BelleStar
and
HeatWave
Teacher Resources

> ***You haven't seen a tree until you've seen its shadow from the sky.***
>
> **-** Amelia Earhart

July 2015

Acknowledgements:

It is important to recognize and credit the resources that were used in the preparation of this manual. When doing the research I discovered a range of references that contained excellent material and borrowed heavily from those resources. Why reinvent the wheel?

- ***Rebecca Elkins,*** *The Air Fair Balloon Company, rebeccaelkins@hughes.net – Much of the material in this manual is credited to Rebecca who was instrumental in collecting it .*
- ***Bonnie Dixon,*** *Jordan School District, Utah – My personal thanks to Bonnie for sorting out the myriad of "stuff" and cataloging that which had value and convincing me to jettison that which did not.*
- ***Wikipedia*** *- http://en.wikipedia.org/wiki/Hot-air_balloon*
- ***Fellow Pilots, Crew Members and Friends***

To assist schools and educators in providing a greater understanding of ballooning and LTA flight we have developed a Hot Air Balloon program for K-12 schools.

Index

Resource Sheet

Reference Books:

- **HOT AIR BALLOONS** by Donna S. Pfautsch (Trillium Press 1993) An excellent 75 pg. book of definitions, lesson plans, experiments and resources. ***This is an outstanding resource book for teachers with many higher-level thinking activities.***
- **A Rainbow Balloon** by Ann Lessen
- **Balloon Flying Handbook** by United States Federal Aviation Administration
- **Ballooning** by Anthony Smith
- **Ballooning** by Dick Wirth and Jerry Young
- **Early Flying Machines** by Henry Dale
- **Hot Air Ballooning** by Terrell Publishing Inc.
- **Hot Air Balloons** by Christine Kalakuka and Brent Stockwell
- **Images of Hot Air Balloons** by Ailsa Spindler
- **National Geographic magazines**…check the spines for balloon articles. Comb thrift stores where multiple copies can be very inexpensive. There are no fewer than 8 issues with articles about various ballooning endeavors.
- **Research Balloons**by Carole Briggs
- **Smithsonian Book of Flight for Young People** by Walter Boyce
- **The Joy of Ballooning** by George Denniston

Children's Books:

- **Altoona Baboona** by Janie Bynum
- **Ballooning (First Book)** by Phyllis J. Perry
- **Ballooning** by Dick Wirth and Jerry Young
- **Cinderella and the Hot Air Balloon** by Ann Jungman and Russell Ayto
- **Come Down Now, Flying** Cow by Timothy Roland
- **Curious George and the Hot Air Balloon** by Margret and H. A. Rey
- **Free Spirits in the Sky** by John Christopher Fine
- **Hot Air: The Mostly True Story of the First Hot-Air Balloon Ride** by Marjorie Priceman
- **Hot Air Ballooning Coloring Book** by Steve Zipp (Specialty Publishing Co, 1982) Great for coloring ideas for primary students.
- **Hot Air Henry** by Mary Calhoun
- **James and the Red Balloon** by D. Mitton, T. Palone and T. Permane
- **Little Polar Bear and the Big Balloon** by Hans de Beer
- **Mr. Mombo's Balloon Flight** by Stephen Holmes
- **Smithsonian Book of Flight for Young People** by Walter J Boyne
- **Time For Kids**, News Scoop Edition, April 2 1999, Vol. 4, No.22 (Breitling Orbiter 3)
- **The Amazing Air Balloon** by Jean Van Leeuwen
- **The Great Town and Country Bicycle Balloon Chase** by Barbara Douglass
- **The Great Valentine's Day Balloon Race** by Adrienne Adams
- **The Mystery of the Hot Air Balloon** (Boxcar Children Mysteries)
- **The Number Team and The Great Race** by Sally Hewitt - A Fun with Math Book

