TEXAS STATE
LBJ Institute for
STEM Education and Research

# The NASA Family Backpack Initiative

**A NASA Minority University Research and Education Project Aerospace Academy Resource**

Leveraging STEM interactive educational activities
to bridge school and home

## Educator Guide

This material is based upon work supported by NASA cooperative agreement Award number NNX15AW25A.
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 Aeronautics and Space Administration (NASA).

## INTRODUCTION

The NASA Family Backpack Initiative guide is designed for use by educators as an inclusive tool to assist in connecting students' experiences between school and home. Sometimes, educators face a challenge in finding effective and novel approaches to bridging a student's learning between school and home in a culturally relevant way. With this program, educators continuously engage with families by sharing students' experiences from the classroom, while simultaneously valuing the families' ideas and expertise—also known as their cultural wealth.

The NASA Family Backpack Initiative was designed as part of a collaborative agreement between NASA's Minority University Research and Education Project (MUREP) and Texas State University. The MUREP Aerospace Academy developed by Texas State University was branded "Future Aerospace Engineering and Mathematics Academies (FAMA)" to target the Spanish-speaking communities it serves. This program is more generally referred to as the NASA Family Backpack Initiative, but examples and some documentation include references to FAMA.

The program utilizes NASA educational interactive activities that focus on students' use of the engineering design process. The activities are designed for students to work in teams of three to four. Educators begin the activity in the classroom during the instructional day. This process engages students in the classroom; then, their families are encouraged to join in the learning process as the activity is extended to the home by drawing families and students to make revisions and improvements. Students are provided inexpensive, recyclable materials to carry out their investigations, but they are not limited to these provisions. Students then return with an improved model or extended experience, and report back to classmates emphasizing their own family's contribution.

The engineering design process used in this initiative is one that NASA has used in educational materials for K–8 students for several years. It includes a series of steps like ones engineers use in problem solving and engineering design. Engineers identify the problem, brainstorm solutions, select a design, build a model or prototype, test and evaluate, and optimize the design. These steps are then repeated with the goal of optimizing before sharing their solutions and designs. NASA activities encourage students to design by providing a list of materials, questions to help the student brainstorm solutions, and basic building steps that allow for student creativity and opportunities for original designs. The concepts showcased in these activities are connected to actual NASA missions. The NASA Backpack activities are not limited to the activities shared in this guide. The concept of taking NASA Family Engineering Design Challenges and adapting them for home extensions can continue to be applied by teachers to different NASA activities. Three activities showcased in this guide are ones that have been piloted for home and school use with 4$^{th}$ and 5$^{th}$ grade students as well as their teachers and families.

This guide assists educators to feel confident and supported in their efforts to integrate the engineering design process (EDP) into their curriculum. Resources and detailed implementation ideas are provided while illustrating student benefits when integrating cross curricular topics, and critical thinking and problem-solving techniques.

Creating a "buy in" of educators and their school districts is important and facilitated by the fact that each of the activities chosen for this guide is aligned to national and/or state learning standards; requires easily accessible recyclable materials; and most importantly, is kid-tested learning fun! We appreciate your willingness to invite and engage your students and their families to participate in STEM learning.

**Citation:** Martinez Ortiz, A., Garcia-Torres, S., Rodriguez Amaya, L, and Thompson, M., (2018). *The NASA Family Backpack Initiative – leveraging STEM interactive educational activities to bridge school and home* (LBJ Institute 2018 STEM Resources Collection). Texas State University: LBJ Institute for STEM Education and Research.

# Table of Contents

# BACKGROUND

The low numbers of students seeking science, technology engineering, and mathematics (STEM) degrees in our country has been a concern for the past decade. Current economic projections indicate a need for approximately 1 million more STEM professionals than the U.S. will produce at the current rate over the next decade (Bureau of Labor Statistics, 2015). According to some research in this area, early exposure to the sciences can increase awareness and understanding of STEM disciplines and career opportunities for students. Based on this research, an out-of-school learning program, affiliated with a school district, was designed to integrate learning experiences in STEM as well as early exposure to STEM careers.

