TEACHER'S GUIDE FOR

# THE PHYSICS OF MODEL ROCKETRY

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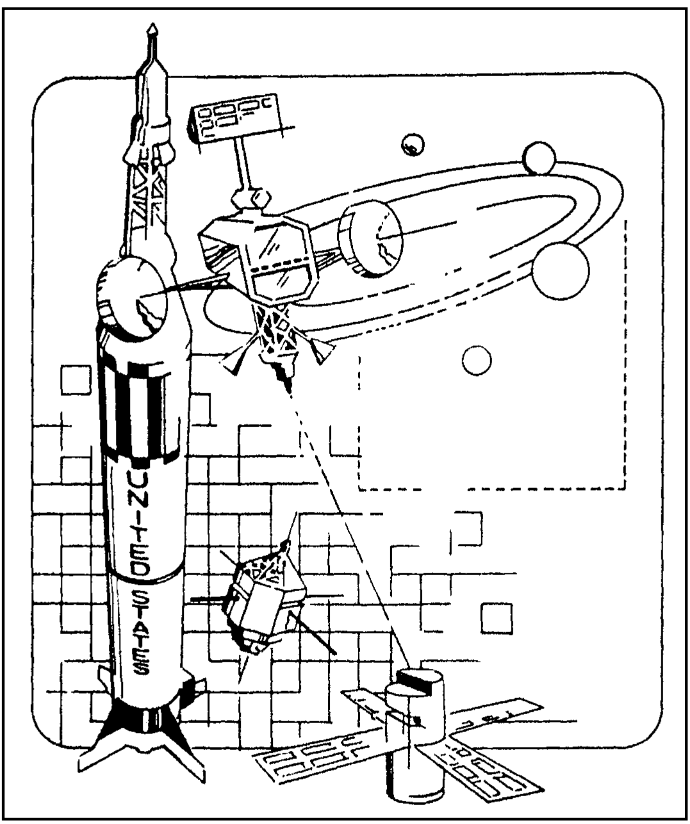




EST 9022

# LESSON PLAN

## GENERAL CONSIDERATION

This software product may be used for independent study. It was designed to be an excellent tutorial for an individual to use to learn about the forces, motion and masses involved in rocketry with emphasis on model rocketry. The coverage is thorough enough for the user to become familiar with many of the concepts involved in full-scale rocketry.

The programs on this disk are very suitable for review for those who were absent when the material was originally presented to the class or for review for those who need reenforcement of the information.

The disk may be used for the only presentation of the information, but this is not recommended for group situations. The programs were written for individual use.

To plan presentation of the material to the entire class, consider at least the following:

1. How much time can you allocate? Two weeks are recommended.
2. How many copies of the disk will be available? The ideal situation is one disk per computer.
3. What information do you want the students to learn? You may not wish to study all of the programs even though they were designed to be used in sequence. You may desire to cover the topics in a different sequence. Determine in advance exactly what goals you hope to achieve.

Once you have determined these parameters, allocate the available time. The following suggestions are based on a two week unit, one class period per day and one computer and disk per student or team of not more than three students.

## SUGGESTED DAILY SCHEDULE

**Monday**

A. Introduce the subject.
B. Review how to use the computer and disk, If necessary.
C. Give instructions on what to do today. Use of the Introduction program is recommended. Students learn using the software.

**Tuesday**

A. Review what was learned yesterday.
B. Give specific instructions for today. Use of Action-Reaction program is recommended. Instruct students on how to go to this program.
C. Students learn using the software.

**Wednesday**

A. Review what has been learned so far.
B. Give specific instructions about what to do today. Use of Inertia program is suggested.
C. Students learn using software.

**Thursday**

A. Review what has been learned so far.
B. If your class is going to build and fly model rockets to apply and reinforce the learnings acquired during this unit, teacher or class members start selecting the model rocket kits and engines which they will use. Limit selections of kits and engines based upon size of launch site available, students' modeling experience and time available. It is possible to have model rockets built at home, but most schools prefer to make a group project of it so students can help each other.

**Friday**

A. Collect the money, combine the orders and mail in one group order for your class(es).
B. Review Action-Reaction and Inertia briefly.
C. Give specific instructions for today's work. Use of the Momentum program is recommended.
D. Students learn by using software.

**Monday**

A. Give specific assignments for today's activity. Use of the Acceleration and Energy program is recommended. You may want to break this lengthy program into two parts, one section to be covered today and that section to be reviewed Tuesday. Complete the program on Tuesday.

**Tuesday**

A. The lesson on Acceleration and Energy is continued. Let students review the first part of the program used yesterday. The students complete that program today.
B. Students learn using the software.
C. You may wish to review the contents of Acceleration and Energy program during the later part of the period.