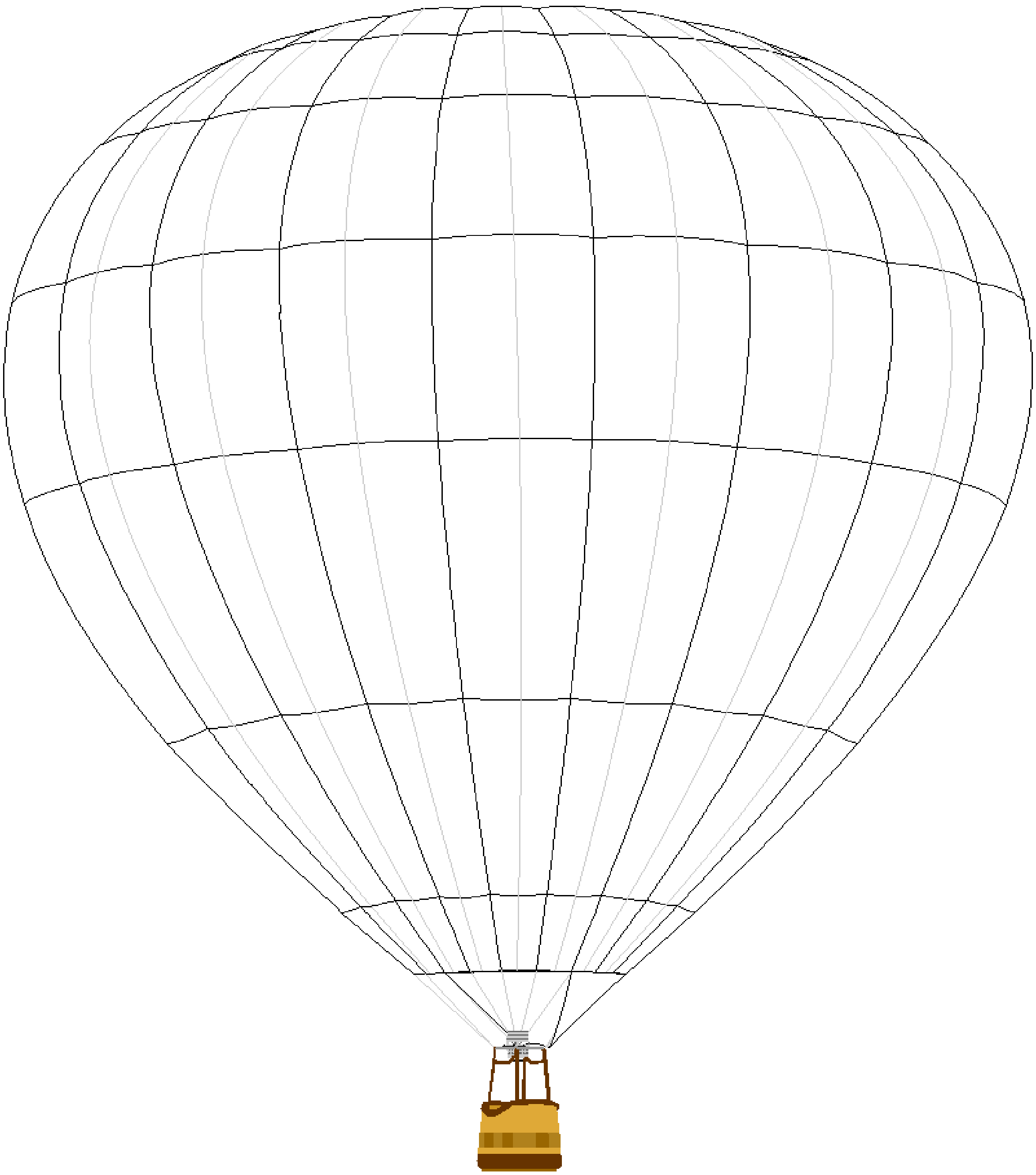
Internet Based Resources

Resources that can be researched on the web for additional teaching materials, support and ideas:

- Balloon Federation of America (BFA) Balloon Life Magazine
- Manufacturers: http://www.eballoon.org/directory/balloon-manufacturers.html
  - Aeromagic Balloons - http://www.aeromagicballoons.com/
  - Aerostar International - http://www.aerostar.com/
  - Cameron Balloons US - http://www.cameronballoons.com/
  - Fantasy Balloons - http://www.fantasyballoonsinc.com/main.html
  - FireFly Balloons - http://www.fireflyballoons.net/
  - Head Balloons - http://www.headballoons.com/
  - Lindstrand Balloons USA - http://www.lindstrand.com/
  - National Balloons - http://www.dwx.com/~balloon/national.html
  - Sky Balloons - http://www.skyballoons.com/
  - Ultra Magic Balloons - http://www.ultramagic.com/
- Other Educational web sites
  - http://www.kathimitchell.com/balloons.htm This has links to many great hot air balloon sites but the music is annoying.
  - travel.howstuffworks.com/hot-air-balloons
  - www.exploratorium.edu/ls/balloons
  - www.hotairballoons.com
  - www.eballoon.org
  - www.pheemcfaddell.com/coloring/Sir Max2Color/SirMaxColoringBalloons This site has balloon patterns for coloring
  - www.omsi.edu/visit/physics/air This resource is primarily for teachers in the upper elementary grades.
  - www.cln.org/themes/hot balloons
  - wings.avkids.com/curriculums/thermals/index
  - www.nasm.si.edu/exhibitions

LOWER GRADES

Coloring Balloons



Balloon Name: ____

Name: ____________________________ Grade: ________________________

Writing Activities

Hot Air: The Mostly True Story of the First Hot-Air Balloon Ride

By Bonnie Dixon

Materials: Book: Hot Air: The Mostly True Story of the First Hot-Air Balloon Ride
By Majorie Priceman
6-Traits Writing Poster for Voice
Example of the beginning of a story
Writing paper
Balloon Designs

Objective:
Using the Voice Writing Traits, students will write a story from one of the animal's point of view.

Steps:
1. Review the key qualities of the Voice Trait.
   - The tone of the writing fits the purpose and the audience.
   - The writer and the reader have a powerful connection.
   - The writing is expressive.
   - The writer takes risks to create text that is distinctive and memorable.
   - The writer is confident, energized, and passionate about the topic.
2. Read the book, Hot Air: The Mostly True Story of the First Hot-Air Balloon Ride, stressing to the students what the animals might be saying, feeling, and thinking.
3. Have the students pretend they are one of the animals and imagine what the animal might be saying or thinking. Show them the pictures from the book again. Using "teacher talk" model what the animals might be saying.
4. Have the students write their story from the balloon ride from the animal's point of view. They can write about where they went, what they did, and how they felt. Share the example of the beginning of the story before the students begin writing.
5. Have the students design a hot-air balloon with their animal inside.
6. Have the students share their stories and their balloons with the class.

Evaluation: Using the 6 Trait Voice Writing Rubric, the students will evaluate their stories.

Example of a beginning of a story:

The Mostly True Story of the First Hot-Air Balloon Ride
By Mr. Rooster

The story goes like this… There I was minding my own business, strutting around the barnyard, cock-a-do-da-ling, waking everyone up, which is my job, of course, when all of a sudden a man with crazy hair grabbed me. He threw me, not set nicely, into this basket with a duck and a sheep….

Creative Writing

WHY: To enhance retention of program concepts through an exercise that uses the student's imagination and challenges comprehension.

What: Compose a short story about an imaginary balloon trip you take. Base it on one or two concepts you have learned about with respect to hot air ballooning (weather, licensing, history, navigation, terrain, rallies, competition, laws, etc).

If you need to, research more information about your chosen concept(s) at the library (to give your story depth and focus).

Discussion – Balloon Uses

A balloon flight can be a beautiful adventure, but why can't balloons be used for daily transportation? *(wind direction and changes, weather, speed of flight, cost of flight, safety concerns such as launch/landing spots and power lines, legalities, social impact and public reaction, times of day that balloons fly, size and weight of balloon, etc.)*

Lesson Plans

Why: To Stimulate Thinking Beyond The Concepts That Are Presented In The Program

What: **Discussion on Balloon Transportation**

A balloon flight can be a beautiful adventure, but why can't balloons be used for daily transportation?

Discuss wind direction and changes, weather, speed of flight, cost of flight, safety concerns such as launch and landing spots, power lines, legalities, social impact, public reaction, times of day that balloons fly, size and weight of balloon.

Why: To Stimulate Creativity and Thought Processes

What: **Product Advertising Campaign**

Hot Air Hype

Pick a product that you would like to see represented by a hot air balloon. Design the balloon shape, remember, a pilot has to be able to fly it. Make up an appropriate catchy slogan and name the balloon. List and explain the places where you would like to fly the balloon and what people you would want to see it.

Why: To Prove That Warm Air Takes Up More Space Than Cool Air

What: S**cience Experiment**

When a pilot gets ready to heat the air in a hot air balloon, the balloon is not filled tightly. As we add the heat, not only does the warmer air rise, but it also expands to fill up the balloon and make it full.