A NASA MUREP-funded out-of-school pre-engineering program was launched in San Marcos, Texas that developed the NASA Family Backpack Initiative discussed in this guide. The Future Aerospace-engineers and Mathematicians Academy (FAMA) program was designed to increase participation and retention of historically underserved and under-represented students in STEM. This NASA-themed program was designed to offer early bilingual (English/Spanish), space-based STEM learning experiences to upperelementary and middle school students, and their families through outreach programs as well as professional development to preservice and in-service teachers.

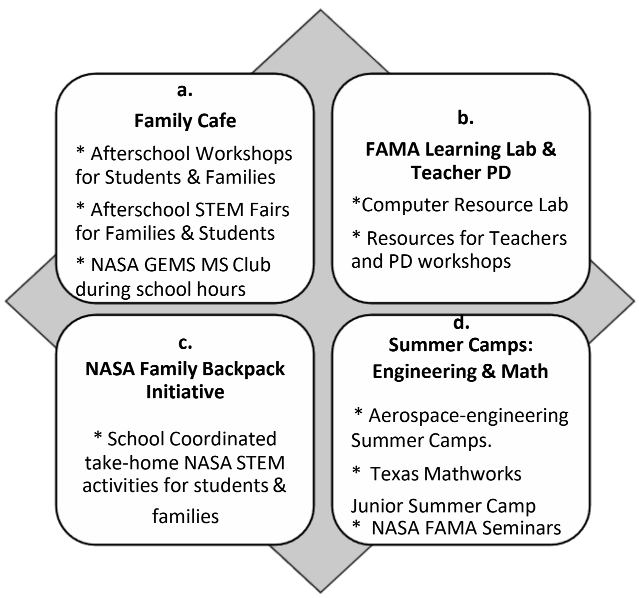



**Figure 1: Overview of the FAMA program**

The NASA Family Backpack Initiative (referred to hereafter as the Backpack initiative) incorporates enriching NASA STEM hands-on activities into the classroom experience, guided by the participating teacher with additional activities traveling to each student's home as a shared family learning experience.