**Wednesday**

A. Give specific assignments for today's work. Use of the Staging program is recommended.
B. Learn using the software.

**Thursday**

A. Give specific assignments for today's activity. Use of the Satellites program is recommended.
B. Learn by using the software.

**Friday**

A. Review the material covered on the Physics of Model Rocketry disk.
B. Let the students utilize the Tech Tip™ on G Forces if time permits. If not enough time today and you want to cover this advanced material, this may be done on next Monday or at another suitable time.

**Culmination**

When the model rockets arrive, students will construct and launch them. This is a great hands-on, fun, learning experience.

## OBJECTIVES

Select from this list the objectives you want your class to master. Add other objectives as appropriate.

1. Learn the parts and functions of each part for solid propellant rockets.
2. Learn the parts and functions of each part for a solid propellant rocket motor.
3. Discover how the operation of a solid propellant rocket motor produces thrust.
4. Know how to calculate the force produced by a rocket motor.
5. Understand the concept of action-reaction.
6. Be able to apply Newton's Third Law of Motion.
7. Expand vocabulary of basic terms.
8. Grasp the concept of gravitational attraction.
9. Know how to calculate the gravitational attraction between two bodies.
10. Appreciate what can happen when an object moving at high speed enters Earth's atmosphere.
11. Understand the concept of static inertia.
12. Understand the concept of kinetic inertia.
13. Know Newton's First Law of Motion.
14. Be able to calculate the momentum possessed by a body.
15. Appreciate the effect of change in mass upon the way a body will be accelerated when a specific force is applied.
16. Learn the effect of a change in mass upon the distance a rocket will travel when a specific force is applied.
17. Discover the importance of thrusting ballistic coefficient and coasting ballistic coefficient upon the performance of a model rocket.

18. Learn what the drag form factor of a model rocket is.
19. Know the types of acceleration.
20. Understand the factors which affect the motion of a thrown object.
21. Know and understand the formula for calculating the drag which an object in motion through the air experiences.
22. Understand the concepts of potential energy and kinetic energy and the source of each.
23. Better understand some of the types of transformation of energy.
24. Know the way model rocket engines are coded to reveal their total impulse.
25. Know the parts and their functions for a model rocket engine.
26. Understand the advantages of staging when launching payloads into space.
27. Learn about balanced and unbalanced forces.
28. Learn the force equation and how to use it to understand the motion of rockets.
29. Know and understand Newton's Second Law of Motion.
30. Know what satellites, primaries and orbits are.
31. Understand the importance of gravity in maintaining a satellite in orbit.
32. Know the different orbits possible for a satellite.
33. Know what escape velocity means and its value for Earth.
34. Understand the relationships between orbital altitude, velocity and period.
35. Know what geosynchronous orbit is and its significance for modern communications.
36. Know what "g force" is and how to calculate it for a model rocket at launch.

## SUGGESTIONS

Model rockets are miniature versions of the full-size rockets used by NASA. The scientific principles are the same.

Your study of the physics of model rockets can be for learning the concepts involved. Your study can be expanded to include quantitative analysis using formulas. The formulas presented in these programs are basic ones and each is discussed in detail to help the students understand the formula.

Many concepts are presented. A good vocabulary of scientific terms is used. Each term is explained when it is introduced. Many of the basic facts are presented in several different programs, as they are useful in understanding the concepts presented.

Let your students experience the unforgettable fun of building and launching their own model rockets. Emphasize that the rocket is <u>his</u> or <u>hers</u> and that it's performance is entirely under the control of the student. "You build it right, it flies right!. You build it wrong, the mistakes affect its flight performance in ways you can <u>see</u>!."

Many experiments with model rockets involving concepts presented in the programs on the disks are possible. Qualitative or quantitative experiments about velocities, masses, accelerations, heights reached, etc. are possible using model rockets. Design and performance of these experiments are good learning projects for your students. Such experiments can make excellent Science Fair projects if carefully planned, carried out, documented and reported.

## INTRODUCTION

<u>THE PHYSICS OF MODEL ROCKETRY</u> is an interactive software tutorial which helps you understand the flight of model rockets. Concepts involved in model rocket flight are studied as they relate to such other topics as acceleration, momentum, gravitation, satellites, etc.

The software consists of a series of programs designed to be used in sequence. Each program builds on what was learned in previous programs.

Graphics are utilized to present the information in a very colorful and attractive manner to engage and retain the interest of your students. Periodic user responses are incorporated to let the user test his/her understanding frequently and to correct misinterpretations before they become fixed. This response system provides excellent positive reenforcement of information learned.

## SOFTWARE CONTENTS



## SUMMARY OF THE PROGRAMS

The programs are interactive. Periodically the user will be asked questions about what has been learned. The computer responds to the user based upon the answer provided by the user.

Some information appears in more than one program. This repetition is used whenever the information is pertinent to more than one program.