MATERIALS LIST:

- 2 plastic bottles (1 liter soda are perfect) with small mouth
- 4 toy balloons
- 2 deep bowls
- Hot water
- Ice

1. Fit one toy balloon over the mouth of one empty bottle so that it stays on.
2. Put the bottle in a bowl that is filled with hot water. Watch what happens after a few minutes.
3. Fit the other balloon over the mouth of the other empty bottle while you wait.
4. Place the second bottle in the other bowl that is filled with crushed ice. Wait and watch.

Draw pictures of what has happened. What can explain this action?

Additionally:

Blow a balloon up so that it is very hard, almost ready to pop (but not quite!!). Put it into or over a warm place (not into the oven) such as a heater vent. Watch what happens.

Blow a balloon up so that it is very hard. Measure the balloon at its widest part and make a mark there. Put it into the freezer overnight and measure it again the next day. What happened?

Why: To Expand General Knowledge About The History Of Flight.

What: Research Project and Timeline

Research the history of balloons and flight. Then make a time-line for display in either your classroom or the library.

Why: To Explore The Weight Of Air.

What: **Science Experiment**

Did you know that the air you hold in your palm weights about 100 pounds! How can this be? How can something you can't even see weigh any thing at all? What does this mean for balloonists? Let's experiment.

Materials list:

- 2 straight pins
- l drinking straw
- 2 toy balloons
- string about l foot long
- tape

1. Push pins through both ends of a straw, the same distance from the ends (about 1/2 inch).
2. Carefully stick the mouth end (just below the rubber rings) of a toy balloon onto each pin so that the balloon stays on.
3. Tie one end of the string onto the middle of the straw. Tie the other end onto something so that straw can hang freely.
4. Move the string along the straw until the straw is perfectly balanced. Tape the string down in this spot.
5. Take the balloons off of the straight pins.
6. Blow one of the balloons up and tie it closed. Blow the other balloon up, but only about half way, tie it closed too.

Put the balloons back on to the pins (careful not to pop them!). What happens??

Why: To Discover Wind Direction, Weather Vanes

What: **Science Experiment**

Hot air balloon pilots do not have a steering wheel or any other mechanical means of steering their balloons. Sometimes though, the wind at several thousand feet above the ground (winds aloft) will be going a different direction than that which is blowing on the surface. With these changes of direction, the pilot is able to do some "navigating" or control to some extent where the balloon will fly and where it will land. Pilots always get weather and winds forecast before every flight so that they will have an idea of what direction and how fast the balloon will travel once launched. Remember though, it's mostly up to Mother Nature!

One way of determining which way the wind is blowing is to build a weather vane.

- Materials List:
- Drinking straws
- Straight pins
- Pencils with erasures
- Feathers about 4 inches in length

1. Put a pin through the middle of a straw.
2. Push the pin down into the pencil erasure. Don't put to much downward pressure on the straw (it has to be free to move).
3. Push the feather into one end of the straw far enough so that it stays.
4. Take your weather vane outside and test it in the wind at different times. Did you notice any changes of direction during the week? Do you think these changes are related to weather systems?

Extension: chart the winds observed outside your window for a week. Use the Beaufort (developed 1806) wind scale:

#0 calm -- smoke rises vertically, flag hangs still
#1 light air -- smoke drifts slowly, flag moves some 2-3 mph
#2 slight breeze -- leaves rustle, weather vane moves 4-7 mph
#3 gentle breeze -- twigs move, flags extended 8-12 mph
#4 moderate breeze -- branches move, dust and paper rise 13-18 mph
#6 strong breeze -- large branches sway, wires whistle 25-31 mph
#9 strong gale -- branches break, roofs damaged 47-54 mph

When is it most typically windiest during the day?
What do you think would cause this?
What is the best time of day to fly hot air balloons?
What would be the best speed of wind to fly in? Why?

Why: To Explore the Concept of "Lift"

What: **Science Experiment**

Pilots tie the balloon to the ground until we are ready to fly away. This prevents "false lift" from picking the balloon up before it is actually hot enough to fly. Much like the air passing over an airplane wing, wind flowing over the top of a balloon can actually pick it up! Since the balloon isn't actually hot enough to fly, this action often results in an uncontrolled, hard landing. Ouch!!!

Materials List:

- Hair Blow Dryer
- Sheets of 8 1/2 X 11 Paper
- Scissors, Ruler, Pencil

1. Using a long flat table as your run way, plug the hair dryer in close to one end of it. Put one sheet of paper flat on the table, a few inches from the end nearest the hair dryer.
2. Turn the hair dryer on low, and hold it a few inches above the table. Moving it around to find the right angle, the paper should then lift off and fly briefly.
3. Explore other shapes (diamond, oval, circle, etc.) to find out which shape flies best. Your flights will not be very high (1/2-1 inch) is excellent!
4. What happens if you use a crumpled piece of paper? Why?

Why: To Stimulate Thinking Beyond The Concepts That Are Presented In The Program.

What: **Listing Items Where Balloons Are Seen**

Balloons are not just seen in the sky. Because of their colors and festive nature, balloon motifs have been incorporated in toys, decorations and some very practical items.

List at least five: (for example: gift wrap paper, coffee mugs)

1.
2.
3.
4.
5.

Now create two of your own:

1.
2.

Why: To Evaluate Program Retention

What: **Follow-up questionnaire**

FULL OF HOT AIR!

Choose the most appropriate word from the list below to complete the sentences.

1. Hot Air Balloons fly because hot air __________.
2. A balloon containing helium is a _________________________.
3. You're a balloon pilot! One of the first things to look at before you go flying is the ______________outside.
4. Describe the kind of day a balloon might fly. _____________ ______________
5. You need one to drive a car. You need one to fly balloons and airplanes. You don't need one to ride your bike. What is it? _________________________
6. What shape balloon would you build if you could?
   My balloon would be a _________________________

Draw a picture of it on the back of this sheet.

