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An Introduction to Model Rocketry for the Classroom Teacher

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AN INTRODUCTION TO MODEL ROCKETRY FOR THE CLASSROOM TEACHER

A Project

Presented to

the Graduate Faculty

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In Partial Fulfillment

of the Requirements for the Degree

Master of Education

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by

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PURPOSE

The writer of this project was in a fifth grade teaching position beginning Fall, 1974, in Lacey, Washington. The writer taught thirty students in a self-contained classroom situation.

The purpose of this individualized study was to develop a general framework and assemble some specific materials which would aid others in starting and developing a program in model rocketry in an orderly and logical manner.

PROCEDURES

South Bay Elementary School is a Title I target school. Recent research with disadvantaged students has lead to the following selected principles:

> Students learn best when the content has direct application to those things that interest them.
>
> Students learn best by active involvement in project activities.
>
> As motivation for learning increases, disruptive behavior decreases.

The fifth grade students at South Bay are for the most part under-motivated. Teachers of fifth grade students do not currently have a framework to build motivation, to increase interdisciplinary learning, and to increase interest in national and world activities.

This program was started in September of 1974 in two self-contained classrooms of 29 students each. The building of a rocket was used as the initial motivational force leading to the development of a program of interdisciplinary activities. So much enthusiasm was created through the use of this program that the nonparticipating fifth grade students were readily infected by the rocket bug. This created pressures upon the other grade level teachers to instigate the program in their classrooms. They enjoyed as much success as the initial group.

The program was expanded upon as teachers from other schools in the district became acquainted with the program and requested additional information. Because of these requests for help in setting up a model rocketry program in other schools within our district, it was decided that a manual would be developed for use by other personnel.

CONCLUSIONS

Problems encountered in piloting this program were not overwhelming in consequence. Preplanning should be stressed; this is necessary to have full success.

Time allotment is one area that must be watched closely. Because of the highly motivational nature of this program, students are continually wanting to work on their rockets. Obviously, this must be limited to fulfill obligations in other curricular areas.

Procurement is another area that is bothersome--at least in my situation. If ordering is done directly from the manufacturer, allow for this time interval. If supplies are purchased at a local retail outlet, supplies will obviously be more readily available. It must be stressed that it is absolutely necessary to devise an appropriate method for handling monies collected.

The enthusiasm of the students for the project carried over into an improved classroom attitude evidenced by increased cooperation, shared experiences, and appreciation of the skills and mutual difficulties of others.

RECOMMENDATIONS

It is recommended that a user do a systematic study to verify that the following would be products of the model rocketry program:

1. Increased attendance
2. Increased parental involvement
3. Increased academic production
4. Improved attitudes toward school

AN INTRODUCTION TO MODEL ROCKETRY
FOR THE CLASSROOM TEACHER

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INTRODUCTION

Model rocketry is a scientific, educational hobby. It involves "hands-on" learning experiences in building and launching small, light-weight rockets made from cardboard, balsa, and plastic parts. The rockets are then launched in miniature "space missions" using safe, commercially manufactured model rocket engines.

The study of aerospace is not intended to be an end in itself. In the elementary classroom it can help students to understand better the world in which they live.

Model rocketry is not limited to vehicles and their flight. It also includes geography, weather study, communications, and environmental control, in addition to the basic skills of reading, writing, and arithmetic.

OVERVIEW

This guide is in no way intended to be an instruction on the legal requirements or the mechanics of model rocketry. A suitable training course in these areas is offered through the Washington State Aeronautics Commission, 8600 Perimeter Road--Boeing Field, Seattle, Washington 98108.

The only intent of this project is as a guideline in how to set up a model rocketry program in an intermediate classroom.

The procedures are simple and easy to use throughout the program. Most important, they are high-interest, attention-getting, and rewarding to the student.

While the study of rocketry rarely needs motivation, some setting of the scene could be advantageous. The teacher should become thoroughly familiar with the available materials so that they may be applied to the students in the particular class.

Materials, charts, displays, models, etc., can be set up in the classroom prior to the study of rocketry.

The students should all build rockets of the same skill level (3) to become familiarized with construction techniques, structure of a rocket, and also to insure initial success. A list of simple design rockets may be compiled and the students may choose from them. Later the types of rockets built will depend upon finances available and the launch area available. Individual abilities should also be taken into account.

The additional supplies which will be needed for the entire class as the students build their model rockets and prepare for the launch include: fine sandpaper, white glue, single-edge razor blades or modeling knives, ruler, pencil, paint (use either spray enamel or dope), and a box to store the individual's rocket supplies during construction.

A demonstration launch is also a good idea. This provides an excellent opportunity to go over launch procedures, and the all important safety code.