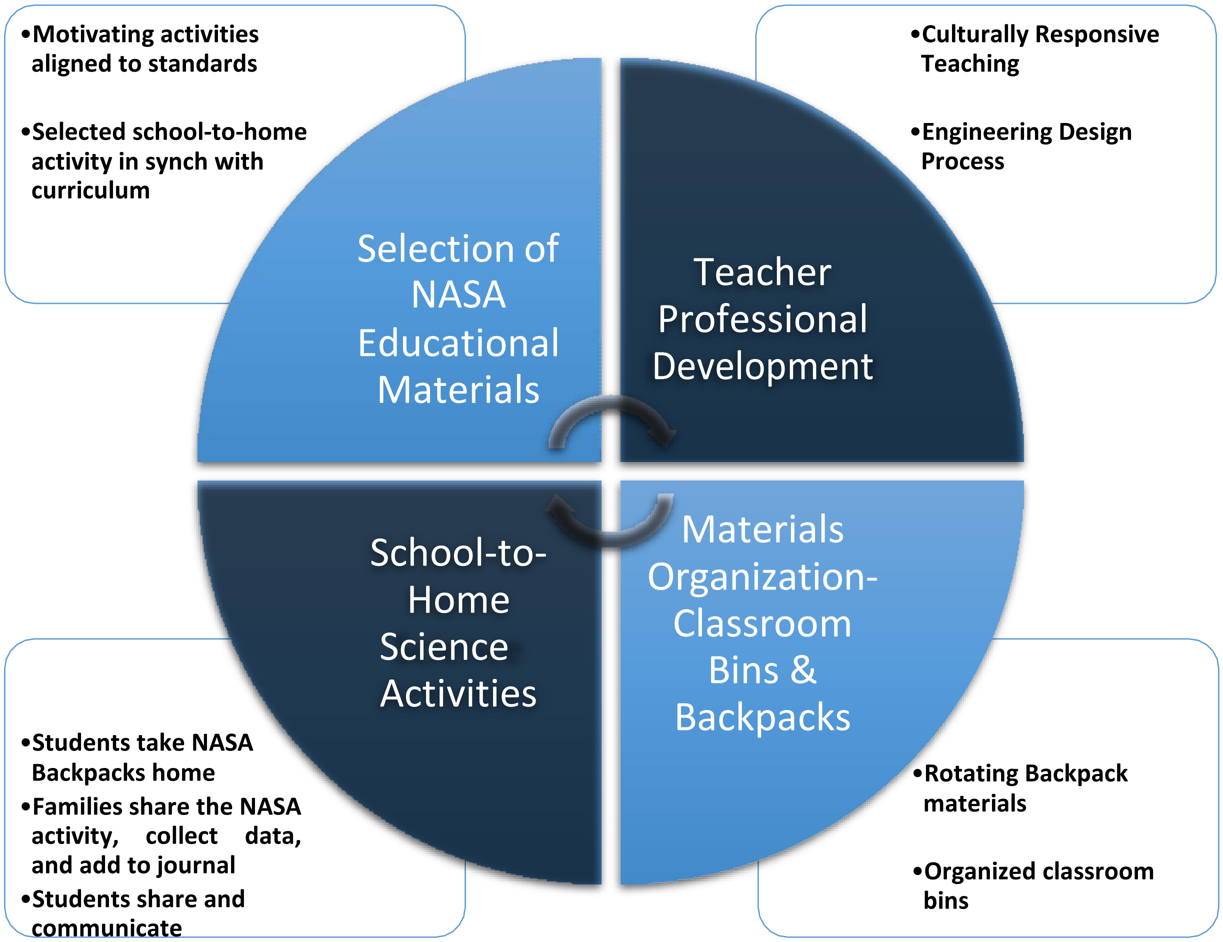



**Figure 2: Components of the NASA Family Backpack Initiative**

# OVERVIEW

**The Backpack initiative is simply a coordinated, grade-wide, classroom-to-home enrichment STEM activity that includes the teacher, each student in the class, and the students' respective families.** Specific planned learning objectives in science and math should be selected to guide the overall learning intent for each grade-level participating.

NASA offers a vast resource base of learning activities that are content rich, motivating, and aligned to science and math standards. These resources are freely available at various NASA websites described in the Appendix 4. Some science content/discipline areas that might be enhanced with this approach for elementary and middle school grades are as follows:

- Physical Sciences
- Life Sciences
- Earth and Space Sciences
- Engineering, Technology, and Applications of Science

Once the themes and lessons are identified, the Backpack activities can be organized, including adding a journal to capture the shared process of connecting the learning experience at school to the learning experience at home with their families. A family STEM night or other back-to-school event that involves families can be used to introduce the project.

Figure 3. FAMA nights-parent involvement

The materials for the NASA activities to be included in the backpacks can be organized using a storage bin referred to from now on as a "classroom bin." Each classroom bin includes the NASA activity, materials for class activity, and extension materials for the backpack. The NASA activity is introduced in class during the school day. Students work in teams to work on the NASA activity.

The backpack filled with materials is sent home as an extension activity to make improvements on the student's design activity. Families are not limited to the materials in the backpack and have a couple days to make improvements. Students then return the improved model to school and show classmates the improvements made. Materials included in the backpacks highlight NASA educational activities, resources, and careers. The NASA name brings excitement to students, teachers, and families alike. Capturing the attention and imagination of participants allows students to actively engage in the activities.

Each backpack is equipped with a copy of the NASA activity, letter to the parents, short survey, journal for family responses, and materials needed to complete the extended activity.

***What FAMA did….***


*Figure 4. Simple backpack with NASA patch*

Teachers from four elementary schools participated in the NASA Backpack initiative as part of the FAMA program initiated in cooperation with the partner school district.