Activities

Paper Mache Hot Air Balloons

MATERIALS LIST:

- Strips Of Newspaper
- White Glue Diluted In Water
- A Toy Balloon For Each Student
- Paints
- String/Yarn
- The Base Of A Milk Carton For Each Student

INSTRUCTIONS:

1. Dip strips of newspaper into diluted glue and paste onto an inflated balloon. While papering the top of the balloon, include a few inches of a long piece of string from which to hang the balloon after it dries. Make sure the piece is firmly anchored and glued in with the newspaper strips.
2. Allow balloon to dry, and then paint designs.
3. Paste construction or contact paper on the sides of the milk carton base.
4. Tie the gondola (milk carton) on with 4 pieces of string after punching small holes (use hole punch) in the mouth of the balloon and sides of carton.
5. Hang up for display!!

Experimental Hot Air Balloon

MATERIALS LIST:

- White household glue
- 10 sheets of 30"x 18" art tissue paper per balloon
- Scissors
- Poster board for pattern
- Magic markers

Also needed-please use with adult supervision:

- Light aluminum pie pan
- Duct tape
- Charcoal
- Matches
- Lighter fluid
- Fire extinguisher/bucket of water
- 1 gallon vegetable can, empty and clean (cafeteria)
- Can opener
- 1 length of stove pipe (9' diameter)
- Long handled pliers

PATTERN:

Make template that is 58” long, 7’wide at bottom, 18” wide at equator, and tapers to a point at the top (resembling balloon gores).

CONSTRUCTION:

1. Group students into pairs or threes. Using glue sparingly so as not to add weight, glue two sheets together at a time, with the end result being 5 sets of 60" x 18" sheets. Pick color schemes with care!

2. Again, use glue sparingly in this next step. You might even want to practice making a thin line with the glue bottle. Take two long sheets from step 1; draw a thin line of glue 1/4 inch from the longest edge on one sheet, going all the way from the top to the bottom.

3. Gently press the remaining sheet onto the glue. Make sure the top and bottom edges are lined up before the sheets contact each other. Glue all of the sets of sheets together, allow to dry.

4. By laying the balloon pattern on the tissue sheets (one time in each set) you can outline the pattern with a marker.

5. Cut one side of the outline. Then, make 1/4 inch cuts into the tissue every inch or so along the freshly cut edge. (This will help when gluing the curved edges together later.) Cut out the remaining side, but DO NOT make the 1/4 inch cuts along this edge. Do this with each of the outlines.

6. Practice this next step on some scrap tissue before attempting the real thing! Find one gore with a clipped side and another with an unclipped side.

7. Lay the unclipped side flat and draw a thin line of glue, 12 inches long, starting at the point of the gore. Gently press the clipped edge along the glue, matching the edges. The 1/4 inch clips make this possible. Lay this larger section over a chair to dry. Do the same with 2 more gores, allow to dry. Glue the remaining single gore to one of the sets. Allow to dry. Glue the section of two to the section of three. Allow to dry.

8. The last seam is the hardest one! Wrap the balloon around a chair or student, and carefully glue the remaining seam as in step 5. Several people may have to assist holding the balloon at this point.

9. Cut the center out of the pie pan about one inch from where it folds. The remaining seam will sit on top of the stove pipe. Attach the balloon to the pan by crimping the outer edge of the pan onto the tissue; tuck and pleat as necessary. Use duct tape to secure the edges.

10. After the last seam has dried, inspect the balloon for holes. Store the balloon on a bulletin board, hanging with a tack at the tip.

FLIGHT TIME!

1. Using the bottle opener, puncture holes around one edge of the 1 gallon can (for air flow to the fire).

2. Shove the stove pipe section into the can.

3. Place about 8 inches of charcoal into the bottom of the can. Using lighter fluid, ignite the charcoal.

4. Allow the flame to burn down below the top edge of the stove pipe.

5. Place a student at each seam of the balloon. Using pliers, have an adult hold the pie pan, and rest the balloon on the top of the stove pipe. Watch carefully for bunches of paper that are resisting being expanded, help as necessary. The balloon will fill well if there is little or no wind. When the balloon seems full, test its buoyancy by having the students let go. If it stays upright, it is almost ready to fly.

6. When the balloon is fully heated, gently follow it up with your hands and give it a gently upward push.

7. Clock and measure how long the balloon flies. Repeat as time and heat allow (provided the balloon has not burned or crashed into a tree or puddle!)

LAUNCH CREW MEMBERS:

- Launch Directors (teacher & 1 team member), to make launch decision.
- Fire Person, ready with extinguisher and water
- Observer, to record flight data (height, distance, etc.)
- Chase crew, to retrieve the balloon

EXTENSION:

While waiting for the fire to burn down before launching the balloon, experiment with marshmallows on sticks. Watch and discuss how the heat affects them. Discuss radiation, conduction, convection.

Ballooning Song

(Sing to the tune of skip to My Lou)

Rise, rise lighter than air,
Rise, rise lighter than air,
Rise, rise lighter than air,
come let's go ballooning.

Float, float through the sky,
Float, float through the sky,
Float, float through the sky,
Come let's go ballooning.

Light the burner, let's go higher.
Light the burner, let's go higher.
Light the burner, let's go higher.
Come let's go ballooning.

Pull the rip cord, ready to land.
Pull the rip cord, ready to land.
Pull the rip cord, ready to land.
Come let's go ballooning.

In a Hot Air Balloon

Chariots of Fire

When fire was discovered,
The human race began,
To dream of heights to conquer,
By woman and by man.

In a million other ways,
We have advanced the human race,
With fire we propel ourselves,
Oon land, on sea, in space.
But remember when you dream
Of heights to which we should aspire,
Balloonists were the first to ride
On Chariots of Fire.

Balloonists Prayer

The Balloonist's Prayer

The winds have welcomed you with softness.
The sun has blessed you with his warm hands.
You have flown so high and so well
that God joined you in laughter
and set you gently back into
the loving arms of Mother Earth.

The author of the Balloonist's Prayer is unknown, but it is believed to have been adapted from an old Irish sailors' prayer from long ago. This prayer is commonly heard after a balloon flight.

The Balloonist's Prayer (in French)

Les Vents vous ont accueillis avec douceur.
Le Soleil vous a béni avec ses mains chaudes.
Vous avez planné si haute et si bien,
que Dieu vous a rejoint dans votre rire.
Et Il vous a remis doucement
entre les bras aimant de notre bonne Terre.

Additional Projects

- Attend a hot air balloon launch or rally.
- Have a photo contest, or just a photo display
- Write a "newspaper" article on the event (number of balloons, competitions, weather conditions, etc.)
- Video tape an interview of a pilot and share with the class.
- Build a hot air balloon or aviation display in the library featuring books pertaining to the same.
- Invite airplane, glider or helicopter pilots to speak (from local airport, or someone's relative) for comparison's sake.