Using different engines in the same rocket at this launch will provide an opportunity to initiate questions that apply to flight such as gravity, thrust, drag, lift, etc.

Actual construction may begin at this point. Work areas should be assigned allowing students to work in small groups so they can assist each other.

Distribute the kits and have the students open them. Using the parts list, check to be sure all parts are present. At this point, the students should familiarize themselves with each rocket part and its function. Distribute similar drawings to each person for this purpose. (Drawing follows.)

BASIC MODEL COMPONENTS

A. Nose Cone. The front end of a rocket. Usually shaped to minimize air pressure.

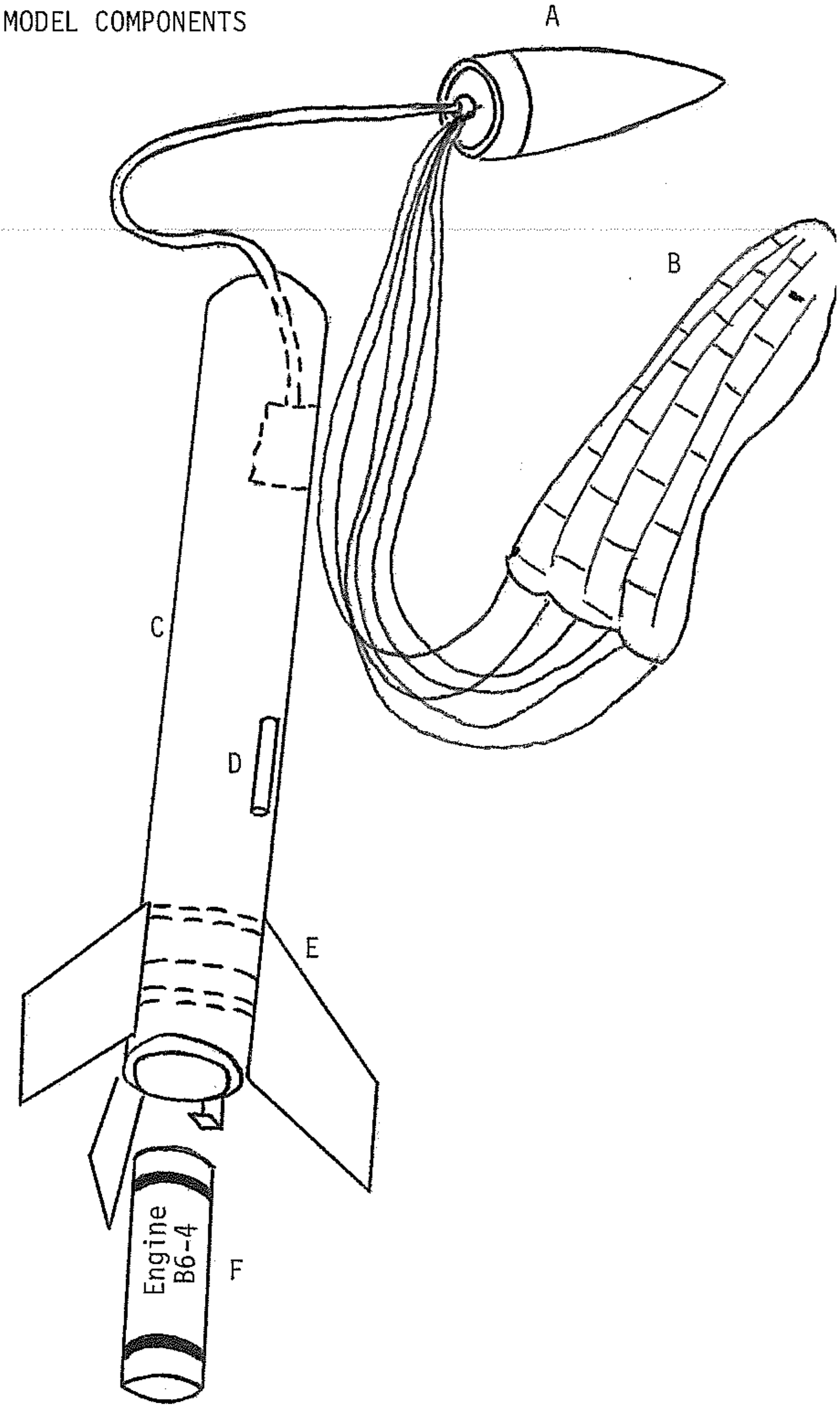
B. Recovery System. Slows rocket descent, bringing rocket back in a reflyable condition. Deployed by an ejection charge.

C. Body Tube. Basic airframe of a rocket around which all other parts are built or attached.

D. Launch Lug. A tube which slips over the launch rod to guide the model until it reaches the speed necessary for the fins to control the flight.

