A UNIQUE PRACTICAL
WAY TO STIMULATE STUDENT
ENTHUSIASM FOR THE SCIENCES

A TEACHER'S
GUIDE
TO MODEL
ROCKETRY

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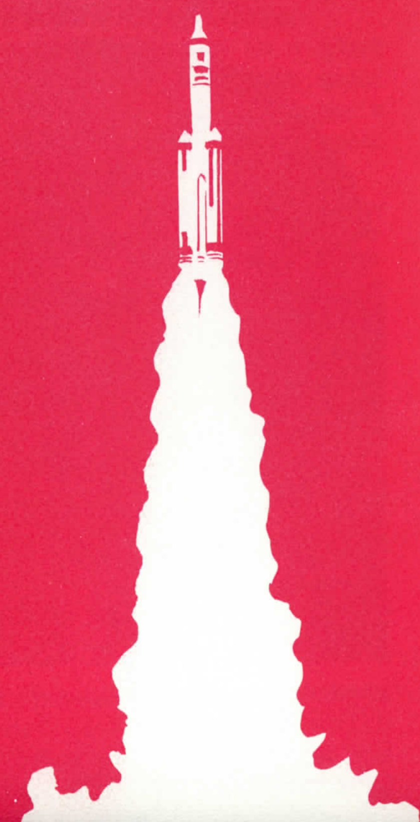


MODEL ROCKETRY HAS A PLACE IN THE SCIENCE EDUCATION CURRICULUM

IN PHYSICS
- Newton's laws of motion
- Vectors
- Rocket propulsion

IN AERODYNAMICS
- Principles of flight
- Wind tunnel effects
- Stability studies

IN MATHEMATICS
- One and two station tracking
- Trigonometry
- Geometry
- Algebra
- Calculus

IN ELECTRICITY
- Ohm's Law
- Communications systems
- Remote controls
- Telemetry

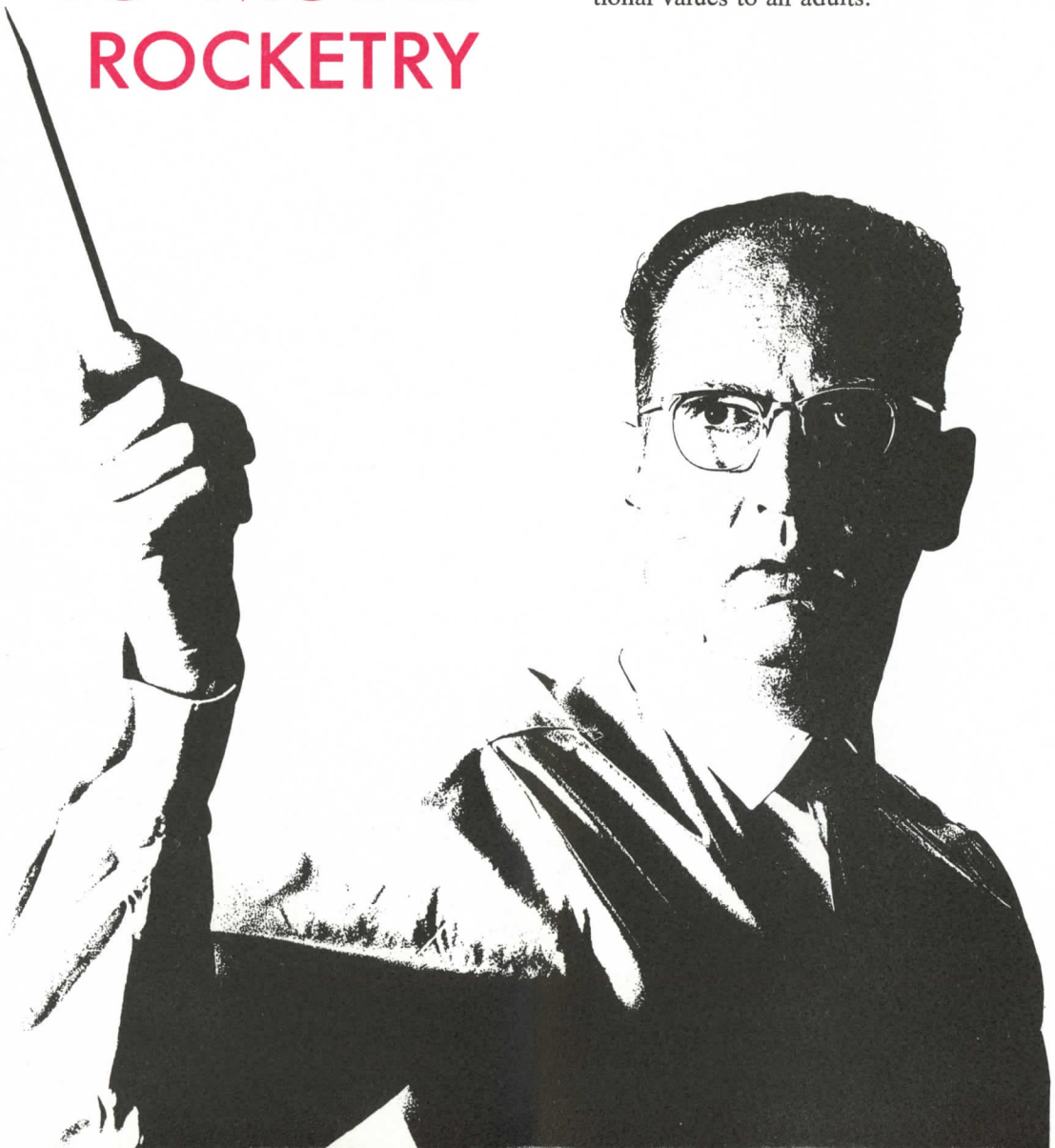
IN OPTICS
- Lens studies
- Aerial photography
- Mapping

