GRAND PRIX

An Applied Physics Project

Teacher Note: This is an on-going project. It can be done consecutively over several days or 10-20 minutes devoted to the project over a number of class periods. While the purpose of the project is to integrate processes used in industry into principles taught in physics, portions of the project can be selected and used according to the individual needs of the students.

Objectives

- Build a vehicle that can be propelled using the energy stored inside an inflated balloon.
- Work in a group to select the best properties of each individual car to produce a single best design.
- Produce a final design using the best features of all the cars.
- Build a car from the final design.
- Develop a logo for the car.
- Test the car to determine the distance traveled.
- Determine the average velocity of the car from distance and time.
- Determine the average acceleration of the car.
- Determine the average forces acting on the car and the balloon.

Resources

Printed Sources

Hewitt, Paul. "Conceptual Physics" Chapter 2, Motion; Chapter 4, Newton's Second Law of Motion-Force and Acceleration; Chapter 5, Newton's Third Law of Motion – Action and Reaction; Chapter 8, Energy.

Murphy, James T., Hollon, James Max, Zitzewitz, Paul W. "Physics: Principles & Problems". Chapter 3, Motion in a Straight Line; Chapter 7, Motion in Two Dimensions; Chapter 10, Work, Power and Simple Machines.

Websites

http://www.balloonhq.com/balloon_car/9.html
http://www.srv.net/~chris/gt.html
http://www.ceeo.tufts.edu/graphics/VintageHills/ballooncar.html
http://www.alaska.faa.gov/flt_std/aved/teachers/Rcar.html

Materials:

- Coke bottles, small boxes, small bottles, CD's, canning jar lids, straws, arrow cut-off's, CD's...or any other material found around the home the student chooses to use.
- Scotch tape, masking tape, or duct tape.
- Hot glue guns and glue sticks.
- Small pliers can be useful.
- Balloons.
- Styrofoam meat trays or other craft material to make logos.
- Paint
- Metric measure tape or meter sticks.
- Stopwatch.

Instructional Concepts

- As an introduction to motion students build a balloon-powered car from materials commonly found around the home or physics lab.
- Measurement of the distance the car travels and the time it takes for the car to cover the distance, enables the student to calculate the average velocity of the car.
- The car with the maximum acceleration can be determine by observing which car covers .50 m in the shortest period of time.
- Greatest "endurance" can be determined by observing which car remains in continuous motion for the longest period of time.
- The car that travels the greatest displacement is determined by measuring the total forward displacement that the car travels after releasing it from rest.
- Once the students complete this initial exercise, they use their problem solving skills to combine the best features of four cars to build a single car that is superior to the individual cars.
- As the course progresses, the student can use the data collected data to determine average net force. (See attached student data sheet)

Project Development

Construction of Individual Cars

a. Each student will build a vehicle that can be propelled across the room or down the hall using only the energy of stored air inside a balloon for the accelerating force.
b. The balloon provided at the Grand Prix itself, will be the official one for the competition. The one provided initially can be used for purposes of experimentation. The car must traverse the course unguided, accompanied by the balloon, using only the air inside the balloon for propulsion and must travel on wheels.
c. The student must confine their use of materials to the type of equipment commonly found at home or around the physics lab. Items such as tape, rubber bands, glass tubing and straws may be used. Costly materials are expressly forbidden.
d. The wheels on the car must not have started their useful life as wheels.

e. Each car will have two attempts in the competition, and may be modified between runs. (See Student Handout)

Testing of the Individual Cars:

a. The teacher will supply each student with a balloon.
b. **Greatest Acceleration** will be tested by marking off a distance of 50 cm. Each student will place their car on the start line and release it when the teacher says go.
c. The teacher or a designated recorder will record the time at which each car passes the 50 cm mark. (Photogate timers can be used if available)
d. To test the **Greatest Distance**, each student will release his or her car when the teacher says "Go." The distance the car travels and the length of time it takes the car to cover the distance will be recorded. The students will use this information to calculate the velocity of the car.
e. **Greatest Endurance** will be tested by having the student release the car when the teacher says Go. The length of time the car remains in continuous motion will be recorded.
f. It is suggested the teacher give awards for each of the above three categories. (See example of award that follows). The teacher may wish to give an award to each student in the class.

   Other suggestions for awards are: the best looking car, the car least likely to move, the car most likely to fall apart, or any other humorous awards the teacher might want to assign based on the way the car is designed.

Working in Groups Redesigning Individual Cars Into One

a. Students will be divided into groups of four. Each person in the group will assume one of the positions as outlined below.
b. The group will discuss the positive and negative aspects of each individual car.
c. The group will discuss how certain features of the cars can be combined to make one vehicle. The group must use at least one part from each car. The balloon does not count!
d. The group will discuss a name for the car with each person contributing suggestions as to what the logo should be.
e. The Engineer will take home all four cars and decide how to redesign them into one vehicle. The engineer will submit a report to the project manager within two days.
f. The Project Manager will submit a report to the teacher detailing the group's work.

Group Positions:

The <u>Project Manager</u> will:

1. Record the materials used by each person in the original car.
2. Write a set of directions to be used by four assemblers in putting the car together.
3. Work with the other members of the teams making sure they are carrying out their individual duties.
4. Design a logo for the car.