E. Fins, Guide the rocket in a precise flight pattern.

F. Engine. Provides the thrust to make the rocket fly.



CODES AND WASHINGTON LAWS PERTAINING TO SCIENCE TEACHING

Model Rocketry

In Volume 3 of the National Fire Codes (5) are a number of specific statements relating to the use of model rockets.

Section I. Model Rocket Definitions

1. As used in Sections 1 to 8 inclusive, "model rocket" means an aero model that ascends into the air without use of aerodynamic lifting forces against gravity; that is propelled by means of a model rocket engine; that includes a device for returning it to the ground in a condition to fly again; and whose structural parts are made of nonmetallic material. "Model rocket engine" means a solid propellant rocket engine produced by a commercial manufacturer in which all chemical ingredients of a combustible nature are preloaded and ready for use.

Sections 2-6, and 8

Sections 2-6, and 8 describe in detail aspects of rocketry listed below. Persons interested in becoming licensed and technically skilled for rocketry activity should consult these sections.

Rocket requirements: weight, propellants, construction, design, absence of warheads.

Engines: propellants, auxiliary packages, design, thrust, testing, manufacturer's responsibilities, shipping, ignition temperatures, storage, handling, performance data, disposal of old or impaired engines.

Location for operation: ground area, hazards to other persons or property, approval.

Launching: electrical, supervision, winds, other aircraft, hours permitted, observers.

Excepted activities.

Section 7. Prohibited Activities

1. The following activities are prohibited:

a. The use of model rockets for pyrotechnic purposes or for the primary purpose of producing a spectacular display of color, sound, light, or any combination thereof;

b. Tampering with or making use of a model rocket engine in any manner or degree which is contrary to the provisions of Sections 1 to 8 inclusive;

c. The use of a model rocket engine which shows signs of physical damage or other defect which might cause the engine to misfunction;

d. The launching, operating, discharging, flying, or otherwise activating of a model rocket engine without first having fully complied with the provisions of Sections 1 to 7 inclusive.

Section 9. Penalty

1. Violation of any provision of Sections 1 to 8 shall be deemed a misdemeanor and shall be punishable as such.

The Washington State Aeronautics Commission has additional regulations pertaining to model rocketry. A pyrotechnic operator's rockets license must be obtained from the State Fire Marshal before an individual may act as a coordinator and supervise model rocketry. A suitable training course and demonstration of knowledge of laws and regulations is required. This license may be obtained by writing Washington State Aeronautics Commission, 8600 Perimeter Road--Boeing Field, Seattle, Washington 98108.

SOURCES

Nationally, there are two main sources for obtaining model rockets:

Estes Industries
Department 161
Box 227
Penrose, Colorado 81240

Centuri Engineering Company
P. O. Box 1938
Phoenix, Arizona 35001

The materials obtainable from these companies seems of equal quality and price. The possibility exists that there may be local outlets which handle these lines, resulting in faster procurement.

ORDERING

Prior to ordering, a letter of permission should be sent to the students' parents, obtaining their approval for participation in the program and informing them of expenditure. A sample letter is included.

A dittoed form can be utilized for ordering rockets of the appropriate skill level, and related supplies. A procedure applicable to the specific situation can be employed for handling monies collected and disbursement of materials. It is recommended this procedure is well planned in advance, and is handled in a somewhat rigid and businesslike atmosphere.

Samples of rockets should be on hand prior to ordering, including a more advanced skill level. These are helpful not only for motivational purposes, but also for familiarization with the different vehicles and their unique properties. Such features as these can be introduced and discussed:

I. Types
   A. Single stage
   B. Multi-stage
   C. Boost-glide
   D. Cluster

II. Engine mounts
   A. Friction fit
   B. Engine clip

III. Recovery systems
   A. Parachute
   B. Streamer
   C. Tumble
   D. Glide

SAMPLE LETTER TO PARENTS

Dear Parents:

Model rocketry is a scientific, educational hobby. It involves "hands-on" learning, experiences in building and launching small, lightweight rockets made from cardboard, balsa, and plastic parts. The rockets are then launched in miniature "space missions" using safe, commercially manufactured model rocket engines.

The study of aerospace is not intended to be an end in itself. In the elementary classroom it can help students to understand better the world in which they live.

Aerospace education is not limited to vehicles and their flight. It also includes geography, weather study, communications, physics, and environmental control, in addition to the basic skills of reading, writing, and arithmetic.

The class has shown interest in this project. This program is completely safe when conducted within the guidelines of the Model Rocketry Safety Code.

This is an optional activity as some expense will be incurred (about $5.00 for the year). Students who become more involved may spend more on different types of rockets, additional engines, etc.