Ten teachers and their students in fourth and fifth grade classrooms participated.

In 1 year, 450 students and their families participated in the program.

# PROGRAM COMPONENTS

## Culturally Responsive Teaching

It is critically important that teachers recognize the individuality of each student as cultural beings. Instruction that empowers ethnically diverse students through their "cultural knowledge, prior experiences, frames of reference, and performance styles" is known as "culturally responsive teaching" (Gay 2010). It is based on the assumption that when academic knowledge and skills are situated within the lived experiences and frames of reference of students; they are more personally meaningful, have higher interest appeal, and are learned more easily and thoroughly (Gay, 2010). Culturally responsive teaching (CRT) creates a bridge between students' multiple cultures (home, self-identity, and community) and learning.

Culturally Responsive Teachers:

- Make culturally relevant connections.
- Encourage students to apply their own insight to design and problem-solving.
- Seek input from your students.
- Acknowledge students' differences as well as their commonalities.
- Validate students' cultural identities in classroom practices and instructional materials.
- Educate students about the diversity of the world around them.
- Promote equity and mutual respect among students.

## Parent Involvement in STEM Education

Programs and interventions that engage families in supporting students' learning at home have been linked to student higher academic performance (Henderson et al., 2002; Rodriguez and Ramirez, 2016). When instituting a family home-based involvement program, careful consideration of the multiple representations of family caregivers is important. Students represent the increasingly diverse society and family structure involving not only parents, but also legal guardians, grandparents, older siblings, and other extended family. When helping students at home, these family caregivers confront different challenges, such as language barriers and lack of awareness of content learning strategies taught at school (e.g., math strategies in multiplication and/or division that are different to what they learned at school). It is important to have conversations with families to identify barriers affecting the families for which you are working. Conversations also spark a greater interest in their childrens' awareness of possible career pathways.

*Figure 5. Family Discussion Event*

***What FAMA did…***

In anticipation of the Backpack initiative implementation, two actions were taken to diminish participation barriers.

- NASA activities were presented in both English and Spanish to make the resources accessible to a significant percentage of English Language Learners.
- At family workshops, family members were asked to fill out a survey. Families engaged in facilitated conversations and ideas were captured as to the type of support they felt necessary to assist them in STEM curriculum.

## Ongoing Communication

When organizing a project, such as the Backpack initiative, it is important to keep ongoing communication with school administrators, participating teachers, students, and families. Conversations with administrators inform of the time commitment, financial investment, and expectations between home and school. It is essential that participating teachers have open communication with each other, students, and their families. Developing a support system with participating teachers provides a structure that strengthens your program.

Students need to be informed of the rotation calendar to know when it is their turn to take the backpack home to ensure equity and motivation in the classroom. A classroom visual calendar is useful. Contents in the backpack include: materials to continue the activity at home, a letter to the families informing them of the engineering design process, the activity the student participated in class, and a journal. A journal with an example entry is helpful for families to continue the communication of their work. The journal then travels with the backpack from family to family allowing for ideas to be shared throughout the learning community.

***What FAMA did…***

A spiral notebook was used as a journal. One of our teachers included an "example page" for families to follow. This strategy helped families to frame their work.