UPPER GRADES

Creative Writing

You are the first one in the field where a huge hot air balloon has landed. This was a preparatory flight for a balloon race around the world. Because you've been so helpful to the pilot, they invite you to help with the upcoming race.

Taking the following into consideration, write a story based on the above idea.

1. Your parent's attitude *(will they support your involvement or not?)*
2. Your schedule *(how will you juggle everything?)*
3. Your responsibilities at home *(will you pay your older brother to take over for you?)*
4. How you feel about being involved? Also, explain what your duties will be, how and where your travels will take you. How many other balloons are involved, what is the outcome of the race?

Discussion

You are at the mall. Big things are happening because of the holidays. Lots of food specials, big sales in the stores, and free tethered hot air balloon rides. Alas, you've lingered too long at the travel booth waiting for the free-trip-to-Hawaii drawing. Running outside to get your balloon ride, you learn that the pilot can make only one more trip because it is getting dark. Since you are with your best friend and another one of his/her good friends, you have to decide who will go up because the pilot can only take two of you (all three of you really want to go...). How will you decide (draw straws, flip coin, maybe none of you go after all)?

Additional questions:

- Why won't the pilot go up after dark? *(Too hard to see the ground to land safely, and by law, the balloon has to have night aircraft lighting.)*
- What determines how much weight (passengers) the pilot can put in the basket? *(Size of balloon, density altitude)*
- Where is that information found? *(Flight Manual)*
- What happens if the balloon is overloaded? *(Over temperature maximum, ages envelope prematurely)*
- What is a tethered balloon? *(The balloon is kept tied down with long ropes that enable it to rise 50-58 feet, but not fly away.)*

Why would a pilot give rides away? *(He/she may just be a nice person who likes to share hot air ballooning, or he may have a "sponsor" who is paying for the balloon rides for the benefit of good will or advertising.*

Lesson Plans

Why: To Explore Low and High Pressure Air Masses

What: **Science Experiment**

Relatively speaking, air which is moving has low pressure. And air that is still has high pressure. This was discovered in the late 1700's by a scientist named Daniel Bernoulli. And it is because of this discovery that we can make airplane wings that actually fly. As the wing slices through the air, the air molecules moving over the top of the wing must make it to the other side at the same time as the molecules under the wing. Because the wing is curved on top, those molecules have further to go and must move faster. The combination of low pressure on top and high pressure below work together to create an upward push called "lift".

How about an experiment to prove this?

Materials List:

- 2 toy balloons, equally inflated
- 2 two strings about 1 foot long each

Tie the strings one to each balloon. Hang or hold the balloons about 1 1/4 inches apart.

Have another student blow gently between the two balloons.

The balloons should "stick" together. Remember, the pressure will be lower between the two balloons while you are blowing air through (because moving air has less pressure). The pressure on the sides of the balloons is higher because that air is not moving.

What happens when:
l. you blow even harder between the balloons?
2. you blow the balloons from the side?
3. You stop blowing altogether?

Extension: Would you think that an area of low pressure in weather report would be windy or calm? What about an approaching high pressure system?

Why: To Explore the Concept Of "Lift"

What: Science Experiment

Pilots often tie the balloon to the ground until we are ready to fly away. This prevents a "false lift" picking the balloon up before it is actually hot enough to fly. This is much like the air passing over an airplane wing. Wind flowing over the top of a balloon can actually pick it up. Since the balloon isn't actually hot enough to fly, this action often results in an uncontrolled, hard landing.

Materials List:

- Hair blow dryer
- Sheets of 8 1/2 X 11 paper
- Scissors, ruler, pencil

1. Using a long flat table as your runway, plug the blow dryer in close to one end of it. Put the sheet of paper flat on the table, a few inches from the end nearest the blow dryer.
2. Turn the blow dryer on low and hold it a few inches above the table. Moving it around to find the right angle, the paper should then lift off and fly briefly.
3. Explore other shapes, diamond, oval, circle, etc., to find out which shape flies the best. Your flights will not be very high (1/2-1 inch) is excellent.
4. What happens if you use a crumpled piece of paper?
5. What happens if you use other types of paper, like tissue paper?
6. Record your findings.

Why: Stimulate Creative/Persuasive Thinking, Decision Making

What: **Word Game**

The words listed below should be considered in an aeronautical light, and the definitions as well.

WACKY WORDS

1. Give each student 5 slips of paper and a pencil.
2. From the list below, write a word on the board.
3. Each student invents (or writes the correct) definition that he believes will convince the other players that he is right. Write both the definition and name on a slip of paper.
4. The teacher writes the correct definition on a slip of paper.
5. All slips are collected and shuffled.
6. After reading each definition, have students vote on the validity.
7. Read correct definition.

SCORING:

1 point for each vote a definition receives
2 points for each player who chooses a correct definition
3 points for each player who submits the correct definition

VARIOMETER	APEX	CONVECTION	CEILING
DEW POINT	ALTIMETER	THERMAL	MSL
AGL	NAUTICAL MILE	MONTGOLFIERE	DIRIGIBLE
DEFLATION PORT	VENTURI	BTU	
EASIER WORDS:			
GONDOLA	CHASE VEHICLE	FAA	TOUCH & GO
ENVELOPE	NAVIGATE	BURNER	SPLASH & DASH

Activities

Experimental Hot Air Balloon

MATERIALS LIST:

- White Household Glue
- 10 Sheets Of 30"X 18" Art Tissue Paper Per Balloon
- Scissors
- Poster Board For Pattern
- Magic Markers

Also needed-please use with adult supervision:

- Light aluminum pie pan
- Duct tape
- Charcoal
- Matches
- Lighter fluid
- Fire extinguisher/bucket of water
- 1 gallon vegetable can, empty and clean (cafeteria)
- Can opener
- 1 length of stove pipe (9' diameter)
- Long handled pliers

PATTERN:

Make template that is 58" long, 7' wide at bottom, 18" wide at "equator", and tapers to a point at the top (resembling balloon gores).

CONSTRUCTION:

1. Group students into pairs or threes. Using glue sparingly so as not to add weight, glue two sheets together at a time, with the end result being 5 sets of 60" x 18" sheets. Pick color schemes with care!
2. Again, use glue sparingly in this next step. You might even want to practice making a thin line with the glue bottle.