Ordering will be done at school.

If you are interested in having your child participate in this program, please sign this paper and return it to the school with your child. A ditto will then be sent home listing supplies your child may order.

If you have any questions, feel free to contact me at school.

Regards,

Parent's signature ____

VOCABULARY

As in any specialized area, it is important for the students to become familiar with, and use, the correct terminology when referring to any facet of model rocketry. Many of these terms can be seen on the previous drawing.

SAMPLE UNITS OF STUDY WITHIN THE ROCKETRY PROGRAM

The more familiarized the students become with every facet of the model rockets with which they are involved, the better.

Following are four areas in which more in-depth study may be appropriate for a particular group.

History

I. Space and you
   A. Steps into space
      1. Space travel in fantasy and folklore
      2. Early pioneers
      3. Interim developments
   B. Exploration of space
   C. Astronomy

II. Solar system
   A. Sun
   B. Earth
   C. Moon
   D. Planets
      1. Explorer's interest
         a. Venus
         b. Mars

III. Principles of space probes and satellites
   A. Motion of bodies in space
   B. Gravity
   C. Satellites and space probes
   D. Laws which effect satellites
      1. Newton's Law of Gravity
      2. Newton's Law of Motion
      3. Kepler's law of planetary motion
   E. Launching satellites into orbit
      1. Gravitational attraction lessens with distance
      2. Orbital velocity in direct proportion to distance
   F. Escape velocity
      1. Varies with distance from earth
      2. Permanent escape
         a. Varies with distance from earth
         b. Permanent escape
            (1) subject to sun's gravity
            (2) continuous thrust

IV. Unmanned interplanetary spacecraft purposes
   A. Obtain information about other celestial bodies
   B. Aid in preparation for future explorations of man

V. Manned space exploration
   A. New dimensions
      1. Velocity
      2. Altitude
   B. Physical environment must simulate earth's atmosphere

C. Problems of man in space
   1. Weight of life-supporting equipment needed
   2. Food, rest, relaxation requirements
   3. Mental limitations
   4. Nonexpendable (such as equipment)

D. Attributes and resources of man
   1. Intelligence
   2. Judgment
   3. Determination
   4. Courage
   5. Creativity
   6. Greatly increases success of space mission

VI. Manned spacecraft projects

A. Mercury (1-man)
   1. Test man's abilities and reactions in space.
   2. Technology of space flight

B. Gemini (2-man)
   1. Effects of prolonged space flight
   2. Orbital rendevous and docking

C. Apollo (3-man)
   1. Three sections
      a. Command module
      b. Service module
      c. Lunar excursion module
   2. Goals
      a. Land two Americans on the moon
      b. Explore surface and report findings
   3. Steps to the moon
      a. Earth orbital flights
      b. Earth orbital flights of command and excursion module
      c. Lunar exploration missile

VII. Space launch vehicles

Name	Stages	Propellant	Satellite Weight	Orbital Distance
Scout	3	Solid	200 lbs.	300 mi.
Delta	3	Liquid	500 lbs.	300 mi.
Thor Agenda D	2	Liquid	1600 lbs.	300 mi.
Atlas D	1.5	Liquid	3000 lbs.	300 mi.
Atlas Agenda B	2	Liquid	5000 lbs.	300 mi.
Titan II	2	Liquid	7000 lbs.	300 mi.
Titan III	3	Liquid	25000 lbs.	300 mi.
Saturn I	3	Liquid	11 tons	300 mi.
Saturn V	3	Liquid	120 tons	300 mi.

Activities

1. Discuss how satellites are put into orbit and how they are useful in modern life.

2. Compile a chart, listing the development of space knowledge and its application to space travel, concluding that the dream of going to other planets is centuries old.

3. Relate in writing the possibility of expanding our environment through manned space flight.

4. Identify by listing the three major manned spacecraft projects.

5. Construct and successfully launch a model rocket.

6. Paraphrase the laws which affect satellites (i.e., Newton's Law of Gravity).

Weather

I. Aims and objectives: This unit is designed to induce each pupil to have a fundamental knowledge of the concepts, causes, and effects of weather by identifying concepts such as the following: (1) Coriolus effect, (2) uneven heating of the earth, (3) relative humidity, (4) stratosphere.