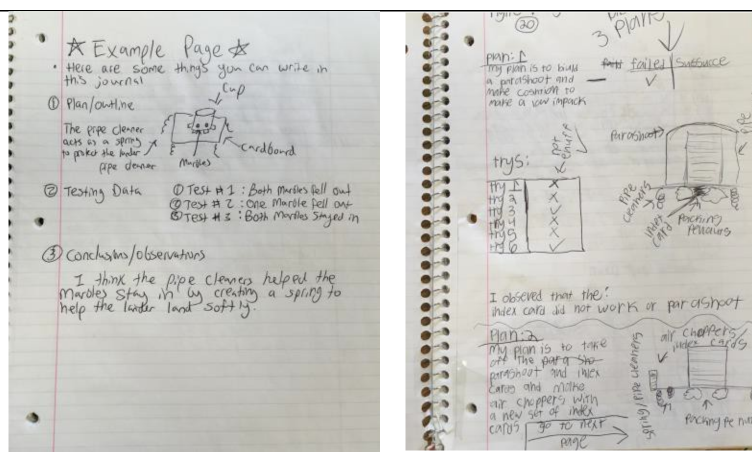



*Figure 6. Sample student journal pages*

## Integrating Engineering, Science, and Mathematics

There are multiple benefits for integrating engineering into the early elementary classroom. These benefits include improving students' achievement in mathematics and science, raising students' interest in engineering careers (National Academy of Engineering and National Research Council, 2009), and preparing students for STEM careers. In addition, K-12 engineering education experiences may facilitate inquiry-based student-centered learning environments (Martinez Ortiz et al, 2017).

By teaching the topics of science, technology, engineering, and mathematics in an integrated manner, within an exciting context and as a shared experience at the elementary school level, a higher level of critical thinking opportunities can be created. By connecting family-time and school-time learning, barriers can be broken regarding when learning happens and students' curiosity and motivation is fomented, while an understanding of technology as a tool for learning is enacted.

The NASA activities presented to students as part of the Backpack initiative result in designs that highlight creative thinking. STEM activities, and in this case, engineering design activities, break barriers, including the stereotype of student achievers and barriers of language between peers. When students work on design activities, you will be amazed in the way that *all* students interact with each other and problem-solve together.

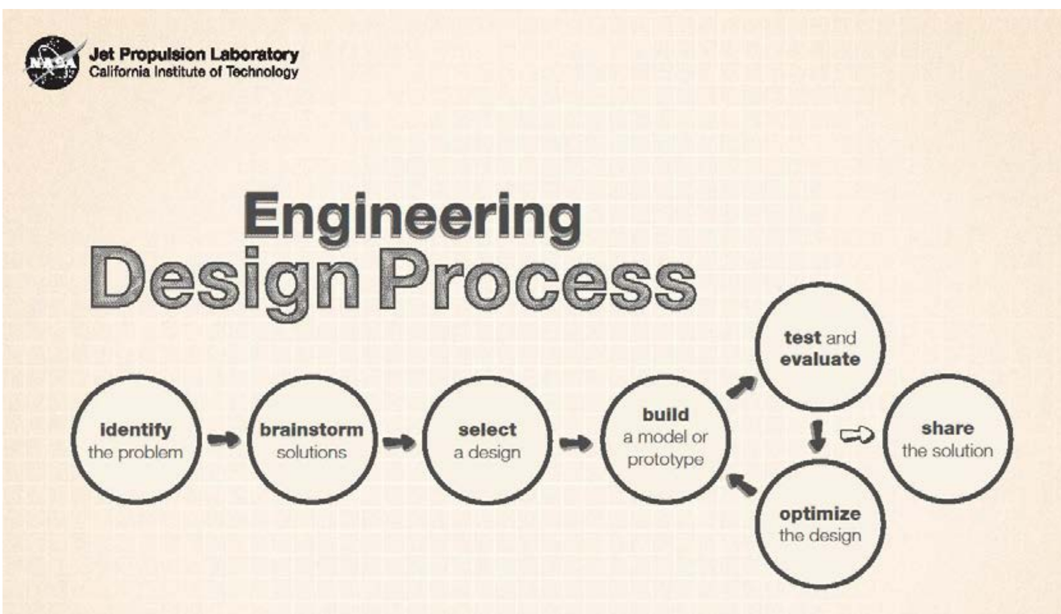



*Figure 7. Example of the Engineering Design Process steps from the Jet Propulsion Laboratory (JPL)*

**Tips for Teachers Implementing the Engineering Design Process:**

- **Identify** the problem. Students listen to or read the NASA activity, and identify what the design is for, and what are the criteria and constraints of a successful solution.
- **Brainstorm** solutions. Students participate in a process for developing potential design solutions. It is useful for students to see and feel the materials they will be using for the

design. However, this step gets tricky because students tend to want to get straight to building instead of spending time on the design. Providing students with a small sample of the materials is sufficient for brainstorming solutions and designs.

