Re-Entry Vehicles

"Aviation is the branch of engineering that is least forgiving of mistakes."
Freeman Dyson

Lesson #3 Helicopters, Whirligigs and Thingamajigs

Grades K-6

Duration 45-60 min

Engineering Criteria: Design a vehicle that floats elegantly in a vertical wind tunnel.
Design Constraints: Materials

Learning Objectives
- Students will use a variety of materials to design crafts that can float on a column of moving air.
- The children will observe and experiment with aerodynamics, and the effects of weight and balance in designing an aircraft.
- Air pressure and
- By using the Engineering Design Process they will try a variety of iterations to achieve their goal.
- Discussions and diagrams will be used to explain and describe the consequences of their design choices.

Materials
- Vertical Wind Tube

Exploratorium Tube Construction Directions online at
http://www.exploratorium.edu/pie/downloads/Wind_Tubes.pdf
- Scissors
- Helicopter blackline masters
- Variety of paper / plastic / styrofoam cups
- Tape (electric, scotch, masking)
- Paper (card stock, construction, copy)
- Any materials one could imagine could be used for a light aircraft

Activity

Teacher Introduction

Tell students that at some point astronauts need to return to Earth. Demonstrate how gravity will naturally pull objects towards the planet. Remind students of the

Engineering Design process and tell them that for the next few experiments they will be solving the problem of having astronauts return safely from space.

Discuss what happens if the astronauts come back too quickly or have a hard landing. Even the youngest students can understand friction by having them rub their hands together quickly. Explain to the students that when objects, including meteors, enter our atmosphere their high rate of speed causes friction with oxygen and the objects often catch fire or explode.

Video clips and photos are available online, and listed in the Resources section of this unit, that highlight how spacecraft use parachutes. They are used to slow the re-entry of spacecraft returning from the International Space Station. They are also used in craft delivering robots to Mars.

For older students one could mention the *Columbia* disaster in 2003 of the dangers involved in re-entry. Another good reference, especially in relation to parachutes and engineering space suits, is Felix Baumgartner's record-breaking free fall jump from and altitude of 24 miles. There are video clips about the jump in the resources section of this unit.

This is the type of lesson where the teacher must decide how much guidance they give students. For younger students one could show models of various helicopters and flying devices. The older children could be given more free rein in deciding how to tackle the engineering problem.

One should remind students that we will be using air pressure to create crafts that glide gently through the air. Refer to the rocket balloon and antacid rocket lessons in discussing how gases can exert pressure and even lift solid objects.

Review the Engineering Design Process briefly and tell them they will be focusing on the *improve* phase of the engineering cycle.

Student Production

1. Have students sketch some initial design ideas and talk with partners about possible solutions.
2. Give students trays with a variety of materials and have them start engineering their fantastic flying machines.
3. Teacher circulates the room checking on progress, innovations and discoveries.
4. Students draw pictures of their most successful designs.

Assessment

Have students share their successes and discoveries. Focus on how they changed their craft as they tried new things and learned from their own designs and that of others. A natural part of engineering is learning from others both during and after the activity and that should be highlighted as productive and the way engineers and scientists further their work in the real world. They can also draw their final products and these images and the actual machines can make for a great bulletin board display.

Wind Tube Assembly
Low-Budget / High Flying Excitement Version

The Exploratorium in San Francisco devised the Wind Tube lesson and although some of the materials are quite easy to obtain I found some alternatives that might be more accessible and affordable for teachers. The original Wind Tube instructions can be found at http://www.exploratorium.edu/pie/downloads/Wind_Tubes.pdf.

Budget Friendly Materials

- **Dowels**
- **Sheet Protectors**
- **Electrical (or masking) Tape**
- **Binder Clips**
- **Rubber Bands**

Dowels - To give the tube vertical strength I used **dowels** that were attached to the fan by **rubber bands** threaded through its frame. I found four dowels to be adequate for small and medium sized fans, but for larger fans five seemed to work better. Having thinner dowels can make it easier for the blades to turn, but the trade off is that they can be a little more flimsy so you might need more of them to hold up the sheet protectors.

Sheet Protectors - To create the transparent tube I used **sheet protectors** connected together by staples and **electrical tape** (although **masking tape** can do the job, it might not endure the jostling enthusiasm of young aviation engineers for long). The number of sheets required depends on the size of the fan. I found that for a 9 inch fan I need a 4 x 4 array of sheet protectors. I also recommend using lighter weight sheets. Initially I tried heavier ones, but they also had weight that can be difficult for the dowels to support. To attach the sheets to the dowels I used binder clips. I also recommend leaving a few inches of space between the bottom of the tube and the fan since this helps keep the air flow from being too strong and allows for easy retrieval of flying devices that have settled on the fan.

Fans - I would recommend a fan of at least 12 inches in diameter. This will allow for a good amount of air flow and permit more than one flying device to be tested at a time.

CAUTION: When buying a fan be sure to check whether there is room around the edges of the fan to allow a dowel to pass through without being within the zone of the moving blades. It is much easier to attach the dowels if the rod can pass all the way through the fan without interfering with the movement of the blades.

Photos on the following page help demonstrate the tips mentioned above.