II. Outline

A. Nature of air
   1. Two arbitrarily named layers
      a. Trophosphere
      b. Stratosphere
   2. Gaseous composition
      a. Oxygen, nitrogen, carbon dioxide, and inert gases
      b. Density; height relationship

B. Air motion
   1. Circulation
      a. Uneven heating of earth's surface
         (1) Warmer air rises creating reduced pressure area
         (2) Cooler air sinks creating high pressure area
         (3) Air moves from higher to lower pressure area
      b. Coriolis effect
      c. Movements
         (1) Horizontal
         (2) Vertical
   2. Uneven heating of surface
      a. Updrafts
      b. Downdrafts

C. Moisture and temperature
   1. Basic relationships
      a. Cooler air holds less moisture
      b. Warmer air holds more moisture
   2. Relative humidity
      a. Moisture capacity of air at given temperature
      b. Indicated as percent of capacity
   3. Density
      a. Warm air less than cool
      b. Moist air less than dry

III. Suggested pupil experiences and activities

A. Demonstrate variable atmosphere pressure by weighing a stack of checkers--then taking random weighings at various points from top of stack.

B. Deomonstrate unequal pressures by collapsing a can. Reduce pressure within the can with a vacuum pump, or fill can with steam and condense the steam after capping the can.

C. Demonstrate the principle of connecting currents of air with colored liquids of different temperature.

D. Demonstrate uneven heating of the earth's surface by exposing materials with smooth, rough, light, and dark surfaces to the sun or a heat lamp; after equal time exposure, measure surface temperatures of each material.

E. Illustrate Coriolis effect by using record turntable with record and attempt to draw a straight chalk line on record while turntable is rotating.

F. Compare maps of winds aloft with surface winds.

G. Compass Rose Game.

Engines

I. Basic types
  A. End burner
    1. All ½A through C engines except B 14
    2. Consumes propellant quickly
  B. Port burner
    1. B 14 engine
    2. Consumes propellant faster, producing higher thrust levels and correspondingly higher accelerations.
    3. Ideal for lifting payloads.

II. How engine works
  A. (Page 48, Centuri)
  B. Use chart for demonstration purposes

III. Choice of engines
  A. Use only recommended engines for the kit
  B. Big and heavy rockets need high thrust with short delay
  C. Smaller rockets can use less thrust with longer delay
  D. Different conditions (launch site, winds, etc., may limit choice of engines)
  E. All first test flights should be done with the least powerful recommended engine.

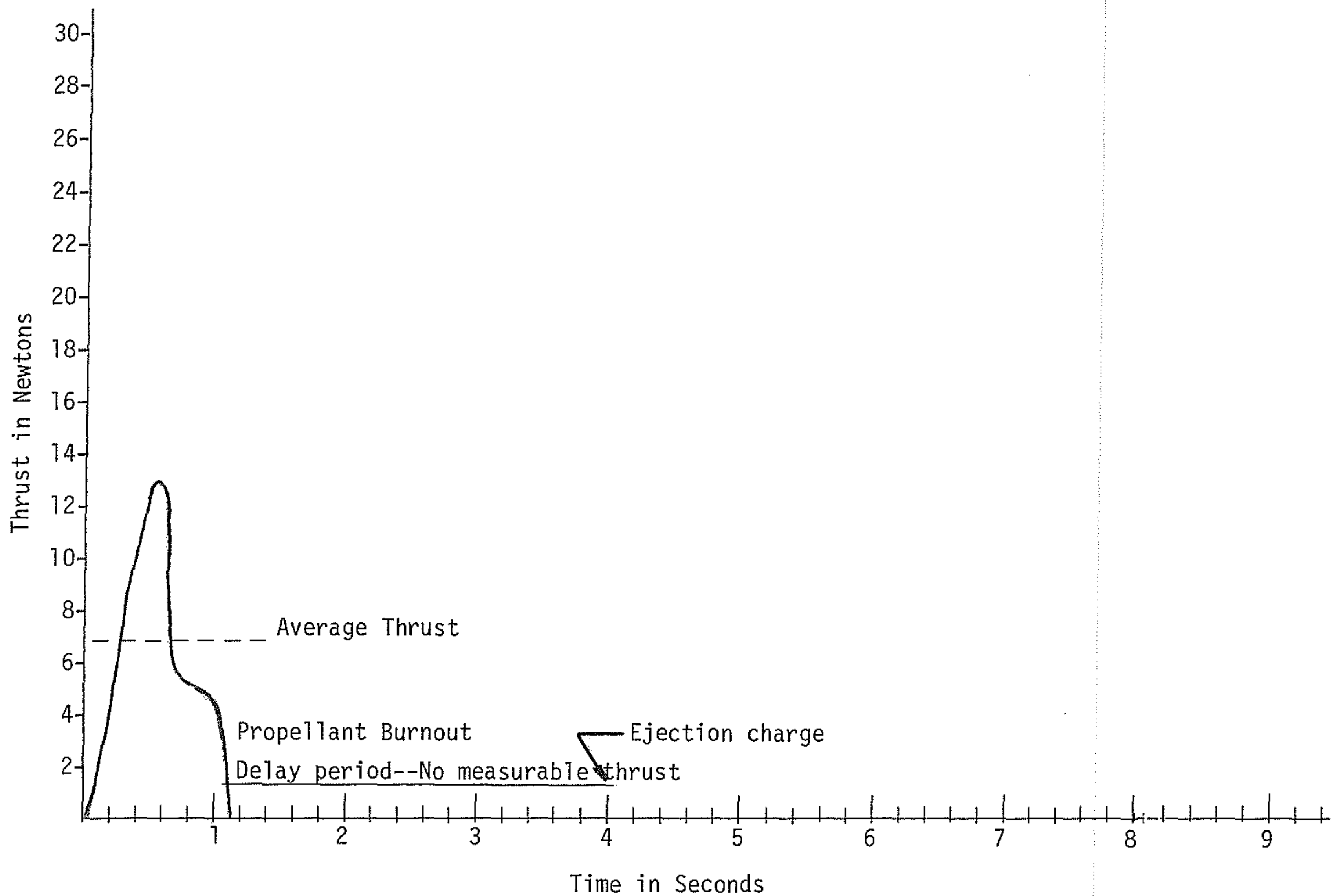
IV. Selection of engines
  (Chart page 49, Centuri)