- **Select** a design. Students have conversations of the various design solutions, and compare and discuss how the solutions can be improved.
- **Build** a model or prototype. Have materials readily available from which students can select.
- **Test** and **Evaluate.** Students take time to test their designs and evaluate performance. It is during this time of the process that students collect data to determine evaluation.
- **Share** the solution. Students share their solutions with peers and receive feedback.
- **Optimize** the design. Students take peer feedback and their data to redesign.
- **Build, Test** and **Evaluate, Share,** and **Optimize** are steps that can be revisited to improve prototypes and/or designs.

## Learning Standards Drive School to Home Learning

Although not all states have adopted the Next Generation of Science Standards (NGSS), most states have rigorous, research-based science and mathematics standards that guide in the teaching of students. NASA activities selected in the Backpack initiative align with NGSS standards (see example in Appendix 1). There is a common goal unifying all K12 educators regardless of the standards they follow in preparing our children to be ready for college and a career—prepared for the academic demands of the STEM disciplines.

**What FAMA did…**

In Texas, the state learning standards for what students should know and be able to do are called the Texas Essential Knowledge and Skills (TEKS). State Standards were consulted along with the input of a representative teacher when deciding on the appropriate activities and lessons to include in a particular years' Backpack contents.

## NASA Activities

NASA Education resources are openly available at no cost to all educators. For this initiative, NASA activities must be selected that align to the learning objectives and standards for the participating grade-level each semester of implementation. Table 1 shows 10 sample NASA activities that may be easily adaptable to include as extension activities contained within the backpacks.

These are a few examples of the numerous NASA educational resources available through the NASA Education webpage (https://www.nasa.gov/offices/education/about/index.html). Another resource to learn more about NASA resources is the NASA Educator Professional Development Collaborative (EPDC) website (www.txstate-epdc.net). This site offers short videos, webinars, short learning courses (badges), and blogs that highlight NASA education resources with great tips on how to integrate these resources into the K-16 classroom.

More importantly, there is an emphasis in the NASA EPDC resources on the importance of CRT in STEM education and how to operationalize it. The NASA activities chosen are of our own choosing and do not necessarily reflect the opinion of the NASA organization or any other group. These 10 lessons are found in the Appendix 5.

**Table 1: NASA activities that can be included in the Backpack initiative**

| NASA Activities | |
|---|---|
| **Title of Activity** | **Summary** |
| **1) Packing up for the Moon** | Students explore the role of plants in ecosystems, determine the biological requirements for plant growth, and discover the conversion of matter and energy through natural processes. Students also use mathematical concepts (ratios and percentages) to compare and contrast the Earth and its moon. |
| **2) Food for Thought: Which Foods to Take to Mars?** | This extension has students measuring the amount of energy contained in various foods and determining the foods suitability for inclusion on a mission to Mars. |
| **3) Lunar Landing Sites** | Within a given background of the Moon's geological conditions, students design spacecraft, choose landing sites, and plan a lunar mission. This activity is a hands-on activity that culminates with oral, visual, and 3-dimensional presentations. |
| **4) Mass vs. Weight: A Heavy Duty Concept** | This lesson is an exploration of the difference between weight and mass. It has video demonstrations that illustrate the effects of mass on acceleration. |
| **5) Touchdown** | Students are designing and building a shock-absorbing system to protect two marshmallow "astronauts." |
| **6) On Target** | Students are asked to design a vehicle to release a marble at a very specific point to hit a target. |
| **7) Exploring the Moon: Lunar Biosphere** | This activity challenges students to create a working model of a lunar biosphere that is a balanced, self-enclosed living system able to run efficiently over a long period of time. |
| **8) Lunar Colonization: Understanding the Challenge** | This lesson is designed to familiarize students with space travel and exploration, the Moon and lunar colonization, and getting to the Moon—past, present, and future. It is very general and broad in scope. |
| **9) Follow the Water** | This lesson covers a broad understanding of water, its effect on and importance to ecosystems and the environment. Included is water in the solar system and the role of water in the search for extraterrestrial life. |
| **10) Feel the Heat** | In this challenge, students adhere to the engineering design process to achieve the following:<br>(1) Build a solar hot water heater.<br>(2) Test to see if it can raise the temperature of water.<br>(3) Use their testing results to improve their heater, and get as big a temperature change as possible. |