### Introduction

This program provides information on how to use the disk. The menu is included. A brief listing of the contents of each program is provided.

### Action-Reaction

The parts of a rocket, the parts of solid propellant rocket and the parts of a rocket motor are illustrated and explained. The functions of each part are described. Rockets are described as a special type of transportation. The propellant is made of a fuel and an oxidizer which produce large quantities of hot gases when combustion occurs.

The application of force to a rocket is covered. The importance of the direction and type of that force is brought out. The operation of a model rocket engine in producing thrust is explained. The formula for calculating the thrust produced is examined. The principle of action-reaction, Newton's Third Law of Motion, is presented.

### Inertia

The theory of gravitation and the gravitational attraction formula are presented and explained. The possibilities of what may happen when a body in space is attracted into the immediate vicinity of another body are presented, including various possibilities for reentry. The concepts of static inertia and kinetic inertia are explained. Newton's First Law of Motion is stated and explained.

**Momentum**

The concept of momentum and how to calculate it are explained. Examples involving model rockets are presented to help understand momentum. Some energy transformations are discussed, including several involved in model rocket operation. The total impulse produced by a model rocket engine is described as it affects the momentum of a model rocket. The energy changes experienced as the model rocket undergoes thrust, burnout and coasting are discussed. The thrusting ballistic coefficient and the coasting ballistic coefficient are explained and formulas for their calculation are presented, as well as their significance to model rocket flight.

**Acceleration and Energy**

Acceleration is defined. Positive and negative acceleration are discussed. The effect of the change of weight of a model rocket during thrusting is noted. The forces slowing down a model rocket during coasting are explored. The effects of gravity and drag upon an object thrown into the air are explored. The effects of speed upon drag are explored. The drag formula is stated and explained. The changes of momentum, potential energy and kinetic energy produced by forces acting on a moving body in the air are studied. The formulas for calculation of kinetic energy and potential energy of an object are presented and explained. The total impulse produced by model rocket engines, and the coding system used to state it, are explained. The importance of specific impulse and how to calculate it are presented.

**Staging**

The concepts of balanced forces and unbalanced forces are presented and explained. Positive and negative acceleration are explained. The force formula involving total force, mass and acceleration is presented and explored. The technique of staging is explained. How staging provides advantages in launching is explained. Momentum and the concept of velocity as a vector force are presented. Newton’s Second Law of Motion is stated.

**Satellites**

The concepts of primaries, satellites and orbits are presented and explained. The actual trajectory of a satellite is compared to the theoretical “no gravity” trajectory. Why a satellite must fall to remain in orbit is explained. Circular and elliptical orbits are described. The importance of rocket power in launching satellites is emphasized. The concept of escape velocity and the required escape velocity for an object to leave Earth are given. Some of the problems involved in placing an object in orbit are explored using a “super” model rocket. The relationships between satellite altitudes, velocities and periods are explored. Data about these aspects of satellites is presented. The importance of geosynchronous orbits is explained.

**Tech Tip™ on G Forces**

This program reviews acceleration, defines g force, gives a formula for calculating g force on a model rocket and gives the formula for calculating burnout velocity for a model rocket. Each of these is explained. A formula is given and explained for calculating the thrust produced by a model rocket engine. The g force produced on an Alpha model rocket at burnout when launched with an A8-3 engine is calculated using the formulas.

The student is left with the question of calculating the g force at burnout produced by launching an Alpha with a C6-5 engine. The answer is 13.17 g's. This is less than that produced by the A8-3 engine used in the example in the program! We must not forget that the A8-3 engine used in the example produces a peak thrust for rapid take-off, while a C6-5 engine produces a brief peak thrust and then a sustained burn at a lower thrust level. The C engine produces four times the total thrust of the A engine. The burnout velocity of the Alpha with the C6-5 engine is 716.45 ft./sec. The burnout velocity of the Alpha with the A8-3 engine was only 206.95 ft./sec.

While the A engine produced more g's at burn-out, the C engine produced a much higher burnout velocity. A core-burning engine produces only a brief, high-thrust burn. You may wish to consider the g force on an Alpha when it is launched with a B8-5 semi-core burning engine.

## THE PHYSICS OF MODEL ROCKETRY

These programs help you understand the interactions of mass, forces and motion involved in the flight of model rockets. You will learn about Newton's Laws of Motion, understand the concepts of acceleration, gravity, momentum, inertia and staging, learn the parts of a rocket and a rocket motor and the function of each part. You will also understand the similarities between full-scale rockets like the Saturn V and model rockets, know about satellites, orbits, primaries and the velocities and periods of satellites.

Clear graphics and easy-to-understand wording help you understand the physics of rocket flight.

You will have frequent opportunities to interact with the computer to test and reinforce your understanding.

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