LIFT OFF!: TEACHER GUIDE

Subject: Earth & physical sciences
Grade Level: Middle School
Last Updated: February 22, 2008

Case Summary

In light of global warming projections, Margarite & Marc decide to answer NASA's call for amateur scientists to design rockets which can orbit Earth or travel to another planet. They are up for the challenge to become Certified NASA Rocket Scientists . . . .

Credits

This case was written by Carly Price and Kevin McMahon (teachers, Renfroe Middle School, Decatur, GA) and Molly Embree (PhD student, Psychology, Emory University, Atlanta, GA), with input from Aimee Webb (PhD student, School of Public Health, Emory University, Atlanta, GA), as fellows of the Emory University PRISM program (Problems and Research Integrating Science and Math) (http://www.prism.emory.edu). Authors may be contacted at carlyprice11@yahoo.com, Kevin_McMahon@decatur-city.k12.ga.us, membree@emory.edu, and aimee.webb@gmail.com.

Learning Objectives

1. Conduct research using textbooks, dictionaries, online encyclopedias and web sources to investigate:
   - What is a force?
   - Why does a rocket have to overcome gravity?
   - What is gravity?
   - What is an atmosphere?
   - How does a rocket "overcome" it?
   - What is an orbit?
   - How does something get into orbit?
   - What are satellites?
   - amateur
   - civilian
   - Homeland Security
   - Review from "Day After Tomorrow" case:
     - What is global warming? Polar melting?
     - How does global warming affect weather patterns on Earth (eg. hurricanes)?
2. Prepare research reports on the above learning issues giving complete definitions, citing sources of information, and explaining concepts in your own words.
3. Identify definitions and examples of Newton's Laws
4. Recognize the scientific definition of pressure

 This material is based upon work supported by the GK-12 program of the National Science Foundation, under Award #DGE0231900. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. *CASES Online* is brought to you by the Emory College Center for Science Education, Emory University, Atlanta, GA. This document and other resources are available from the *CASES Online* Web site, http://www.cse.emory.edu/cases

5. Write a paragraph describing observations during the Demo Launches (on Day 6) in terms of Newton's Laws and using technical vocabulary (correctly) including "force," "gravity," and "trajectory."
6. Design and draw a scale model of a bottle rocket, complete with SI unit measurements of size, water volume, and target PSI for launch.
7. Select materials and build a bottle rocket according to design specifications and using lab safety skills in cooperation with team members.
8. Cooperate with team to launch bottle rocket using lab/field safety practices (supervised by facilitator)
9. Record & graph class launch data (PSI & time-in-air for each rocket)

<u>Major Concepts</u>
Forces
Gravity
Mass
Trajectories
Straight and circular motion
Newton's Laws 1 & 3
Satellites
Orbits
Space exploration
Global warming
Junior high crushes & dating

Georgia Performance Standards

S8CS1. Students will explore the importance of curiosity, honesty, openness, and skepticism in science. (NSES Content Standard A)

S8CS2. Students will use standard safety practices for all classroom laboratory and field investigations. (NSES Content Standard F)

S8CS3. Students will use computation and estimation skills necessary for analyzing data and following scientific explanations. (NSES Content Standard A)

S8CS4. Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities. (NSES Content Standard A)

S8CS5. Students will use the ideas of system, model, change, and scale in exploring scientific and technological matters. (NSES Content Standards A, F, & G)

S8CS6. Students will communicate scientific ideas and activities clearly. (NSES Content Standards A & E)

S8CS9. Students will understand the features of the process of scientific inquiry. (NSES Content Standard A)

SCS10. Students will enhance reading in all curriculum areas (NSES Content Standards A, D, F, & G):

a. reading in all curriculum areas (e.g. technical texts in science)
c. building vocabulary knowledge
d. establishing context

S8P2. Students will be familiar with the forms and transformations of energy. (NSES Content Standard B)
S8P3. Students will investigate relationships between force, mass, and the motion of objects. (NSES Content Standards B & D)
S8P5. Students will recognize characteristics of gravity, electricity, and magnetism as major kinds of forces acting in nature. (NSES Content Standards B & D)
a. Recognize that every object exerts gravitational force on every other object and that the force exerted depends on how much mass the objects have and how far apart they are.
S6E3. Students will recognize the significant role of water in earth processes. (NSES Content Standard D)
S6E4. Students will understand how the distribution of land and oceans affects climate and weather. (NSES Content Standard D)