   Take two long sheets from step 1, draw a thin line of glue ¼ inch from the longest edge on one sheet, going all the way from the top to the bottom. Gently press the remaining sheet onto the glue. Make sure the top and bottom edges are lined up before the sheets contact each other!

   Glue all of the sets of sheets together, allow to dry.
3. By laying the balloon pattern on the tissue sheets (one time in each set) you can outline the pattern with a marker.

4. Cut one side the outline. Then, make 1/4 inch cuts into the tissue every inch or so along the freshly cut edge.
(This will help when gluing the curved edges together later.)
Cut out the remaining side, but DO NOT make the 1/4 inch cuts along this edge. Do this will each of the outlines.
5. Practice this next step on some scrap tissue before attempting the real thing! Find one gore with a clipped side and another with an unclipped side. Lay the unclipped side flat and draw a thin line of glue, 12 inches long, starting at the point of the gore. Gently press the clipped edge along the glue, matching the edges. The 1/4 inch clips make this possible. Lay this larger section over a chair to dry.

   Do the same with 2 more gores, allow to dry.

   Glue the remaining single gore to one of the sets. Allow to dry.

   Glue the section of two to the section of three. Allow to dry.
6. The last seam is the hardest one! Wrap the balloon around a chair or student, and carefully glue the remaining seem as in step 5. Several people may have to assist holding the balloon at this point.
7. Cut the center out of the pie pan about one inch from where it folds. The remaining seam will sit on top of the stove pipe. Attach the balloon to the pan by crimping the outer edge of the pan onto the tissue; tuck and pleat as necessary. Use duct tape to secure the edges.
8. After the last seam has dried, inspect the balloon for holes. Store the balloon on a bulletin board, hanging with a tack at the tip.

FLIGHT TIME!

1. Using the bottle opener, puncture holes around one edge of the 1 gallon can (for air flow to the fire).
2. Shove the stove pipe section into the can.
3. Place about 8 inches of charcoal into the bottom of the can.
Using lighter fluid, ignite the charcoal.
4. Allow the flame to burn down below the top edge of the stove pipe.
5. Place a student at each seam of the balloon. Using pliers, have an adult hold the pie pan, and rest the balloon on the top of the stove pipe. Watch carefully for bunches of paper that are resisting being expanded; help as necessary. The balloon will fill well if there is little or no wind. When the balloon seems full, test its buoyancy by having the students let go.
It stays upright, it is almost ready to fly.
6. When the balloon is fully heated, gently follow it up with your hands and give it a gently upward shove.

7. Clock and measure how long the balloon flies. Repeat as time and heat allow (provided the balloon has not burned or crashed into a tree or puddle!).

LAUNCH CREW MEMBERS:
A. Launch Directors (teacher & 1 team member), to make launch decision.
B. Fire Person, ready with extinguisher and water
C. Observer, to record flight data (height, distance, etc.)
D. Chase crew, to retrieve the balloon

EXTENSION:
While waiting for the fire to burn down before launching the balloon, experiment with marshmallows on sticks. Watch and discuss how the heat affects them. Discuss radiation, conduction, convection.

Ballooning As a Science Project

by the editors of Balloon Life

Introduction:

This report is designed to answer a number of frequently asked questions about ballooning, provide some additional resources for information, ask some thought provoking questions, and otherwise supply some ideas about how to make a science project out of aerostation.

Suggested books:

"Ballooning, The Complete Guide to Riding the Winds" by Dick Wirth, ISBN 0-934-51338-X published by Random House. The book was originally published in 1980 in hardback. In 1990 it was reissued with a soft cover and 16 pages were updated. Both versions are basically the same, and the information is a little old. Still, the book is the best general reference that you can use for explaining the various aspects of ballooning. It is an excellent general introduction.

"The Aeronauts" by Donald Jackson, ISBN 0-8094-3268-8. This book is more a history book and is part of the Time/Life "Epic of Flight" series on aviation.

"Just Wind" by William G. Armstrong, Jr., ISBN 0-595-28705-0. The adventures of two dramatic stratospheric balloon expeditions - to be first across the Atlantic and first around the world - are chronicled with wit by a true insider. For more information, see www.JustWind.net

"The Eagle Aloft" by Tom Crouch, ISBN 0-87474-346-X published by The Smithsonian Institution. This is a 200 year history of the balloon in America. If you want US history of ballooning this is the book.

"Hot Air Balloons" by Christine Kalakuka and Brent Stockwell, ISBN 1-56799-620-5, published by Friedman/Fairfax in 1998. This is a modern up to date coffee table style book on the sport of ballooning.

"The Pre-Astronauts" by Craig Ryan, ISBN 1-55750-732-5, published by The Naval Institute Press.

Questions and Answers about Hot Air Balloons

What are hot air balloons made of?

The bag-or envelope, as it's more properly called-is made of a reinforced fabric called rip-stop nylon (some balloons are made of Dacron). The material is very light weight, but is very strong. The fabric is coated on the inside to prevent leaks.

How is it inflated?

During the inflation process, ballooning becomes a group sport. Since a balloon is quite unwieldy on the ground, especially in gusty winds, it takes about four people to get the balloon inflated. Of course, the more people there are the more fun you can have. To start off, the envelope is stretched out on the ground and attached to the basket, which is lying on its side. A small gasoline-powered fan blows air into the balloon. Then the burner is turned on, and the air in the balloon is heated. The hot air rises, lifting the balloon upright.

What are the baskets made of?

The baskets are made from rattan or wicker and each one is individually woven by hand.

How big are hot air balloons?

The typical sport balloons range in size from 65,000 to 105,000 cubic feet in volume and stand around 70 feet tall.

How do you steer the thing?

Strictly speaking you don't. The balloon goes where the wind takes it. However, the winds at varying altitudes may blow in different directions and at different speeds, so the trick is to climb or descend to an altitude where the wind is blowing in the direction you want to go.

How fast does it go?

As fast as the wind, or as slow. Since the balloon has no forward propulsion system, its speed is determined entirely by the speed of the wind. That's why balloon races are events of accuracy not speed.

When is the best time to fly a balloon?

Usually just after sunrise and one or two hours before sunset. This is the time of day when winds are calmest and the air most stable.

How high do balloons fly?

Most balloon flights occur between 500 and 1,000 feet above the ground. But balloons can fly at treetop level or go much higher. The world record for altitude in a hot air balloon is about 77,000 feet.