IN METEOROLOGY
- Wind speeds at various altitudes
- Thermal and vertical air currents
- Weather prediction

A TEACHER'S GUIDE TO MODEL ROCKETRY

PURPOSE

To stimulate the teaching profession's interest in the use of model rocketry in science education curriculums. To suggest means of applying model rocketry within the curriculum. To provide a better understanding of model rocketry's safety program and educational values to all adults.



PRACTICAL WAY TO STIMULATE STUDENT ENTHUSIASM FOR THE SCIENCES

It is generally accepted that a student learns most rapidly and retains a larger part of what he learns when he can relate his learning activities with his other interests and needs, realizing that the subject of his studies will have a practical application at some future date. Arousing the student's interest and bringing home to him the practical value of learning are initial benefits that can be derived from model rocketry.

There are few young people who will remain unimpressed by the sight of a small rocket soaring hundreds of feet into the air and returning suspended by a parachute. Most of them will automatically ask the question, "Can I build one too?" The teacher can encourage them to do so, secure in his knowledge of the safety factors of model rocketry. Today's sophisticated form of model rocketry is indeed safe, sane and highly educational. The early amateur approach to model rockets created many problems that have since been eliminated by commercially prepared rocket engines.

Model Rocketry is Born

The advent of the first Sputnik in 1957 inaugurated a new scientific challenge to the young men and boys of America. In their own basement or backyards they set out to emulate the accomplishments of the professionals. The results were tragic. Stories of injuries and deaths attributable to rocket fuel experiments by amateurs appeared in news bulletins across the nation. Match heads, gun powder, zinc and sulfur and other mixtures were poured into gas pipes, conduit, or almost any other containers to form rockets. Probably the climax of this madness came in Floydada, Texas, when seven students were injured and a chemistry teacher killed by the explosion of a "small" demonstration rocket engine built by the teacher.

Commercial Engines Bring Safety

Model rocketry was intended from the beginning to provide a safe, reliable means to allow America's young enthusiasts to express their desire for the stars without injuring or killing themselves. In the years since its inception in 1957, model rocketry has enjoyed one of the best safety records of any sport or active hobby.

