Title: **Bernoulli and Bubbles**

Grade Level: 9 - 11

Florida Sunshine State Standards:

Description/Abstract of Lesson: This activity introduces the students to aerodynamics by challenging them to determine methods that will keep a bubble from hitting the ground without touching any objects. Bernoulli's principle is introduced and air flight is discussed.

Student Learning Goals:
After this lesson the student will

- State Bernoulli's principle
- Make bubble juice
- Describe methods to keep a bubble from hitting the ground
- Describe aerodynamic principles of flight
- Demonstrate, describe, and present methods discovered that will keep a bubble in the air

Teacher Materials/Technology Connection:

- 1 gallon of bubble juice or 1 gallon of water, 1 gallon container, 1 cup of dishwashing liquid, 60 drops of glycerin
- Straws or hollow tubes or bubble blowers
- Small bowls or containers (one for each student team)
- Paper towels
- Index cards
- Graphing calculator
- Pictures of airplanes
- Diagrams of airplane wings

Student Materials/Technology Connections:

- Student Learning Journal (notebook)
- Graphing calculator
- Index cards
- Graph paper

Duration: 120 minutes

Essential Questions/Key Vocabulary:
Essential Question: How are air flight and bubbles related?

Key Vocabulary: pressure, lift, flight, force, dynamic lift, Bernoulli's principle

Lesson Lead/Opening:

1. Place the day's agenda on the overhead projector. Have the teams copy the agenda in their notebooks. Once completed they should begin logging in and discussing their homework. To compare homework solutions, the students will find the similarities and differences in approaches used to determine the solution(s). The students will discuss both solution and process used when completing the assigned problems.

2. Prepare the bubble juice by mixing the dishwashing liquid, glycerin and water.

3. Give each student learning team a small container of the solution, 4 straws or bubble blowers.

4. Read the history of Daniel Bernoulli to the class (or give the students copies and have hem do a jump in reading).

5. Present a diagram of an airplane and an airplane wing. Ask the student teams to discuss what they know about airplanes. Encourage the teams to make a concept diagram that identifies everything they know and understand about air planes and air flight. Send the teams to work on this discussion. Allow 5 minutes for this discussion. Return the teams to the full class and recap the discussions. On the overhead, make a large concept map created by input from each team.

Steps to Deliver Lesson (Guided Practice/ Independent Practice/Differentiated Instruction):

6. Conclude the discussion by
   - Demonstrate Bernoulli's principle
   - Point out that as air hits the wings of a plane, some of it has to go over it and some has to go underneath it. Scientists have explore this movement of air over and under a wing and have discovered that the air from the top and the air beneath the wing will arrive at the other end of the wing at the same time. What does Bernoulli's principle say about faster moving air?
   - Explain that the force pushing upward is called *dynamic lift.*

7. Discuss the approaches to keeping an object in the air: (1) increasing the pressure under it and (2) decreasing the pressure over it.

8. Challenge the teams to devise methods of keeping bubbles in the air and from hitting the ground.
   - Teams will discover methods of keeping bubbles from hitting the ground
   - They may not touch the bubble
   - They will keep two lists – methods that work by increasing the pressure under the bubble and methods that work by decreasing the pressure over the bubble.

9. Send the teams to work. Circulate to observe, assist, and intervene as needed.

Lesson Closure:

10. Test the student developed methods by setting up a bubble obstacle course. Include obstacles such as curves, steps, hoops, and corners. Each teams will test their best, most effective methods on the bubble obstacle course. The team that completes the course in the shortest time without letting the bubble touch the ground (an with out touching the bubble with any object) wins.

11. Have the teams determine the similarities and differences in their approaches. Can they combine ideas to develop a “best” method?

12. Remind the teams to write a report describing what they set out to do, what they did, and what they discovered. Each team should prepare an oral presentation to include but not limited to a PowerPoint presentation, posters, charts, and diagrams.

Extension: Challenge the students to detect the flow of the air in the classroom.

Assessment:

The students will be assessed on the

- Quality of the student discussions
- Contribution and participation in the discovery activity
- Quality of the solution of the original posed problem.