How long can it stay up?

It depends. Normally, the balloon carries enough fuel to remain aloft for 2 hours, but factors like outside air temperature, weight being carried in the basket, and weather determine the duration of the flight.

What kind of fuel is used?

Propane, kept in pressurized tanks on the floor of the basket. The balloon carries 30-40 gallons of liquid propane. It is carried under pressure and passes to the burners through flexible hoses. When the valves are opened, the propane atomizes and is ignited by a pilot light in the burners. The flame may shoot out as much as ten or twenty feet, making a loud "whoosh."

How do you get it back?

With the help of friends who drive a van or pickup truck. This chase crew follows the flight of the balloon (as well as the existing roads allow) and should be on hand to make the recovery when the balloon touches down.

What is the difference between a gas balloon and a hot air balloon?

A gas balloon is completely enclosed and is filled with helium or hydrogen. A hot air balloon gets its lift from heating the air within it.

Do you need a license to pilot a balloon?

Yes. A Balloon Pilot Certificate is issued by the Federal Aviation Administration. You must pass an FAA written examination, obtain a prescribed number of hours in a balloon, make a solo flight and a flight to altitude, pass a flight test and submit a medical statement.

Brief History of Balloon Flight

The first recorded balloon flight occurred in France in June 1783 when two brothers, Jacques Etienne and Joseph Michel Montgolfier, sent a large, smoked-filled bag 35 feet into the air. Three months later, a duck, rooster and sheep became the first passengers in a balloon, since no one knew whether a human could survive the flight.

Finally on November 21, 1783, before a vast throng of on-lookers that included the King and Queen of France, Marquis d'Arlandes and Pilatre de Rozier piloted man's first aerial voyage more than a century before the Wright brothers' historic flight at Kitty Hawk!

Ballooning became quite popular for over half a century in Europe. Ten days after the first manned hot air flight, a French physicist named J.A.C. Charles made the first manned flight in a hydrogen-filled balloon. Eighteenth century farmers, frightened by these strange objects descending from the heavens, attacked the balloon with pitchforks.

With the advent of powered aircraft, ballooning became a less practical mode of flight, practiced by only a few enthusiasts. The modern day sport of hot air ballooning evolved through research for the U.S. Navy in the 1960's and has enjoyed a remarkable comeback due to the development of a durable, inexpensive nylon for the envelope in combination with an improved and efficient propane burner system. Today there are more than 5,000 balloon pilots in the U.S. alone.

Suggestions for getting started on a science project using ballooning as a theme:

- What are the basic principles of physics apply to hot air ballooning?
- Build a "trash bag" or "tissue paper" hot air balloon to demonstrate the science of lighter-than-air flight.
- Demonstrate "Boyle's Law of Gasses."
- Discuss Archimede's Principle of Buoyancy Force. The greater the difference of temperature between the air inside the envelope (the balloon) and the air outside - the greater the lifting capacity.
- Discuss weights and balances.
- Mathematical calculations.
- Venturi Effect.

- Discuss the effect of weather on balloons.
- Effects of the jet stream in relation to the recent around-the-world by balloon attempts.
- Since geometry is a really basic field of science, go through the system of projections to develop the shape of a balloon. Start with a simple sphere. Then do a sphere on cone. Then approximate the "Natural Shape" balloon.
- To do a simple natural shape, there are lots of sources for computer programs such as the LTA Builders groups and the CD ROM (Balloons! IBM compatible, http://kumo.swcp.com/balloons/) by Ojo Magic. Make a tailored balloon to the computer program and then make a plain cylinder with the same gore length and excess material circumferentially. Inflate them side by side to show they end up the same shape! (The plain cylinder will have a lot of wrinkles, but the same silhouette.)
- An analysis of the radius of curvature at any elevation showing that it is directly related to the internal pressure at that point and the vertical load there (total payload divided by the circumference at that point) will likely blow away his comment that everyone knows how they work, as most high school science teachers I have met would not know.
- Try a "Solar" hot air balloon made of black tissue paper, inflated by a very small fan (like from a computer ventilation system) and buoyed up by infra red heat lamps. If it does not rise, that may be all the better because then you can theorize on why it doesn't rise and your electric toaster supported hot air balloon does. This shows that a "Scientific Experiment" is a success if the results are properly observed, especially when they are different from the hoped for results. The scientist will be able to explain why one works and the other didn't and propose modifications to make it work (Bigger balloon, lighter tissue paper, and more radiant heat - maybe with parabolic reflectors so the lamps can be farther away and so there is room for more of them.)
- Make a model balloon that is filled with plain air, but is submerged in an aquarium. (Tissue paper won't work for that one.) Measure the lift as compared to the bigger hot air one. Call that unit of the project "Eureka". Why? Who was Archimedes? What was the difference between Archimedes and Montgolfier? What was the difference between the Stratosphere Balloon and the Bathyscaph? Which one was invented first and which one was an adaptation of the other?
- Validate the balloon project as an important scientific venue by citing Craig Ryan's book "The Pre-Astronauts," The Naval Institute Press, ISBN 1-55750-732-5.
- Tape a couple of telephone interviews with college physics professors.
- Make a video of an actual hot air balloon flight, especially showing the inertia, momentum and heat loss reactions not easily demonstrated indoors.

Internet resources:

- A few suggestions for exploration:
- Balloon Life magazine http://balloonlife.com
- Team RE/MAX, a great education site built around ballooning provided by RE/MAX International
- www.remax.com/balloon/edu/index.htm
- Larry and Anne Nelson in Redmond, Washington have created some links to history ballooning and a few other resources. Take a look at their web page at www.nwlink.com/~lwnelson/index.htm

- A complete, or least as complete as it can be, listing of pages related to ballooning on the World Wide Web
- www.euronet.nl/users/jdewilde/index.html

