocketry unit.

This will be our 11th year of rocketry at the XXX School. The 6th grade rocketry unit has become an important part of the 6th grade science curriculum. It is a highlight of the 6th grade at the XXX School and is something that the students in the lower grades look forward to. Since we have completed 10 years of rocketry we thought it would be interesting to recount some statistics. In the past 10 years we have built a total of 304 rockets (Thing-a-ma-jig, Razor, Alpha, School Rocket). We have had 626 launches (A and B motors) not including the 'fun' launches at the end of each launch session. We have lost 28 rockets; have had 5 lawn darts, 4 core samples and no CATO's. More significantly, there have been no injuries, mishaps or complaints of any kind. On the contrary, we have only received compliments and positive feedback from students, parents and the administration. These last two points are something we are very proud of.

This year, as in past years, the rocketry unit is multi-day and revolves around a one-day build session and one-day launch session. In addition, XX XXXX works with the students teaching them how to use the Estes AltiTrak, a tangent table to calculate rocket flight altitude, and stop watch. The students practice on stationary objects like trees, and moving objects like a tossed football or baseball. We have found these practice sessions very important for the success of the actual flight. To fulfill STEAM requirements, the students are assigned a one page composition describing what they've learned while participating in the rocketry unit. The students are also given an assignment to draw/sketch what they thought were significant events during either the build or launch sessions. We also have an activity that occurs between the build session and launch sessions. The assignment is to have the students recount what they have learned so far and to focus their attention on the upcoming launch. This pre-launch assignment is as follows:

a. Draw and label your rocket from two different points of view.
b. List the different parts of your rocket and explain what each does.
c. Explain the physics of how a rocket launches and remains in flight until the parachute is deployed.
d. Write a paragraph explaining how you and your partner worked together to build your rocket and how you think your rocket will perform.

There is also pre-build session that happens a few days before the build. Several students (typically 6 to 10) stay after school and under the supervision of Dr. XXXX and myself, assemble parachutes, motor packets, etc.

The build session varies a little from year to year and is dependent upon class size and the particulars of the 6th grade schedule. However, what we have found to work best and what we always work to schedule is a 90-minute session for each homeroom to build their rocket (Figure 1). The morning of the build, Dr. XXXX brings in several of his rockets for display and we decorate the classroom with pictures of many different low, mid and high power rockets. At the start of the session the students are grouped in pairs with each pair building a single rocket. For most years each homeroom builds a different rocket - Custom Rockets *Razor*, FlisKits *Thing-a-ma-jig,* and the Estes *Alpha*. However, since the 6th grade class size was very small last year (44 students), we decided to build only one rocket, *Thing-a-ma-jig*, in one build session. This year the class size is larger, and we will go back to our normal three rockets, with each homeroom building a different rocket.

There is a break designed during the build session for each rocket at a point where it is useful for glue to set. During that time, Dr. XXXX gives a short PowerPoint presentation that encompasses the basics of model rocketry, some simple concepts of thrust, motor combustion and triangulation. Since the students use triangulation to calculate the height of their flights, we feel it is useful to give examples of how triangulation is used in many other fields and just how powerful the technique is. Geometry is beyond their mathematics at this grade, so the lesson is kept simple. We just give brief descriptions of surveyors' tools including theodolites, map making, and GPS.

The launch session always starts in the classroom with an explanation of the events to take place on the launch field and prep of the rockets for the first launch. There is then a short walk to the launch field (Figure 2) across the road from the school. The launch itself is run much like a CMASS launch with an LCO doing all of the launches. We use a Pratt Hobbies 6-Pack launch controller and six Fade-to-Black launch pads. The responsibilities are pretty much the same each year. I act as LCO and Dr. XXXX is the RCO and addresses any issues that arise during the launch. The other proctor responsibilities include:

a) help teams to track and time their rocket flights
b) help teams load their rockets onto the launch pad
c) help teams reload rockets for the second flight (usually two proctors)
d) keep teams together as they wait their turn for launching
e) make final check of each team's rocket

The launch sequence is as follows with no change from previous years:
1) Each team with a pre-numbered launch card presents their rocket and card to the RSO

for final inspection.
2) Teams present their launch card to the LCO and load their rocket onto the designated launch pad.
3) Teams go to a marked spot, 200 ft from the launch pad. One member of the team operates the AltiTrak and the other a stopwatch.
4) Teams take their angle and time measurements of their rocket's flight, record them on a Flight Log (Figure 3) and retrieve their rocket.
5) Teams go to a reload table and prep their rockets for their second launch, fill out a second launch card (not numbered) and the procedure repeats.