V. Engine coding systems
  A. Color coding
    1. Ejection charge engines
      a. Green--delay is best for average single stage rockets
      b. Purple--needed for longer coasting sustainer of multi-stage rockets
    2. Booster engines
      a. Red
        (1) Never use in single-stage rocket
        (2) Have zero (0) delay times
        (3) On propellant burnout, hot gasses issue forth from forward end of the casing which ignite the engine in the next stage.
  B. Number coding
    1. Total thrust code
      a. Total power rated in Newton-seconds.
      b. Each letter class is twice as powerful as the previous class.
      c. Found by multiplying the average thrust force of engine by thrust duration.
      d. The higher the total impulse, the higher a rocket or a given weight and size will go.

2. Average thrust code
    a. Show how power is delivered.
        (1) Long duration, low thrust
        (2) Short duration, high thrust
3. Delay code
    a. Indicates in seconds, time between engine burnout and recovery system deployment.

B6-2

Total thrust curve | Average thrust curve | Delay code



Typical Time-Thurst Curve of Engines--B6-4

Demonstration of Rocket Stability

I. Center of gravity
  A. Point where all the weight appears to be concentrated
    1. Suspend on string and balance

II. Center of pressure
  A. Point where the aerodynamic forces appear to be concentrated

III. Rule
  A. Center of pressure should be at least 1 body tube behind center of gravity (width)
    1. Make cardboard outline of rocket
    2. Cutout
    3. Find CG of outline
    4. Compare cutout CG to true CG of vehicle

IV. Correction procedure
  A. Add weight at nose
  B. Subtract weight at fins

V. Swing test
  A. Suspend rocket at center of gravity
  B. Swing rocket overhead in a circular path--fins first
  C. If stable, it will point forward into the wind created by its own motion

VI. Unstable rockets
  A. DO NOT LAUNCH!

PRECAUTIONS DURING ACTUAL LAUNCHES

Rocket launches are an exciting time for the students; however, strict safety codes must be met and strictly adhered to during this time. Remember, you are out to launch rockets and for no other reason. This attitude will kep the launch a learning experience and also eliminate unnecessary hazards that may arise from misconduct at the launch site.

It is best to pick an area free of power lines, low flying aircraft, buildings, and flammable vegetation such as dry hay. By following the same common sense rules as they would with any outdoor recreation, students have many happy times. These rockets are big performers and need a lot of room. An ideal launch site is one whose side dimensions are at least half the expected altitudes of your rockets. Simply pace off the area, measuring your stride to get a rough idea of its size. The expected altitudes for all combinations of engines and rocket diameters are given in the "Estimated Altitude Chart." This chart is included in the Appendix of this project along with an explanation of the launch operations team. These team members are necessary to a successful launch and should be appointed in advance of a launch. They should be very familiar with their duties.

TEACHER CONSIDERATIONS

You must take the time of year into consideration before you begin a project on model rocketry. Since the launch is dependent upon weather, you must consider winds, temperatures, and rain or snow. It is quite sad to build up enthusiasm and then have to wait two or three weeks for the weather to clear before scheduling a launch. In the time lapse, the students may have forgotten the information you wanted for the future launches.

Model rocketry can also become an expensive project. While an Alpha may cost only $1.95, you also need paint, thinner, sandpaper, and various other items. The engines average $1.50 for three. These all add up to close to $5.00 per student. Many students will want to build several rockets and will need more engines and paint. The main concern here is for the student who cannot afford to buy a rocket and who is very involved in the project. Perhaps something could be done to purchase a rocket for these students.