"ENTHUSIASM" (continued)

Model rocketry's excellent safety record is largely due to the nature of the propellant used. The model rocketeer does not build his own engine, but uses one which is commercially prepared and has been proven safe. The model rocket engine is non-metallic, highly insensitive to heat and shock, and limited in size. There are no 100 pound stove pipe missiles in model rocketry. A model rocket, by definition, weighs no more than 16 ounces, with most weighing between one and three ounces. The amount of propellant used rarely exceeds ¼ ounce.

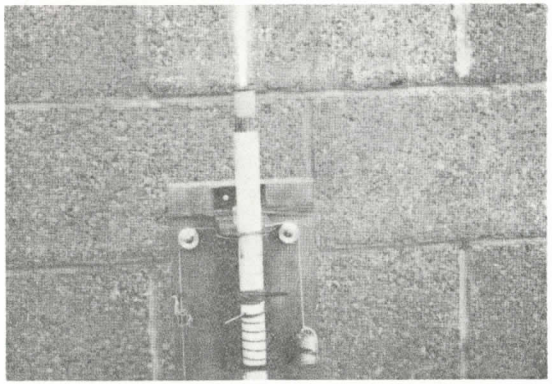
The typical model rocket engine consists of a non-metallic casing, a nozzle, propellant, a time delay charge, and an ejection charge to activate the recovery system. The rocket itself can attain altitudes of over 1,000 feet, single staged, and is returned by a parachute or similar device to be flown again and again by simply replacing the expended engine. While some high school senior chemistry classes may feel they are ready to start research into fuel mixtures, generally little will be learned by such a program since the student still does not have sufficient background or safe equipment to handle thermosetting resins, binding agents, inhibitors, and the other basic elements of modern propellant technology. Rather than waste time trying to find the best mixture of zinc and sulfur, an unsatisfactory and unreliable propellant at best, teachers are discovering the safety and reliability of model rocket engines and consequently are focusing the attention of students on the more rewarding aspects of rocketry.

A Dramatic Educational Aid

Aided by the excitement of actual rocket launchings the teacher can discreetly step in and encourage both cooperative and competitive activities. After the student has read some of the literature supplied by the manufacturer, listened to a few simple explanations by the teacher, and discussed rocketry with his peers, he begins to understand some of the underlying principles associated with rocketry, such as propulsion by reaction, center of mass, stability, drag, acceleration, and trajectory. He has by no means mastered these fields, but he is beginning to realize their existence and recognize their value. In short, he is becoming interested in learning.

The actual methods used by the teacher are not of prime importance, and the teacher need not be a science expert to use model rocketry. By discreet manipulating, the teacher can get the enthusiasm of the students to lead them into studying areas the teacher might not be able to cover in class.

PHYSICS



Simple static thrust stands, made from common materials, can be used to teach much about rocket propulsion, including specific impulse, total impulse, average thrust and mass ratio.

Rocket propulsion can be demonstrated more effectively and impressively by using either a model rocket engine and simple static thrust stand, or a model rocket engine on a flying rocket, than by balloon and blackboard.

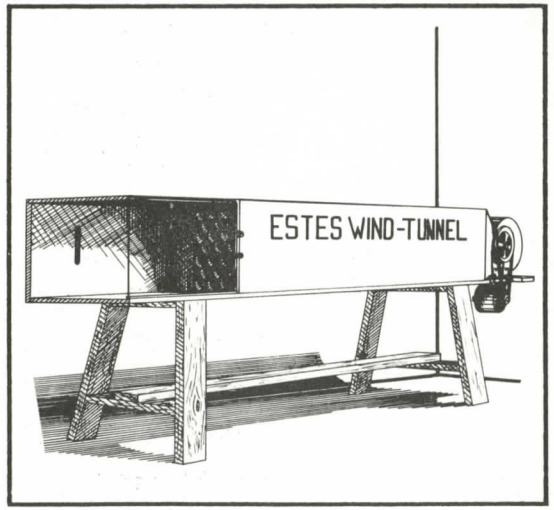
Similarly, vector forces can be demonstrated by showing the relative effects of wind and forward velocity flight.