**What FAMA did**….
NASA activities were selected that aligned to the learning objectives and standards for 4th and 5th grades. *Touchdown* and *Packing for the Moon* (adapted to Mars) were used in the first 2 years of the Backpack initiative. As seen here, families were not limited by the materials provided in the backpack. Families were able to include their own cultural interpretations in the in this activity.

*Figure 8. Touchdown family project*

# IMPLEMENTATION CONSIDERATIONS

## Fostering Community Buy-in

Assuring school leadership and teacher buy-in of the Backpack initiative program is an important building block of the long-term sustainability plan for the initiative. Continuous teacher support for integrating the engineering and science practices in the classroom must be a deliberate act. Supplying materials and allowing time to continue teacher conversations on what is working and what is not working is essential. Valuing families' contribution as a learning tool in the classroom will shift the communities' mindset to acknowledge cultural wealth, which is valid and important for everyone in the classroom and school community. By communicating to families and community members and sharing our collective work, we open doors to future partnerships and opportunities.

***What FAMA did…***
To foster community buy-in, we collaborated with the local school district and a community center to host family events and STEM outreach events before launching the Backpack initiative. We invited the local newspaper to observe and report on this big initiative for such a small community! This partnership led to the local school district valuing the project to the extent that they agreed to fund it in future years.

## Professional Development and Support for Teachers

Teachers can benefit by receiving additional opportunities for professional development (PD) in STEM. In this PD, teachers practiced modeling approaches to assist in integrating engineering and science practices in a culturally relevant way. Through deliberate and quality teacher professional development, teachers begin to visualize how the engineering and science practices can be integrated into an existing scope and sequence and curriculum. Teachers also review content and learn about NASA resources.

**What FAMA did…**

The FAMA program invited 4th and 5th grade teachers in the district to participate in a full day of professional development. At this event, teachers explored NASA resources, culturally relevant pedagogy, and the engineering design process. Teachers received first-hand experience in employing the engineering design process, by identifying, brainstorming, selecting, building, testing, sharing, and improving their lunar landers and biosphere's designs.

*Figure 9 Teacher PD*

**Tips for Teachers:**

- Introducing the engineering design process through a story or conversation and a series of questions allows for authenticity and real-world application.
- Teachers who facilitate student exploration of *what technology is* and connect this to *how technology is manmade* can then effectively lead into discussion of the engineering practices and engineering design process.
- The use of visual models and key vocabulary gives the students tools to begin using the engineering design process and helps them apply the concepts across the curriculum.
- Additional resources, such as the *STEM Curriculum Review Rubric* (Martinez Ortiz et. al., 2016) and *NASA CRT Lesson Update and CRT Addendum* (Martinez Ortiz et. al., 2016) provided the framework from which to enhance the NASA activities selected.