Building the rockets can become quite time consuming if you allow it to be. You want the students to refrain from taking the rockets home as it is a class project, yet there is not much time in the day for rockets and all the required subjects. It works well setting some time apart once a week for rockets. Any other work on rockets must be done during recesses or any free time they may have. If you do not have a specific time, the students will continually ask for time to work on their rockets and this may interfere with classroom procedure.

Although you may consider the rockets time consuming, you must also realize the motivation they create for other subject areas. The solar system is interesting because "their rockets" go there. The English lesson is fun because it is a story about rockets. The interest evoked by a model rocket project cannot be underestimated.

When going out to the launch area, you won't forget the vital items, such as the launch pad and the launcher, but there are a few usually overlooked items that are needed as well. You may need an extra engine or two. Igniters may burn in half, causing a misfire; therefore, extra ignitors are useful. Someone may not have packed his rocket and you may need extra fire-proof wadding. Tape may be needed for a friction fit. These items should be kept in a range box.

Field kits may be purchased that contain extra body tubes, balsa wood, nose cones, parachutes, and many other items. These kits are interesting because they allow the students to build a rocket using their own designs and ideas. This increases interest and awareness in the center of gravity, center of pressure, and stability. The main problem that arises from this kit is making sure that the rockets are stable and well constructed to insure a safe flight. You must stress from the beginning exactly how you expect the rockets to be built and tell them that no rocket will be launched if there is a question of stability. These kits should not enter the program until the students are fully acquainted with rocket components and their functions.

Assembly of rockets must be done with care and be exacting. Stress to the students the importance of reading all directions before starting construction. This will familiarize students with the various phases of construction and may eliminate misplacement of an engine block or shock cord mount. Fins are critical to the stability of a rocket and they must be glued on straight to obtain this desired stability.

Safety is a big must in this type of program. Procedures around the rockets, engines, and launch area must be thoroughly understood and adhered to by all participants. All engines should be stored in a secured place, preferably a locked, fireproof box with access limited to the coordinator.

Students are always eager to launch their rockets. Even on seemingly "nice" days precautions must be taken to insure a successful launch. The weather bureau should be contacted to learn wind velocity both at ground level and aloft. This information will help insure recovery of all vehicles.

As in any other academic endeavor, you should thoroughly acquaint yourself with the terms and subject matter of the project before attempting to teach your students. You should not rely on someone else to lead the way for you. Classes are available in this area through the Washington State Aeronautics Commission, previously mentioned in this paper.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Aerospace Workshop Guide. Phoenix, Arizona: Centuri Engineering Company, 1971.

2. Elementary School Science Safety. Printed and distributed through the Office of the State Superintendent of Public Instruction, Olympia, Washington.