Acceleration and motion can be demonstrated in numerous ways, along with g forces, time velocity relations, average velocity, negative acceleration, trajectory, air drag effects and theoretical vs actual performance with no more than a model rocket, a simple tracking device, a stopwatch, and the blackboard.

In the area of force alone, model rocketry provides for interesting and clear demonstrations of Newton's laws of motion. The effect of rocket weight on rocket velocity and altitude can demonstrate that the body at rest tends to remain at rest and the body in motion tends to remain in motion. The take off and flight of the model rocket shows that unbalanced forces cause the body to accelerate, and the engine itself, during operation, shows that for every action there is an equal and opposite reaction.

Aerodynamics

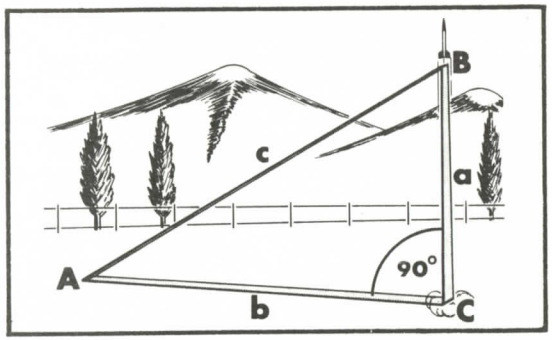
Rocket gliders offer a dramatic means for aerodynamic demonstrations.



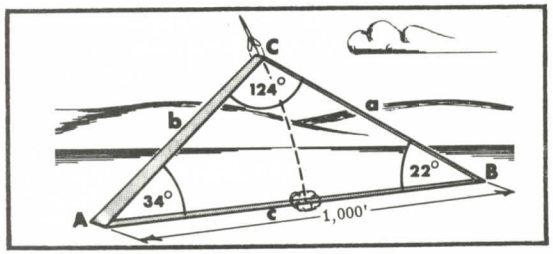
Wind tunnels especially designed for checking the stability of model rockets can be built by a student with moderate experience in woodworking.

The wind tunnel, an ideal classroom project, offers an opportunity to study the stability of model rockets by determining the center of gravity and the center of pressure. Airfoils can be studied and demonstrations made of vertical, longitudinal and lateral axes.

MATHEMATICS



The above single station tracking diagram illustrates an application of trigonometry used in determining altitudes achieved during a rocket's flight.



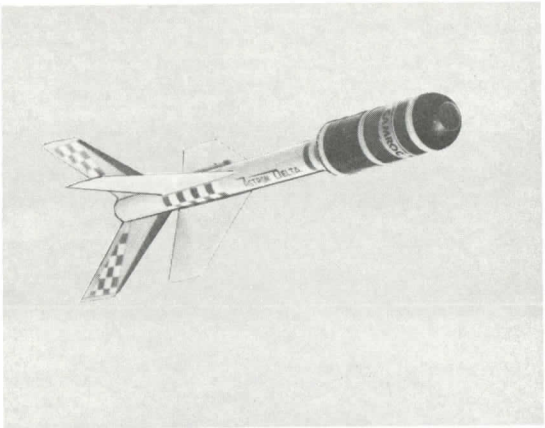
Two station tracking as shown above provides a more accurate altitude computation.

In the area of mathematics the determination of a rocket's altitude, by one or two station tracking, provides a very effective means of introducing trigonometry. The calculation of rocket flight characteristics can involve geometry, algebra and even calculus.