Fly a Hot Air Balloon

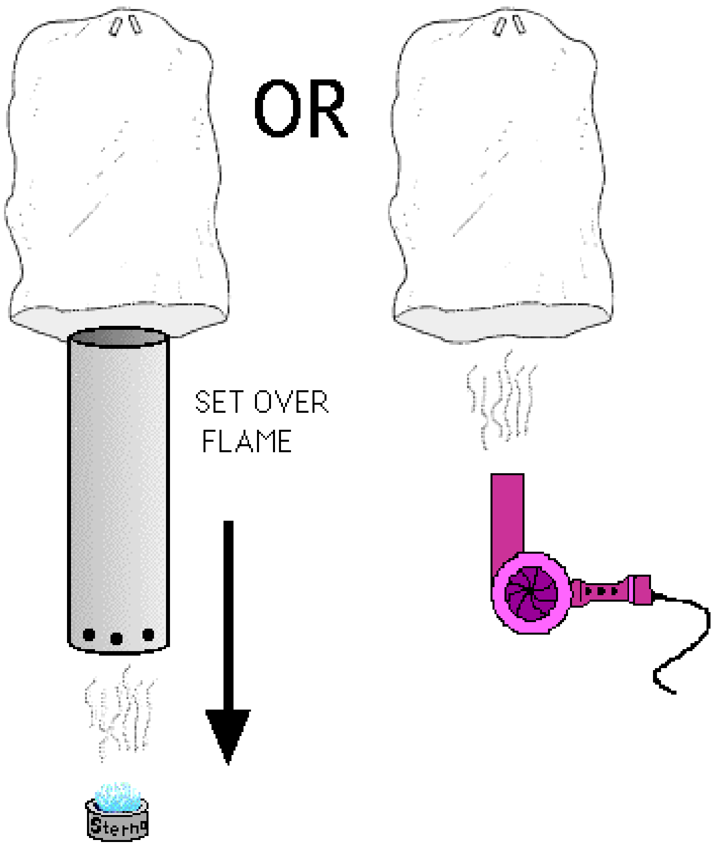
SUBJECT: Aeronautics
TOPIC: Lift
DESCRIPTION: An indoor hot air balloon made out of a plastic film dry cleaner bag.
CONTRIBUTED BY: Gregory Vogt (OSU)
EDITED BY: Roger Storm, NASA Glenn Research Center

MATERIALS:

- Dry cleaner plastic film bags (select a bag with the thinnest possible plastic and have several on hand. You may have to experiment with bags of different thicknesses.)
- Several small paper clips
- Cellophane tape
- Heat source (Blow dryer, Sterno, backpacker camp stove, etc.)
- Matches
- Three feet of aluminum heat duct (if using open flame heat source)
- Electric drill (to put holes in the heat duct)

PROCEDURE:

1. Seal any openings and tears in the upper end of the bag with a minimum of cellophane tape.
2. Attach several paper clips to the plastic around the lower opening. The number of paper clips to attach is determined by experimentation.
3. If using Sterno or some other open flame heat source, prepare the heat duct by drilling several holes around the base to allow air to flow in.
4. Turn on the blow dryer (or light the Sterno or stove and then set the heat duct over it) Spread the bag opening wide to capture the rising hot air while supporting the upper end with your hand. It is best to have assistance in keeping the bag open so that it does not melt.
5. When the bag is inflated with hot air, test its buoyancy by letting it go for a moment. If it rises quickly, stand back and let it fly otherwise continue heating it for a little while longer.
6. If the bag tips over and spills its hot air before it reaches the ceiling, add a few more paper clips to weigh down the bottom slightly. If the bag will not rise at all, remove a few clips.



CAUTION: Be careful not to brush clothes or fingers into the flames or touch the metal heat duct. Keep a fire extinguisher handy if you use flames. If the bag starts to crumple and melt from the heat, set the blow dryer on a lower setting or hold the bag farther from the heat source.

DISCUSSION:

Hot air is less dense than cold air. Heat accelerates the motion of the air molecules causing fewer molecules to occupy the same space as a much greater number of molecules do at a lower temperature. With fewer molecules, the hot air has less mass, and therefore is buoyant than an equal volume of colder air.

Placing the dry cleaner bag over the heat source captures the hot air and forces out the cooler air in the bag. The bag becomes a mass of low-density air which floats up-ward in the higher denser air surrounding it. The paper clips are placed at the bottom of the bag to keep the open end downward in flight to prevent it from prematurely spilling the hot air and terminating the flight.

Research Project:

Using the resource list, contact the manufacturers and the Balloon Federation of America. Collect information from these and the library regarding hot air balloons.

1. Draw up a price comparison list.
2. What balloon make do you think you would ultimately buy?
3. Why (costs, certain design features, popularity of make, etc)?
4. What would your balloon look like?
5. Would you like to pursue a career as a hot air balloon pilot?
6. Would you compete and/or sell rides or seek out a commercial contract? How would you decide this?
7. What are some of the positive and negative aspects of becoming a balloon pilot?
8. Why would you pilot balloons instead of airplanes, helicopters or gliders? Maybe you would earn several ratings so you could fly these other aircraft? Maybe you would decide to crew for a pilot instead of actually learning to fly?

Contact a local hot air balloon pilot and interview him/her about the above questions. Develop other relevant factors.

Discussion:

1. What makes a hot air balloon float? What makes helium balloon float? *(Both are lighter than air).*
2. When was the first hot air balloon built? *(1783 in France)*
3. How high can balloons go? *(All the way to 77,000' or higher. More typically they fly any where from tree top height to several thousand feet.)*
4. How do you steer a hot air balloon? *(Basically, you fly on the breeze in whatever direction it is blowing. However, variations in direction at different altitudes allow for some control).*
5. Are hot air balloons safe? *(Anytime you leave the ground in anything, there is some risk of injury or worse. But basically, balloons are safe provided the pilot uses good judgment with respect to weather, wind and power lines. Also, the Federal Aviation Administration, who regulate balloons and other aircraft, work hard to keep ballooning safe.)*
6. What are the best weather conditions in which to fly hot air balloons? *(Calm surface winds, clear days)*
7. How do you think weather conditions affect airplanes and other types of aircraft?
8. Where are the best places to fly hot air balloons? *(Away from city congestion and power lines)*
9. How do you think these places different for airplanes and other types of aircraft?
10. How far does a hot air balloon fly? *(It depends on how fast the wind is blowing. If the wind is moving 5 mph across the ground, then it will fly about 5 miles in an hour. Also. Sometimes the wind is blowing faster several thousand feet up and we can go up there to get into faster wind.)*
11. How much does a hot air balloon cost? *(About $30,000 or more for a new balloon. Less for a used one.)*
12. How much does a ride in a balloon costs? *(About $175 for an hour ride. A tethered ride might cost between $5-10).*
13. Why do we fly hot air balloons? (*It's a beautiful and unique way to see the world and sky. We love to share it with new people (who become friends), and flying is a fun and challenging way for us to make a living.)*