Rockets

Lesson Plan: Rocket Physics

Grade Level: 11-12

Subject Area: Science

Time Required: ***Preparation:*** the rocket should already be built, so preparation time involves preparing the rocket for flight (about 5-10 minutes)
Activity: 10 minutes plus time to do calculations and write up the lab report.

National Standards Correlation:

Science (Grades 11-12)

- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Science and technology Standard: Understandings about science and technology.
- Unifying Concepts and Processes Standard: Evidence, models, and explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Physical Science Standard: Motion and forces.
- Science in Personal and Social Perspectives Standard: Science and technology in local, national, and global challenges.
- History and Nature of Science: Nature of scientific knowledge.

Summary: In teams of five or six, students will investigate the relationships between impulse, momentum, kinetic energy, potential energy, and aerodynamic drag. They will do this by launching a model rocket and observing its average mass, the average force on the rocket, the impulse delivered by the engine, its velocity at engine burnout, and its height at engine burnout. Appropriate calculations can then be made.

Objectives: Students will:

- Build their own simple astrolabes.
- Calculate theoretical values for the maximum velocity and height of the rocket.
- Measure the maximum height and approximate maximum velocity of the rocket.
- Calculate the energy lost to atmospheric drag.

Materials: You will need:

- Protractor
- String
- Drinking straw
- Clear plastic adhesive tape
- Small mass (a large washer or an eraser)
- Model rocket, preferably a large, slower accelerating rocket, like the Big Bertha
- Rocket engines that provide a fairly constant force, such as the B-4 or C-6
- Launch pad with igniter system
- Wood splint and match or lighter
- Wadding
- Estes catalog
- Balance

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Procedure:

A. Making the Astrolabe

Each student will attach the drinking straw to the flat side of the protractor with the adhesive tape. The string (about 50 cm.) is to be attached to the protractor as shown, and the mass is to be attached to the string. (See Fig. 1.)

B. Activity

1. Find the total mass of the rocket and engine before launch.

2. Take the rocket, launch equipment, and students to a field large enough to accommodate the rocket and engine performance.

3. Light the wood splint and blow it out. Use the smoke to determine the direction of the wind.

4. Place students (trackers) with astrolabes on opposite sides of the rocket at a distance of 50 meters from the launch pad. Make sure that the students and the launch pad are in line with the wind direction.

5. Place the safety key in the launcher, start a ten second countdown, and have a student launch the rocket. Have the trackers follow the rocket through their drinking straws, up to the point where the engine stops burning. At that point, have other students record the angles of elevation of the rocket by noting where the strings crosses the protractors. (Remember to subtract the angle on the protractor from 90o to get the correct angle of elevation.)

C. Analysis

1. Using the angles of elevation and the length of the line between the trackers (100m), students can calculate the height of the rocket at burnout using trigonometry. Please examine figure 2. It can be shown, through the use of the law of sines, that h = (100•sinA•sinB)/sinC.

2. Impulse is equal to force multiplied by the time over which the force acts, if the force is constant. The impulse of the engine is given on the engine and in the catalog. Net impulse, which is the impulse of the engine minus the impulse from the weight of the rocket (Imp - W• t) is equal to the change in the momentum of the rocket, mavg(vfinal-vinitial). The average mass can be calculated by taking the measured mass of the rocket and engine, and subtracting one-half of the mass of the fuel. The mass of the fuel is in the catalog. The weight of the rocket and engine is mavgg. As the initial velocity of the rocket is zero, the theoretical final velocity can be calculated easily: vfinal = (Imp - W • t)/mavg.

3. As the engine selected provides nearly uniform force, acceleration should be fairly constant. In that case, h = vavg • t, and vavg = vfinal/2 (why?), so the vfinal = 2h/t. Thus, the actual final velocity can be calculated and compared to the theoretical value.

4. Kinetic energy is computed as follows: KE = ½mv2. Compute the theoretical and actual values of the kinetic energy of the rocket at engine burnout, and use them to calculate the energy lost due to atmospheric drag.

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Assessment/ Evaluation: Students should write lab reports indicating the purpose of the experiment, the procedures, the data obtained, and the conclusions drawn. They should determine the percent difference between theoretical values and experimental values of maximum velocity and kinetic energy.

Extension: Given the kinetic energy of the rocket at burnout, what is the maximum height that the rocket should reach (if the parachute didn't pop too early)? What effect would aerodynamic drag have on this calculation?

References:

Zitzewitz, Paul, et al, *Physics, Principles and Problems.* New York: Glencoe/McGraw Hill, 1995.

Stine, G. Harry, *Handbook of Model Rocketry.* New York: John Wiley & Sons, Inc, 1994.

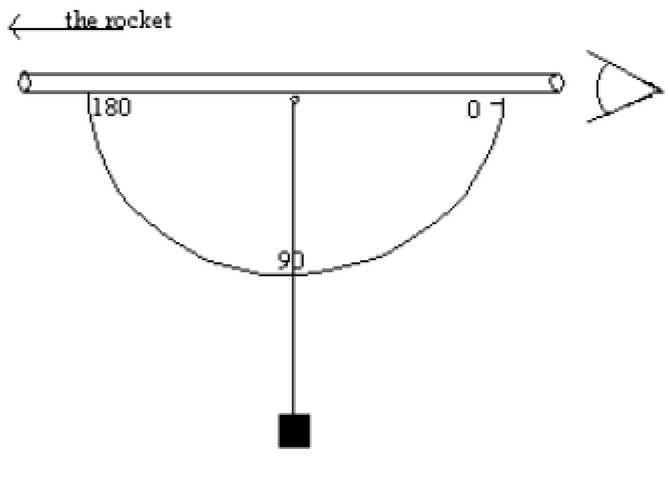

Figure 1

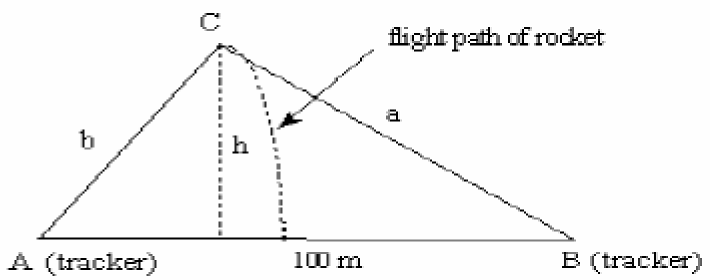

Figure 2

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