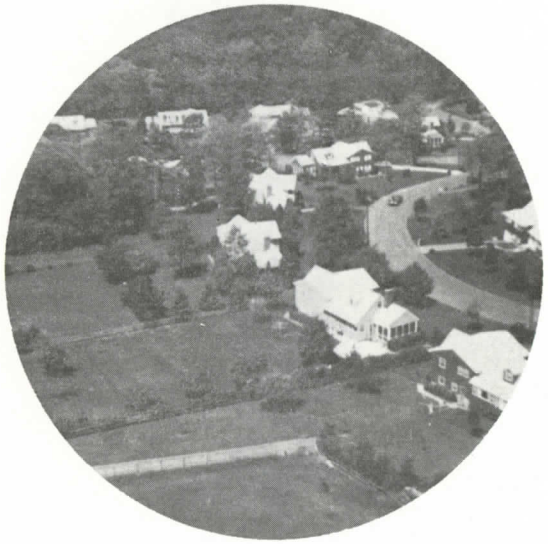
ELECTRICITY

Electricity can be covered in the design and function of launching systems, communications devices and other accessories for model rocket operators. Ohm's law can be demonstrated in the construction and operation of the launching systems. The system is required to develop sufficient heat in a conductor (the ignitor) to reach an ignition temperature of 1100°.

OPTICS



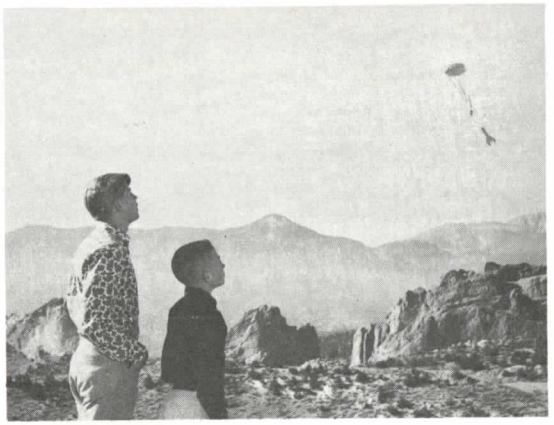
Principles of camera construction and operation can be learned with the rocket borne camera.



Clear, detailed photos can be obtained with rocket cameras.

Optics and photography can be introduced by the design and launching of a camera rocket, leading into studies of lenses, reflection and refraction, studies of the eye, telescopes, aerial photography and mapping.

Meteorology



Studies of air currents can lead to further interest in meteorology.

In meteorology the rocket can provide for studies of wind speeds at various altitudes and studies of thermal and vertical air currents.

MORE INFORMATION

If more information on projects, supplies, and literature is desired, Estes Industries will be pleased to furnish all possible assistance. Estes Industries recognizes the paramount importance of education in American life and is prepared to devote their staff's efforts in assisting you with your science education curriculum.

Mail to: ESTES INDUSTRIES, INC.
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"ENTHUSIASM" (continued)

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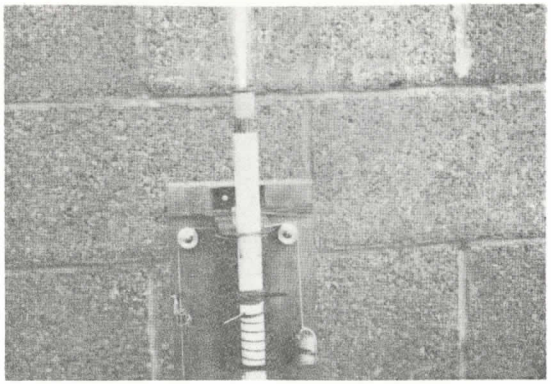

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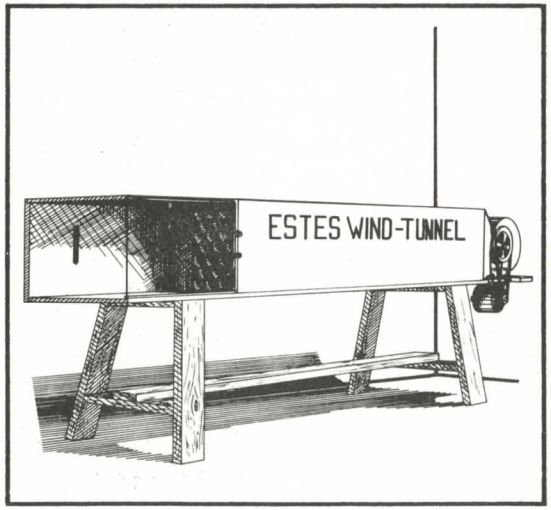

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