For the first launch, the teams use an Estes A8-3 motor and a B6-4 motor for the second launch. The teams use a 12" parachute with the A8-3 motor and streamer with B6-4 motor. The past two years we experimented with three launches per team. However, we have found the third launch not successful. The additional flight did not give the students any more useful data; their attention was waning, and some teams chose not to launch a third time. So, we will go back to two launches per team this year.

As usual, once all of the teams have launched their rockets, we have a few fun launches. Any student that has his/her own rockets is encouraged to bring them and Dr. Maina brings a few of his rockets to launch. We end the launch session with a group picture (Figure 5).

The students perform their altitude and velocity calculations, writing and art assignment later that day. After the assignments are handed in and graded, we average the altitudes and velocities for each rocket (using the students' measurements) and calculate standard deviations. The standard deviation can be used here as a crude assessment of how well the students take their measurements. Figure 4 shows results for 2018. Analysis was done on only the first two launches. Not all of the students performed a third launch and those that did, used either the A or B motor.

National, state and local standards or benchmarks addressed:
a) Recognize that gravity is a force that pulls things on and near the earth toward the center of the earth.
b) Differentiate between weight and mass, recognizing that weight is the amount of gravitational pull on an object.
c) Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.
d) Graph and interpret distance vs. time graphs for constant speed.
e) Identify and explain lift, drag, friction, thrust and gravity in a vehicle or device, e.g. rockets.
f) This unit greatly enhances our established status as an Innovation school in the state of Massachusetts.

Brief Description of Activity:

The 6th grade XXX School Rocketry Program is a component of the science curriculum and designed to use rocketry to teach Math, Physics principles, and help to enforce writing and art skills appropriate for 6th grade students in an exciting way, which hopefully will keep students interested in science. The unit encompasses a build session that has students, in teams of two, build one of three rockets, *Razor* (Custom Rockets), and *Thing-a-ma-jig* (FlisKits), and Alpha (Estes). During the build session, the students are given a lesson in the basics of model rocketry, some simple concepts of thrust and motor combustion, and triangulation. The launch session is run similar to an NAR launch with an LCO doing all of the launches. The launch field is a triple soccer field directly across from the Page School. The teams launch their rockets twice, first with an A8-3 motor, next a B6-4 motor. Using an AltiTrak (Estes) and stopwatch, the students measure the apogee angle and time of flight. Using the measured angle and tangent table, the students calculate their flight height and average velocity in both feet/sec and miles/hour. After the launch, the students spend the afternoon doing their calculations and complete a reflection assignment that has them both draw and write about their experience.

Continuation Plan:

The rocketry unit is in its 11th year and has become a standard part of our science curriculum. Each year we evaluate the entire unit, make modifications as needed and are always looking to improve and add to it. We have had the continued support of our principal, the 6th grade team of teachers and Dr. XXXX, and hope to continue the unit for many years to come.

Has this activity been supported by NAR Cannon Grant before?

Yes, we were awarded grants in 2010, 2011, 2013 through 2018. We did not apply in 2012.

Have you done this activity before? If so, how will this activity be improved or refined this time.

The basic framework of the unit has not changed during the ten years it has been in existence. The 6th grade students build one of two or three rocket kits, in teams of two, on day one. The build session contains a lesson in rocketry and physics. The rockets are launched on day two, with each team computing their rockets altitude and speed. The launch is followed by a reflection assignment. In 2013 we introduced a second launch for each team, in 2014 an ELA and Art component, in 2016 a pre-launch assignment, in 2017 a third launch.

There are only one modification we are making for 2019. We are going back to two launches per team. Several teams did not attempt a third launch last year and there was no additional useful data obtained from those teams that did launch a third time. And in general, the students attention span seemed to wain during the third launch.

Facilities

The pre-build and build sessions are done in my classroom at the XXX School. The classroom is 37' by 33' with a desk for each child, sink, and additional tables, chairs and work areas (Figure 1). The launch field is a triple soccer field directly across the road from the Page School (Figure 2).

Will local NAR section be involved?

Dr. XXXX is a member of CMASS and MMMSC. Neither section is formally involved, but Dr. XXXX does promote CMASS and MMMSC to the students and tells of upcoming local launches. In addition, Dr. XXXX writes a short article for the CMASS web site and post pictures. The article for the 2018 rocketry unit can be seen here: http://www.xxx

Publicity

Parents are invited to the launch and each year the number of parents attending has grown. On average, we have 40 to 50 parents attending.

