EXHIBIT: **INNOVATION CLOUD**

ACTIVITY: # Hot Air Balloon

How can you overcome the pull of gravity to create flight?

DISCOVER

Students will investigate the effects of different variables on flight as they search for solutions to create a working hot air balloon using simple objects. The finished product should reflect correct principles of both physics and design—it should successfully fly and look good.

MATERIALS

For each balloon you will need:

- A lightweight(6-10 microns) plastic trash bag (We used 10-gallon, 8.6 micron Kirkland brand bags from Costco, but you can experiment with different sizes & styles)
- 4 birthday candles
- Matches or a lighter
- Balsa wood - 1 piece of 1/8" x 1/8" at least 10" long and 2 pieces of ¼"x ¼" at least 13" long each (You can also use straws or other lightweight material)
- 4-6 feet of thread
- Aluminum foil - about 4" square
- Scotch tape

Optional supplies:

- Cardboard or other material to protect the floor from dripping wax
- A pitcher or bucket of water nearby (just in case)
- Markers, paint, and other decorations

PONDER

- Gravity affects all objects on the earth. How can you overcome the effects of gravity to create flight?

Grades: 6th-12th

Group Size: 3-7 people per group

Time: 1-2 hours

Utah Core Curriculum:

- 6th Science 6.1 e
- 7th Science 1.3 a, b, c
- 8th Science 1.3 b
- Physics 2.3 c

Process Skills & Higher Level Thinking Skills:

- Observing
- Investigating
- Problem solving
- Applying concepts
- Evaluating
- Creating

WHAT'S GOING ON?

Hot air balloons rise because of buoyancy. There is more air pressure at sea level (about 14.7 psi) than at higher altitudes because the air is supporting the weight of all the air above it. Because air pressure is generally greater below an object than above, air pushes up more than it pushes down. But this buoyant force is weak compared to the force of gravity. For buoyancy to lift an object, the object has to be lighter than an equal volume of the air around it.

Hot air balloons rise because warm air is less dense than cool air, so the mass per volume is less. One cubic foot of air weighs approximately 28 grams. If you heat that air by 100 degrees F, it weighs about 7 grams less. Therefore, each cubic foot of air contained in a hot air balloon can lift about 7 grams. That's not much, which is why it is important that the balloon have as much volume and as little mass as possible.

Archimedes figured out this principle of buoyancy more than 2,000 years ago, but nobody built a successful hot air balloon until 1783.

Step 4: The alumunium foil catches dripping wax and protects the wood frame from catching on fire.

- The first successful hot air balloons were made in 1783. The same basic designs are still being used today. What physics principles do you need to know to create a hot air balloon?
- You've probably heard that hot air rises. Why is that?
- What are volume, density, mass, and air pressure? How do they affect flight?

EXPERIMENT

There are several ways to create a hot air balloon. Listed below are the steps of one way to make a small balloon that will fly in your classroom. For older students, rather than giving them the step-by-step directions below, talk about the various factors that affect lift and give them a variety of materials to design their own hot air balloon.

You may be tempted to do this activity outside, but if there is any wind at all, the balloon will not fly and there is a greater likelihood that the flame will spread. The best location is an open room without fire hazards that is relatively cold (a science classroom or gym work great).

Safety Note: This is a very fun activity. However, it can also be dangerous, as you will be using open flame. Be sure your students can handle the responsibility. You may want to have the students design and create the balloon (steps 1-6) then light the candles and handle the balloon while it is flying yourself (steps 7-8).

1. If the plastic bag you are using is gathered at the bottom, cut off the bottom just below the seam. Lay the bag flat and tape the end shut. (This is to increase the volume of the bag).
2. Cut the 1/8" balsa wood into two 13" segments and the 1/4" wood into one 10" segment. Tape these pieces to form an "H" with the longer segments on the side and the shorter one forming the horizontal bar.
3. Wrap a small piece of aluminum foil around the middle of the horizontal bar of the "H" so that it covers about 4" of the wood and has sides that come up 1/4" - 1/2" (to catch the melting wax from the candles).
4. Cut 3 or 4 candles in half. Trim the cut ends so that each of the half candles has a wick showing. Using the match, melt the bottom of each candle and stick it inside of the aluminum foil "boat" on the wood frame.
5. Decorate your hot air balloon (optional).
6. Tape the edges of the "H" to the open edge of the bag.

Step 9: Set the lit balloon carefully on the floor.

Step 10: Flight! Watch the balloon carefully as it flies and extinguish the fire before it reaches the wood frame.

7. Tie the thread to the wood frame to keep it from flying away from you.
8. Put a piece of cardboard or other cover on the floor to protect from dripping wax. Carefully light the candles while having someone else hold the top of the bag so that the sides don't touch the lighted candles.
9. Set the lit balloon on the cardboard on the floor, holding the sides away from the flame as it fills with hot air.
10. After a minute or two, the balloon will fill up with heated air and rise. Hold on to the string so you can keep it away from anything flammable in the room. The wax from the candles may drip a little. Watch the balloon carefully.
11. Use the string to bring the balloon down and blow out the candles before they melt all the way down. If you let the candles burn all the way down, the wooden frame may catch on fire.
12. If you have time, change the variables (size & weight of the bag, number of candles, shape of the frame, different materials, etc.) to investigate how changes affect the lift.

EXPAND

Experiment: How can the principle of buoyancy be applied to objects other than hot air balloons? (For example, boats, things that float or sink in water or other fluids.)

Extend: This activity can be used in conjunction with other activities to teach about density, air pressure, or inventions.

Discuss: What hot air balloons are being used for exploration? For information on current NASA projects, see www.nsbf.nasa.gov.

Exhibit: The Leonardo's Innovation Cloud highlights local inventions and innovations. How is the process to develop a hot air balloon similar to the process these innovators used?