Assessment

Boxcharts (individual assessment)
Learning Issue Research Reports with proper citation (individual assessment)
NASA certification application (individual assessment)
Rocket Blueprints (group assessment)
Demo Launch observations and proposed parameters: specific PSI and water volume (individual assessment)
Finished rocket (group assessment)
Graph of class launch data: PSI and time-in-air for each rocket launched (group assessment)

Implementation Strategy

This is a Problem-Based Learning (PBL) case, designed for use in standard public school classrooms of about 30 students. Subgroups of about 4-5 students were ideal for small group (team) work, such as reading the scenes, breaking down the data, questions, hypotheses, and learning issues, and assuming research responsibilities. Small groups were facilitated by at least one adult (teacher, parent, or PRISM graduate or undergraduate student). Students researched learning issues individually and in pairs and reported findings to the small group. Small groups reconvened with the whole class and their teacher frequently to review separate findings and summarize data and new directions.

This case was designed to run two consecutive weeks, beginning with Day 1 on a Monday.

<u>Day 1 (facilitated small groups)</u>

Brief announcement about case	5 min
Move into small groups; student-facilitator introductions	5 min
Read Scene 1 (first silently, then aloud, as a rule)	5 min
Brainstorm Data/Questions/Hypotheses/Learning Issues (DQHL)	10 min
Read Scene 2 (first silently, then aloud) + DQHL	10 min
Assign Learning Issues (individual and duplicate responsibility)	5 min
Self and small-group evaluations	10 min

<u>Day 2 (small groups)</u>	
Teams visit website; get "NASA" instructions	
Individuals & pairs research with laptops, textbooks, in-class resources	50 min
<u>Day 3 (small groups)</u>	
Individuals & pairs research with laptops; team discussion	35 min
Whole class brief discussion of main Q's & initial findings	15 min
<u>Day 4 (small groups)</u>	
Team discussion of LI's & prep for certification test	50 min
Computer simulations	
<u>Day 5 (individual, small group)</u>	
Scene 3: NASA certification test	15 min
If <u>all</u> team members succeed, begin rocket design	35 min
If <u>any</u> team member does not pass, team discussion of LI	
<u>Day 6 (large group)</u>	
Demonstration Launch of 2 L bottle (no fins, no cone)	35 min
No water, 70 PSI	
2 L water, 70 PSI	
1 L water, 70 PSI	
Individuals summarize demo launch observations	15 min
Record a water volume and PSI to propose to teammates	
<u>Day 7 (small group)</u>	
Teams discuss observations from previous day & rocket design	15 min
Team consensus on water volume & PSI for rocket → turn in for clearance	
Cleared teams select materials and finalize rocket design	35 min
<u>Day 8-9 (small group)</u>	
Teams divide tasks & begin rocket construction	50 min
(NASA certification retesting opportunities)	
<u>Day 10 (large group, small group)</u>	
Safety review	5 min
Teams launch rockets outside with teacher supervision	40 min
Return to class; write down results (cool down)	5 min

Case Notes

This Problem-Based Learning (PBL) case, entitled *Lift Off!*, was third in a series of four cases addressing physical science concepts in two sixth-grade classes at Renfroe Middle School, in the city of Decatur, Georgia (*see Resources section for other cases in this series*). In this case, our trusty characters, Margarite & Marc, find a NASA flyer in Little Five Points of downtown Atlanta inviting amateur scientists to create models of rockets that would orbit Earth or travel to another planet. They take the challenge and learn about Newton's Laws.

Goals

We reduced the structured guidance for the students in this case relative to the first three. Students were responsible for developing their boxcharts individually and discussing their learning issues as a group. We did not provide Learning Issue (LI) guides or blank LI report forms. We left it up to the students to hold each other accountable for reporting adequately on their specific LI's. We reduced the amount of parent/teacher facilitation as well, and left teams to run their own discussions after Day 1, although we did have parent and teacher facilitators during construction and launch days for extra safety supervision.