5. Make sure the team remains on task.
6. Make all reports to the teacher.

The <u>Engineer</u> will:

1. Work with the group to design a car that will meet all the requirements as set forth in the original Grand Prix using only the materials used in the original exercise.
2. Modify the car to assure that it runs straight for at least three meters.
3. Assist the Project Manager in writing a set of directions for the assemblers to use in putting the car together.
4. Assist the project manager in designing a logo to place on the car

The <u>Designer-Draftsperson</u> will:

1. Produce a scale drawing of the car design showing the front, back, side, top and bottom view.
2. Show all measurements on the drawing.
3. Make any modifications in the scale drawing as may be required by the engineer.
4. Produce a scale drawing of the logo showing all measurements.

The <u>Quality Controller/Assembler</u> will:

1. Verify that the car meets all requirements as set forth in the original Grand Prix.
2. Verify that the car runs at least three meters in a straight line.
3. Verify that the final design matches the scale drawing.
4. Verify that the Bill of Materials matches the final design.
5. Use the scale drawing to cut out and finish a logo to go on the car.

Group Final Design

a. The group will discuss the Engineers report to the project manager.
b. The group will decide on the final design of the car.
c. The group will decide on the final design of the logo.
d. The Designer-Draftsperson will submit a scale drawing of the new car within two days.
e. The Designer-Draftsperson will submit a scale drawing of the logo within four days.
f. The project manager and the engineer will write a Bill of Materials for the car.
g. The project manager will submit the engineer's report to the teacher along with modification suggested by the group, and the bill of materials.

Working together as a team to produce the new car.

a. The draftsperson will submit the scale drawing of the new vehicle for project manager's approval.
b. After approval is obtained from the project manager, the engineer and the project manager will work together to write a program ("set of instructions") for the assembler to use in constructing the automobile.
c. The draftsperson will produce a scale drawing of the logo and produce a bill of materials for the logo.
d. The assembler will cut two sets of materials for the car from the bill of materials produced by the project manager and the engineer.

e. The assembler will cut two sets of materials for the logo.
f. The group will build and test a prototype model of their car.
g. The group will make a logo to go on their car.

Assembly of Cars by Another Group:

a. Each group will receive the materials, scale drawing and program of another group.
b. The group will follow the directions and drawing to assemble the car. There should be no consulting with the group who originally built the car.
c. The quality control person of the assembly group will:
    1. Verify the car meets all requirements as set forth in the original Grand Prix.
    2. Verify that the car runs at least three meters in a straight line.
    3. Verify that the final design matches the scale drawing.
    4. Verify that the Bill of Materials matches the final design.
d. Return the cars to the original group to make any necessary modification.
e. The original group will test the car in the same manner as outlined in the original Grand Prix. They will also verify that the car runs straight.

Students' collection of data:

a. The student will collect data on distance and time for three trials.
b. The student will determine the mass of the car.
c. The student will use the data collected to determine the average velocity, average acceleration, and average force.

Evaluation between and among groups.

a. Each person in the class will evaluate the group that assembled their car and evaluate the group whose car they assembled. (Refer to Group Evaluation sheet that follows.) This is done on a scale of 1-5 with 1 being low and 5 being high.
b. Each person in the group will evaluate the individual members of their group. (Refer to Group Member Evaluation that follows.)

Suggested Grading Rubric:

Car ..... **25 pts**.
Does the car look neat? Does it appear to be well thought out? Does it run appropriately?

Bill of Materials ..... **5 pts**.
Are all of the materials listed that are necessary to build such a car? Are the correct number listed to reproduce 150 cars?

Instructions ..... **25 pts**.
Are the instructions clear and concise? Are the instructions given in a logical order? Are the instructions divided equally such that four people can work together during the assembly process?

Drawing ..... **25 pts**.
Does the finished product match the drawing? Does the drawing show a front, back, side, top, and bottom view. Is the drawing scaled correctly?

Evaluation ..... **20 pts**.

The individual and team member evaluation along with the student data sheet can be used to make this determination.

Additional Projects

Additional studies can be done with acceleration using photogate timers and computers. Students can be placed at one-meter intervals with stopwatches and the time recorded at each interval. The students can then graph a "picture" of the motion of their car. Another idea would be to use tape timers to evaluate the velocity and acceleration of the car. The tape could be attached to the body of the car and evaluated when the car stops.

Applications

The student will produce a list of all industry skills required to design, produce, test and market a wooden car kit propelled by a carbon dioxide cartridge.

The student will produce a list of which classes they have taken to learn the skills identified for producing the car kit.

The student will produce a list of various industry functional areas and teams required to produce and market the cars: i.e. research and design, manufacturing, human resources, marketing and quality control.

The student will design a layout for a plant to produce an automobile.

The students will design a container to hold the cars.

Integration Across the Curriculum

After identifying the functional areas and team members required to produce and market the cars, the students will work with teachers and students in other disciplines on completing the task of building the toy cars.

Physics students will prepare the design and specification sheets for the toys.

Chemistry students will evaluate different types of paint to be used on the automobile.

Art and drafting students will work to prepare the industry logo and the drawing of the cars.

English students will produce a promotional scheme for selling the cars.

Computer science students will help design a web page to market the cars.