Expenses

The Cannon Award will be used to purchase materials for next year's rocketry unit. Specifically:
a) *Thing-a-ma-jig* rocket kits (bulk); FlisKits.
b) Estes Alpha (bulk); Animal Motor Works.
c) Estes A8-3 motors (24 pack); Animal Motor Works.
d) Estes B6-4 motors (24 pack); Animal Motor Works.
e) miscellaneous building supplies; Wal-Mart, Home Depot.

Figure 1. View of the classroom during the 2018 build session.

Figure 2. Launch field. Launch pads are in the foreground and tracking area in the background. Launch table is in the center foreground and re-load tables are to the left foreground.

Flight Log

Name(s) ________________________________ **Date** ______________

Rocket ____________________________

Flight 1

Motor __________________

Altimeter Angle _______________

Tangent of the Angle (refer to table on back) ___________

Tan ____ **x Distance from Launch Point to Altimeter** ________ **= Height**________

Height _______ **/ Time to Apogee (Highest Point)** _______ **= Ft/Sec** _________

Ft/Sec _______ **x 0.6818 = Miles/Hour** __________

Flight 2

Motor __________________

Altimeter Angle _______________

Tangent of the Angle (refer to table on back) ___________

Tan ____ **x Distance from Launch Point to Altimeter** ________ **= Height**________

Height _______ **/ Time to Apogee (Highest Point)** _______ **= Ft/Sec** _________

Ft/Sec _______ **x 0.6818 = Miles/Hour** __________

***Distance from launch pad to recording stake is 200 ft.**

Tangent Table

Angle	Tangent	Angle	Tangent	Angle	Tangent
0	0	30	0.58	60	1.73
1	0.02	31	0.60	61	1.80
2	0.03	32	0.62	62	1.88
3	0.05	33	0.65	63	1.96
4	0.07	34	0.67	64	2.05
5	0.09	35	0.70	65	2.14
6	0.11	36	0.73	66	2.25
7	0.12	37	0.75	67	2.36
8	0.14	38	0.78	68	2.47
9	0.16	39	0.81	69	2.60
10	0.18	40	0.84	70	2.75
11	0.19	41	0.87	71	2.90
12	0.21	42	0.90	72	3.08
13	0.23	43	0.93	73	3.27
14	0.25	44	0.97	74	3.49
15	0.27	45	1.00	75	3.73
16	0.29	46	1.04	76	4.01
17	0.31	47	1.07	77	4.33
18	0.32	48	1.11	78	4.70
19	0.34	49	1.15	79	5.14
20	0.36	50	1.19	80	5.67
21	0.38	51	1.23	81	6.31
22	0.40	52	1.28	82	7.11
23	0.42	53	1.33	83	8.14
24	0.45	54	1.38	84	9.50
25	0.47	55	1.43	85	11.42
26	0.49	56	1.48	86	14.28
27	0.51	57	1.54	87	19.04
28	0.53	58	1.60	88	28.54
29	0.55	59	1.66	89	56.92

Figure 3. Launch Log and Tangent Table

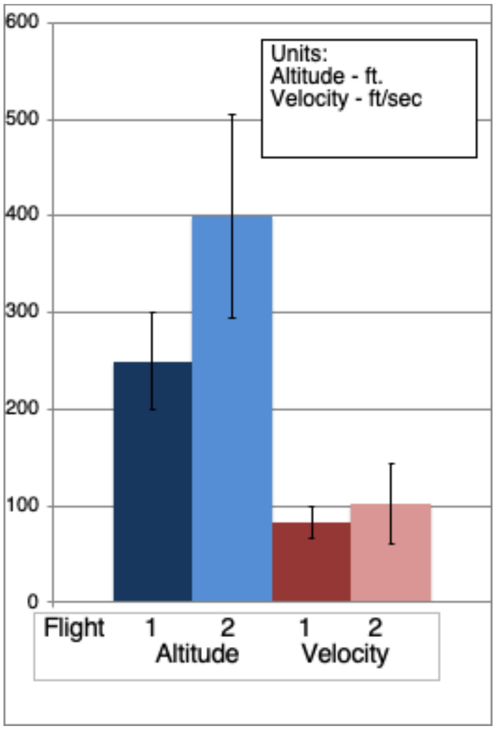

Figure 4. Launch Analysis for 2018.

Figure 5. Group photo for 2018.