SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

From the Edge of Space **Grade 9 Academic – The Study of the Universe**

Lesson Plan

Assessment	AFL, discussion, self assess.
Cross-curricular	Math, Technology

Big Ideas

- Assess some of the costs, hazards, and benefits of space exploration and the contributions of Canadians to space research and technology

Learning Goals

- How balloons can be used to reach near-earth orbit
- How to make a reasonable hypothesis
- How to calculate the mass of gas in a balloon

Materials

Electronic Scale
Helium Balloons (one per group)
White boards or chart paper
Lego Figure
Edge of Space Visuals (see link)
Balloon Releases Threaten Wildlife Handout (see link)

Safety Notes

It is not advisable to release the balloons outside, as there is an environmental impact - See Consolidation

Specific Expectations

A1.1 formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research
A1.2 select appropriate instruments and materials for particular inquiries
A1.3 identify and locate print, electronic, and human sources that are relevant to research questions
A1.8 analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty
A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions
A1.13 express the results of any calculations involving data accurately and precisely
A2.2 identify scientists, including Canadians who have made a contribution to the fields of science under study
D1.1 assess, on the basis of research, and report on the contributions of Canadian governments, organizations, businesses, and/or individuals to space technology, research, and/or exploration
D1.2 assess some of the costs, hazards, and benefits of space exploration
D2.4 gather and record data, using an inquiry or research process, on the properties of specific celestial objects within the solar system (e.g., the composition of their atmosphere, if any; the composition of their surface; the strength of their gravitational pull)
D3.6 describe various reasons that humankind has had for studying space

Description

Students will conduct an experiment to calculate how many helium balloons would be needed to send a person to the edge of space. An understanding of how to calculate the volume of a sphere (grade 9 math) will be useful.

Introduction

As a lesson hook the teacher will play the following two videos:

- Lego Man In Space (The National)
- https://www.youtube.com/watch?v=Lum1DMTdccE
    - 6.4 km up (21 000 ft) GPS stops working
    - 24 km up - estimated peak height (3x higher that commercial airliners)
    - Landed more than 100 km from the launch site

- Sky Dive From the Edge of Space (Channel 4 News)
- https://www.youtube.com/watch?v=erFZotpjnEM
    - 39.0 km up (128 000ft)

Action

This lesson is framed as a **3-Act Problem**. Students will:

Act 1: Engage with a question intuitively.
Act 2: Decide what they Need to Know in order to answer the question.
Act 3: Collect data and answer their question.

ACT 1:

- The teacher should pull out one helium balloon.
- Each student will be given 1 sticky note and asked to write down something that they are wondering about the balloon.
- Students will stick the note at the front of the class - if they discover another note with the same question, they should cover it with their sticky note.
- The teacher will read off the list of questions on the sticky notes.
    - If students don't ask it, the conversation should be guided towards the (likely) inevitable question: "**How many of these balloons would it take to send a person to the edge of space?**"
- In small, pre-assigned groups, students should answer the following questions on whiteboards or chart paper.
    - How many balloons do you think it would take? (Guess as close as you can)
    - Give an answer that you know is too high
    - Give an answer that you know is too low
    - Groups will post their answers on the class board and the teacher should lead a brief discussion highlighting trends in the hypotheses.

ACT 2:

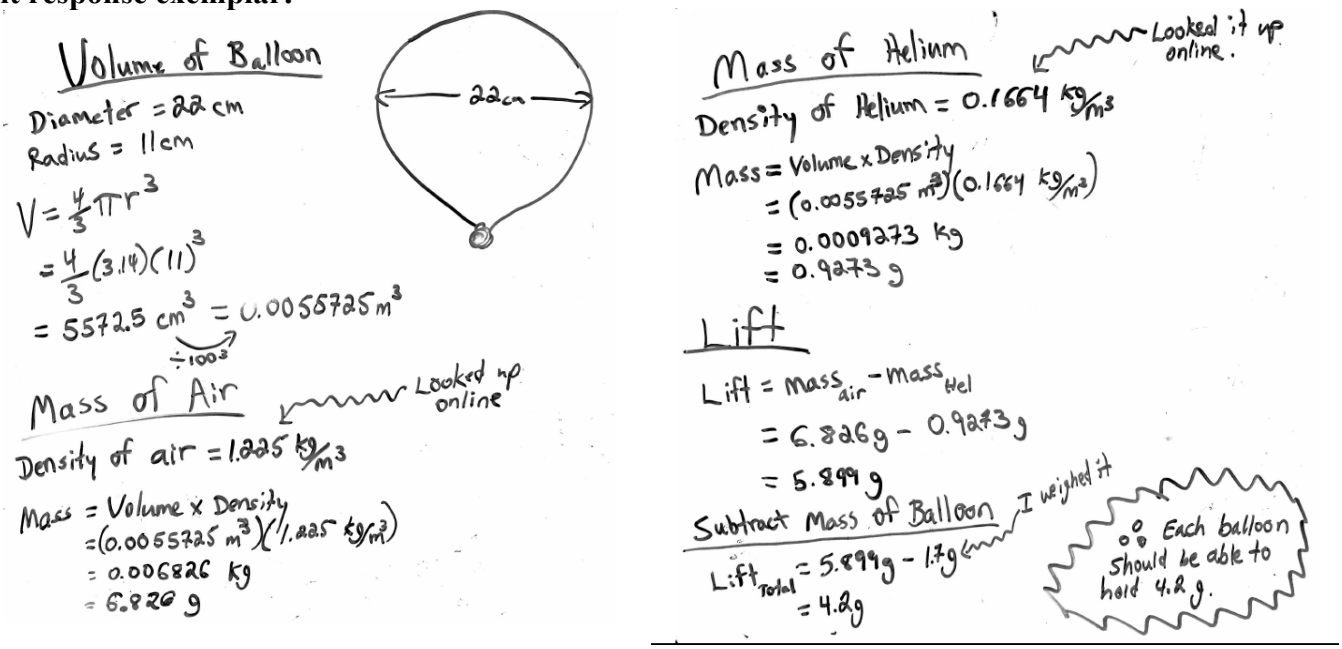
- The teacher should post the question: "**What information do you need to know to answer the question**?"
- Students should brainstorm with their group on their chart paper or whiteboard to create a list of necessary information for solving the problem. Entries will likely include:
    - The mass of the person being lifted
    - The mass of things attaching the person to the balloons
    - The lift force (amount of mass that it can keep suspended) of one balloon
    - The mass of one balloon
    - etc.
- Groups should take turns sharing their lists aloud and the teacher will consolidate the list on the board.
- The teacher should ask students, "**Which of these is most difficult to figure out?**" coaxing students to identify the lift force of the balloon.
    - The teacher should indicate that the electronic scale can easily measure the mass of the balloon and other small objects and the teacher can volunteer their own mass (in kg) for lifting OR take a volunteer from the class willing to share their mass.

ACT 3:

- Each group should be given a helium balloon.
- Groups will work collaboratively to calculate the expected lift of their balloon.
    - The teacher should show students **slide 2** (see Visuals link) and discuss the following concept of buoyancy.

- Buoyancy Concept
    - A balloon full of air feels like it weighs nothing because it is surrounded by air. Similarly, a bag of water feels heavy on land but feels like it weighs nothing when it's in a swimming pool. The lift from a helium balloon is the difference between the mass of the helium and the mass that air WOULD have in the space that the helium takes up (displaced air). In order to get lift, we need to figure out the mass of helium in the balloon and subtract it from the mass that an identically sized air balloon would take up.
- Depending on the independence of the students they may be left to work their way through the calculations OR together the class could brainstorm what students will need to know to perform this calculation (density of air, density of helium, volume of balloon).
    - Students should be encouraged to use phones, iPads, and any other tools to get answers.
- Students may choose many varied methods to get the volume of the balloon.
    - One such method is to assume that the balloon is spherical, measure the radius, and complete a volume calculation.
    - If students have recently taken math they will be familiar with calculating the volume of a sphere. If not, the following Khan Academy video can be used: https://www.khanacademy.org/math/basic-geo/basic-geo-volume-surface-area/basic-geo-volumes/v/volume-of-a-sphere
    - Students will need to be supported and coached through this process but should work to challenge themselves and struggle with the problem.

Student response exemplar:



- Note: Students may not think to subtract the mass of the balloon itself from the 'Lift' calculation.

- Students should keep a separate column to list ‘sources of error’ (ex. Density changes with pressure and temperature, balloon isn’t spherical, etc.).
  - Any time they suggest an issue that is beyond their control you should suggest that it goes into their 'sources of error'.
- Once students have a calculated the lift from one helium balloon they will perform a calculation to find the number of balloons needed to lift the teacher (or other chosen person).

TESTING CALCULATIONS:

- Students should now test their calculation.
- A suggested method is that students create a tape ball with a mass equal to the their calculated mass and affix this to the bottom of their balloon.
  - Students should adjust the tape ball until the balloon is neutrally buoyant (neither goes up nor down).
  - Students will compare and contrast the calculated and measured numbers and speculate why discrepancies might exist.

CLASS TEST:

- As a class, find the mass of a Lego figure. Groups should calculate how many balloons would need to be affixed to create neutral buoyancy.
- As a class, choose a number of balloons that would make the Lego figure fly and test it out in the school gym! (NOTE: It is not advisable to release the balloons outside, as there is an environmental impact - See consolidation).

Consolidation/Extension

Here is an enjoyable video for students to see balloons really lifting a person.

- Crazy Lawn Chair Balloon Flight https://www.youtube.com/watch?v=2GLrr_Xp0qc

Students should read 'Balloon Releases Threaten Wildlife' by the RSPCA to gain a deeper understanding of the environmental impact of balloon releases. (see Balloon Releases link)