3. Flying Model Rockets. Centuri Catalog No. 73. Phoenix, Arizona: Centuri Engineering Company, 1974.

4. Model Rocketry Catalog. Penrose, Colorado: Estes Industries, 1974.

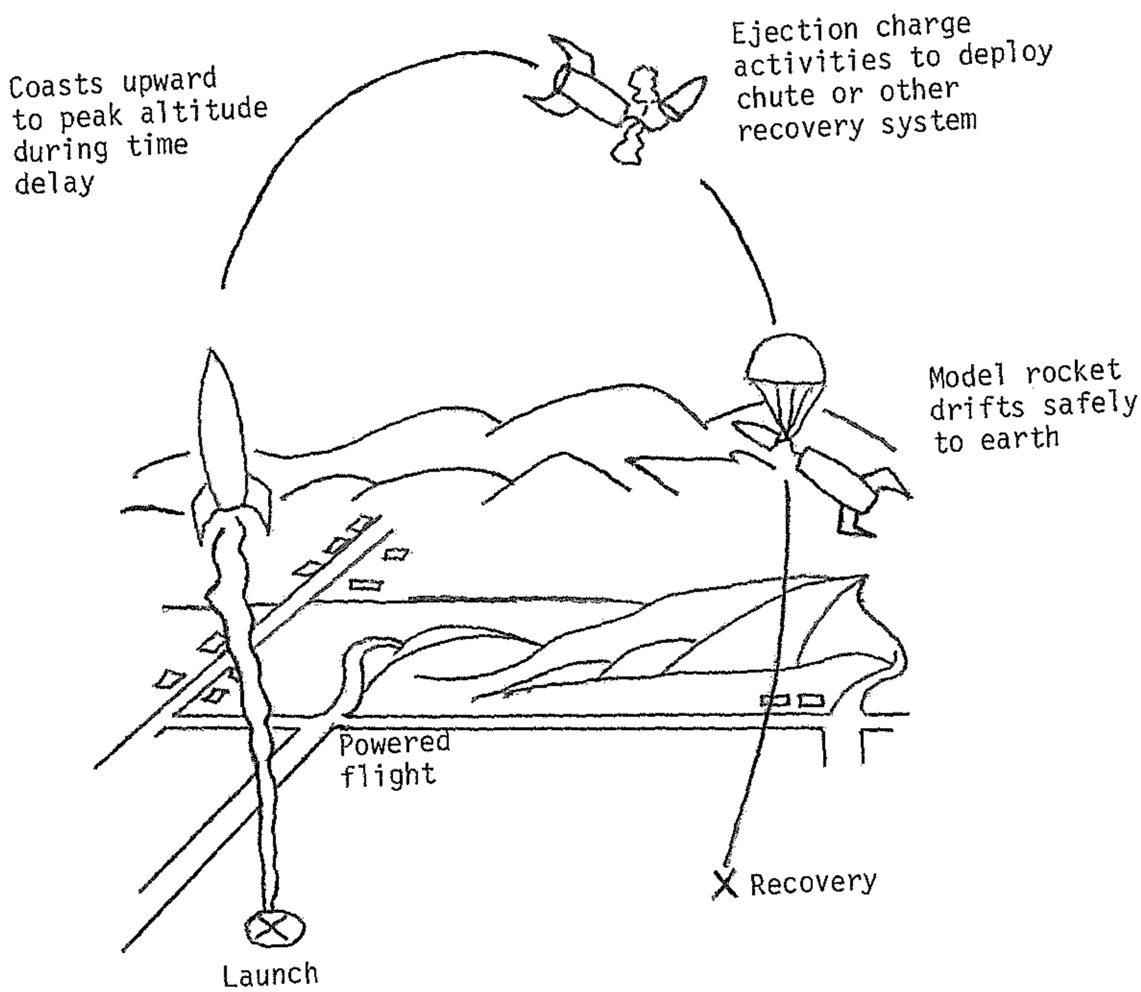
5. National Fire Codes (Vol. 1). Boston: National Fire Protection Association, 1970-1971.

6. Oths, Florence V. Teaching to Meet the Challenges of the Space Age. National Aeronautics and Space Administration. Washington, D.C.: U.S. Government Printing Office, 1963.

APPENDIX

The following forms are included for purposes of making dittos and transparencies for student use.

STEPS IN A ROCKET FLIGHT



WEATHER INFORMATION

	Flight #1	Flight #2	Flight #3	Flight #4
Wind Direction				
Wind Velocity				
Humidity				
Temperature				
Visibility				
Remarks				

LAUNCH

Flight Number		Flight #1	Flight #2	Flight #3	Flight #4
Date of Launch					
Launch Location					
Payload	Description				
	Weight				
Recovery System	Type				
	Color				
Method of Launch					
Engines No. of/ Type	1st Stage				
	2nd Stage				
	3rd Stage				
Total Weight					
Launch Angle					

Flight Data

Altitude	Estimated				
	Tracking Information				
	Computed Altitude				
Flight Duration					
Stability Information					
Flight Performance					

TABLE OF TANGENTS

Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan.
1	.02	17	.31	33	.65	49	1.15	65	2.14
2	.03	18	.32	34	.67	50	1.19	66	2.25
3	.05	19	.34	35	.70	51	1.23	67	2.36
4	.07	20	.36	36	.73	52	1.28	68	2.48
5	.09	21	.38	37	.75	53	1.33	69	2.61
6	.11	22	.40	38	.78	54	1.38	70	2.75
7	.12	23	.42	39	.81	55	1.43	71	2.90
8	.14	24	.45	40	.84	56	1.48	72	3.08
9	.16	25	.47	41	.87	57	1.54	73	3.27
10	.18	26	.49	42	.90	58	1.60	74	3.49
11	.19	27	.51	43	.93	59	1.66	75	3.73
12	.21	28	.53	44	.97	60	1.73	76	4.01
13	.23	29	.55	45	1.00	61	1.80	77	4.33
14	.25	30	.58	46	1.04	62	1.88	78	4.70
15	.27	31	.60	47	1.07	63	1.96	79	5.14
16	.29	32	.62	48	1.11	64	2.05	80	5.67

LAUNCH OPERATIONS TEAM

1. Range Safety Officer. To make certain that the launch area meets all safety requirements and to keep all students away from the launch area.

2. Inspector. To make certain the model rocket is well-built, properly balanced to be stable, has the proper type of engine, and has a safe recovery system.

3. Weather Officer. To check the wind direction and wind speed.

4. Tracking Team. To determine altitude reached by each rocket.

5. Recovery Team. To retrieve Rockets.

6. Recorders. To keep records on all launches.