Results

Overall, we were impressed with the level of discussion run in the peer-facilitated groups. Our impression was that the removal of adult facilitation allowed the teams to take more responsibility for their own direction. Many groups conducted themselves far beyond the expectations we may have of "typical sixth-graders" in their treatment of peers, in type of discussion (hypothetical, evaluative), and in the level of focus on the goal. Predictably, groups varied considerably in dynamics and quality of final products. We liked using the "certification" test (and team tutoring with retesting) as a way to ensure that each individual student mastered the basic science concepts of the case. Also, while allowing students more responsibility for the direction of their groups meant that quality of work varied, this too offered an opportunity for development of PBL skills in reflection and evaluation. Students saw their team product alongside those of other teams and the range of accomplishment by teams depending on how energetically and how cooperatively they worked. Whether the outcomes were disappointing or exhilarating for teams, the fundamental lesson of this PBL case (aside from the science objectives) was responsibility for one's own learning.

Suggested Improvements

1. Guide Q's on the board for Day 3 to help teams assess their comprehension of the main concepts underlying the Learning Issues they are researching.
2. Demo Launch Observation Sheet for Day 6 – blank data table for 0, 1, 2 L water & 70 PSI; space to record observations; could include graph axes (X=vol water, Y=time in air)
3. Rocket Materials & Design Q's for Days 5-7– how do design elements like cones & fins affect a rocket's motion (*in terms of Newton's Laws*)? How do they expect changes in water volume & PSI to affect their rocket's motion?
4. NASA certification tests (4 or 5 separate versions) for Days 5-9 – to ensure conceptual understanding & not just rote memorization in students who retake the test; understand concepts? Can give/recognize examples?
5. Launch Disqualification and Consequences Contract for Day 10 safety review – teams need to know that certain behaviors by ANY team members will disqualify their whole team for launch, and they will have to leave the launch pad. Required behaviors (safety goggles, staying outside the launch circle, etc) and prohibited behaviors (pushing, trying to catch rockets, etc) should be clearly specified. Quick safety Q & A, and clear explanation of what disqualified teams will do after leaving launch pad.

6. Cool Down for Day 10 – after coming in from the launch pad, students (especially younger ones) could benefit from a brief minute to switch gears. A "minute paper" response about their observations can help them calm down for their next class.
7. Description of class trajectory beyond the case – what did KM do after the case, and how did he relate back to concepts addressed in case?

Case Synopsis

Scene 1
Margarite and Marc (presumably on a date) hear news of continued global warming trends as they walk in Little Five Points on a warm January day. A NASA flyer catches Margarite's eye.

Scene 2
The NASA flyer indicates that NASA is looking for amateur scientists to design models of rockets which could either orbit Earth or travel to another planet. It provides a website for more specific details of the project requirements.

Scene 3
NASA "Application to Become a Certified NASA Rocket Scientist." This is a pretest to see if students have mastered concepts of pressure, air resistance, friction, and Newton's First and Third Laws. All members of a team must pass the test (and are responsible for tutoring each other) before the team is certified to build a rocket.

This case was originally run without additional scenes or an epilogue. However, middle schoolers typically like to know what happens to the characters at "the end." Our characters Margarite and Marc appear in every case, and so, in a way, the case following this one serves as an epilogue for the whole series.

Facilitator Guide

Lift Off!

<u>Scene 1</u>

It is an unusually warm day in January. Margarite and Marc are walking to the popular store in Little Five Points, The Junkman's Daughter. The televisions across the street are blaring ". . . this global warming trend continues to cause trouble for citizens around the world. Many are considering how to leave Earth, because they fear polar melting, increased hurricanes, and high temperatures. Satellite images show odd movements of air masses, causing unpredictable forces . . ."

Margarite and Marc pass the post office, and then see a telephone pole with several flyers attached to it: "Free puppies," "Yard Sale Saturday," "Work from home on the Internet!"

Margarite stops in her tracks and says, "Hey, Marc! Hold on! Here's somethin' about NASA!"

Marc and Margarite read the NASA flyer.

<u>FACTS</u> • ATL is warmer than usual in January • Margarite & Marc are in Little Five Pts • They hear TV news talking about global warming trends • The TV news claims that some people are thinking about leaving Earth because of global warming-related weather problems • Satellite images show "odd" changes in air mass movements • Margarite sees a flyer from NASA & she stops Marc to read it	<u>HYPOTHESES</u> • Global warming may make Earth unlivable in the future • Margarite is more interested in the NASA flyer than the free puppies & yard sale • M & M are on a date • Margarite wants more information from NASA
<u>QUESTIONS</u> • What do M & M see on the flyer? • Are they on a date? • Why is Margarite interested in NASA?	**<u>LEARNING ISSUES</u>** **1. global warming & polar melting** **2. what are satellites?** **3. what is a force?** **4. is leaving the Earth a reasonable solution for dealing with global warming?** **5. What is "NASA" ?**

Scene 2

NASA Needs You!

Global warming is heating up the Earth and making weather disasters more frequent and more severe! Many people are busy trying to improve life on Earth, but the possibilities of living beyond the Earth must be explored also. The U.S. Department of Homeland Security and NASA are calling for amateur civilian scientists to form teams who can find solutions!

Your mission is to design a model of a rocket which can lift off with enough force to overcome the Earth's gravity and atmosphere. The rocket may orbit the Earth or travel to another planet. Teams must present their designs to NASA scientists for review.

For more information, contact your local NASA Recruiter.

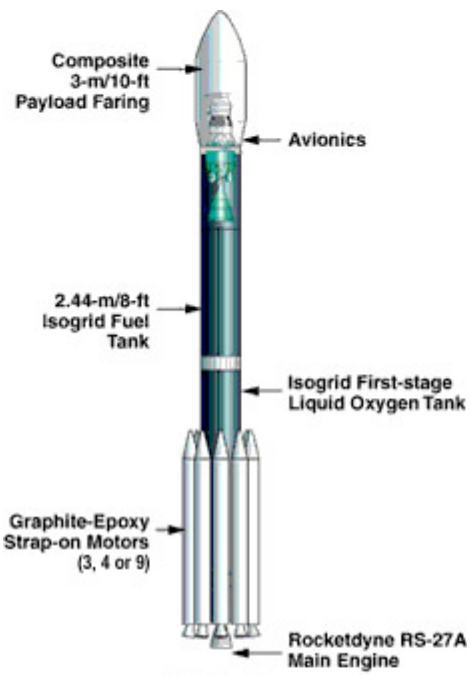
FACTS • Global warming is making weather disasters more frequent & severe • Homeland Security & NASA are looking for help from civilian scientists • The goal is to design rockets which can orbit Earth or reach another planet • NASA will review the designs made by civilian teams of amateur scientists	HYPOTHESES • Margarite & Marc may visit the website to find out more information • M & M will submit a rocket design to NASA • Global warming may cause disastrous effects to humans (& our ecosystems) if we do nothing to reduce it • Humans can take action to reduce global warming
INTERVIEW QUESTIONS • What do M & M plan to do?	**LEARNING ISSUES** **6. amateur** **7. civilian** **8. what is gravity?** **9. what is an atmosphere?** **10. what is meant by "enough force to overcome gravity & the atmosphere"?** **11. what is an orbit?** **12. How does something get into orbit?** **13. What does NASA do?** **14. What is Homeland Security?**

Scene 3

NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

Global warming is heating up the Earth and making weather disasters more frequent and more severe! The U.S. Department of Homeland Security and NASA are calling for amateur civilian scientists to form teams to design rockets to explore possibilities beyond the Earth!

Your mission is to become a NASA-certified rocket scientist. Then your team can design a rocket to leave this unpredictable planet.



Delta II

Step 1. Fill out a NASA application (provided by your science teacher).

Step 2. Gather information about gravity, forces, Newton's Laws, orbits, etc. and organize it into a boxchart. NASA suggests this format:

Facts	Hypotheses
Questions	Learning Issues

Step 3. Your team must help each other prepare for the NASA rocket scientist certification exam. You may take this exam at the following locations on the following dates:

Date	Time	Address	Room
[date]	[time]	[school address]	[rm]
[date]	[time]	[school address]	[rm]
[date]	[time]	[school address]	[rm]
[date]	[time]	[school address]	[rm]

Please note that your team will not be cleared to build a rocket until EVERY team member has been certified. NASA suggests group study and good teamwork for best results. When all of your team members are certified, you will receive confidential instructions and information on how to proceed. Good Luck!

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Application to Become a Certified NASA Rocket Scientist

Team Name: ____

Names: ______________________ ______________________ ______________________

______________________ ______________________ ______________________

School Name & Address: ____

____

Grade: ______ Teacher's Name: ____

Please answer the following questions without using the textbook or other resources:

1. What is inertia?
   a. A magnetic force that brings two objects together.
   b. The flow of electricity that helps objects go forward.
   c. The tendency of objects to keep moving unless acted upon by another force.
   d. The idea that forces always come in pairs.
   e. None of the above.
2. Choose an example that demonstrates Newton's Third Law:
   a. When Becky kicks a soccer ball, the ball pushes back on her foot.
   b. Gravity pulls things downward.
   c. When you push off the ground to take a step, the ground pushes back on you.
   d. Answers a & c are correct.
   e. All of the above.
3. What is the scientific meaning of pressure?
   a. Gravity pulling down on an object.
   b. Force over a certain amount of space.
   c. An amount of force sometimes measured in pounds per square inch (psi).
   d. Answers b and c are correct.
   e. None of the above.
4. True or false? Air resistance and friction are often the "unbalanced force" that slows down or stops objects. _________
5. A rocket displays Newton's Third Law by:
   a. Burning everything underneath it (grass, trees, etc.) in order to have enough fuel to go upward.
   b. Pushing downward with enough thrust so that the ground will push upward.
   c. Using electricity to just go upward without pushing on anything.
   d. Answers a and c are correct.
   e. None of the above.

Resources

For research of learning issues, students used their textbooks, in-class dictionaries and encyclopedias, books from the school library, and the following on-line resources:
http://www.nettrekker.com/
http://www.worldbookonline.com/

The following links (in projectile_links.doc) provide simulations which allow students to manipulate gravity, air resistance, mass, thrust, angle, etc, to understand how these interact in launches to achieve (or miss) orbit.

Cannonball projectile motion lab/simulation.
Bothun, G. (n.d.). Cannon. Retrieved June 8, 2006, from http://jersey.uoregon.edu/vlab/Cannon/

Good base website which links to many activities, simulations, including cannon ball arc and cannon ball satellite.
Motions and forces: American Physical Society. (n.d.). Retrieved June 8, 2006, from http://pdg.lbl.gov/~aerzber/aps_motion.html

Simulated rocket launches.
Gravity launch! (n.d.). Retrieved June 8, 2006, from http://www.sciencenetlinks.com/interactives/gravity.html

Other Marc & Margarite Cases

1. **Vortex**
   Embree, M., & McMahon, K. M., Price, C. J., & Webb, A. L. (2005). Vortex. Retrieved May 25, 2006 from Emory University, CASES Online Web site: http://www.cse.emory.edu/cases/casedisplay.cfm?case_id=243

2. **The Day After Tomorrow**
   Webb, A. L., & McMahon, K. M. (2005). *The day after tomorrow*. Retrieved May 25, 2006 from Emory University, CASES Online Web site: http://www.cse.emory.edu/cases/casedisplay.cfm?case_id=245

3. **Liftoff!**
   Price, C. J., & Webb, A. L., McMahon, K. M., & Embree, M. (2005). *Liftoff!* Retrieved May 25, 2006 from Emory University, CASES Online Web site: http://www.cse.emory.edu/cases/casedisplay.cfm?case_id=244

4. **Mars**
   Embree, M., & McMahon, K. M., Price, C. J., & Webb, A. L. (2005). *Mars*. Retrieved May 25, 2006 from Emory University, CASES Online Web site: http://www.cse.emory.edu/cases/casedisplay.cfm?case_id=246