## Scheduling and Organization

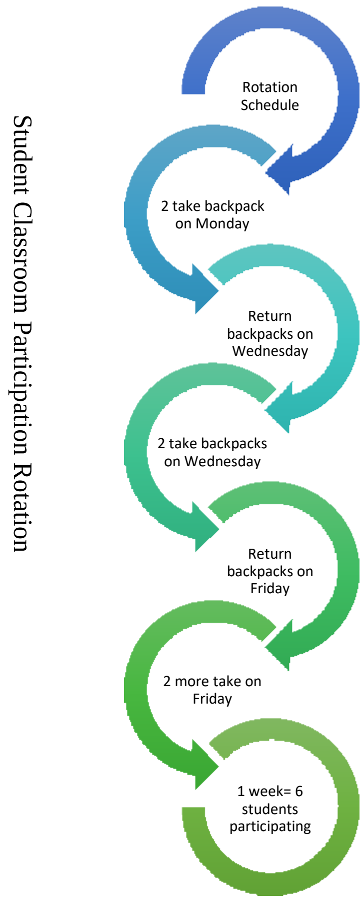



*Figure 10. Backpack rotation*

It is important to organize the rotation of the student backpacks to give all students an opportunity to take the backpack home and allow enough time during class for sharing.

In our implementation, students took the NASA activity home for 3 days, the first group from: a) Monday through Wednesday and the next group b) from Wednesday through Friday.

We communicated with the families by informing them that the journals were a class tool and would be used as a place to document findings and design improvements. Students were asked to return the backpack at the end of their assigned period and present their family's improved design to the class.

Teachers then gave students time to test their designs in front of the class, which usually takes place at the beginning or end of each day. Table 2 shows a more detailed overview of the Backpack initiative implementation steps and timeline.

**Table 2: Backpack Initiative Implementation Timeline**

| Step | Description | Time Period (sample) |
|---|---|---|
| **1. Creating buy-in** | Begin a conversation with school district administration and campus administration on benefits of incorporating Engineering Design Process using NASA activities. | Spring Semester |
| **2. Communication** | Work with your school district administration to organize and plan the best timeline for implementation of the NASA activities selected. | Spring/Summer Semester |
| **3. Classroom bin** | Collect materials for the NASA activity, activity design and instructions, and teacher support materials; and then organize into a bin. Two backpacks complete with materials should be also included in the bin. | Summer/ Early Fall Semester |
| **4. Professional Development** | The PD should be delivered before the teacher introduces the NASA activities. Teachers should take time to go through the NASA activity before engaging students in the classroom. | Fall or Early Spring Semester |

| | | | |
|---|---|---|---|
| 5. | **Distribution of materials** | The backpack bins should be distributed to all campuses participating. | Early Spring Semester |
| 6. | **Implementation** | An identified person is needed to work closely with each campus to provide professional development. | Spring Semester |

The classroom bin can be organized and distributed by grade level or by classroom needs. Some classrooms are a combination of two grade levels. NASA activities are appropriate for a multiple-age group. Each classroom bin needs to be filled with enough materials listed in the NASA activity for students to work in groups of three or four. In an average classroom, enough materials to make six sets is common. Each NASA activity lists the materials needed for that lesson. The materials required are easily accessible, recyclable, and inexpensive. In addition to the listed materials on the NASA activity, each classroom bin has a teacher folder complete with a hard copy of the lesson, journal and/or a spiral notebook for families to record their work, copy of the letter to the parent, copy for an optional family survey, and NASA Backpack initiative fact sheet for each teacher to know exactly what is included in the bin as well as two backpacks filled with materials to go home. Please refer to the Appendix 3 for an example of the parent letter, NASA activity, and NASA Backpack initiative fact sheet.

## Team Roles

For success with this program, it is helpful to have a team dedicated to supporting school campus efforts as well as being an advocate in the community.

- **Administrators.** Support by finding the funding and allowing time during the day for planning and organization of the classroom bins and materials.
- **Out of school activities coordinator**. This person is responsible for communicating the list of the materials needed for each NASA Backpack initiative activity, coordinating the organization of the classroom bins, and delivering the professional development to the teachers.
- **Academic coach or someone with flexibility in their school day.** This person could also fill the role to lead a team of educators by delivering the professional development to teachers and organizing, inventorying, and distributing the materials to teachers.
- **Teachers.** Participating teachers deliver the NASA activity during the school day and manage the logistics of the sending out and returning the backpack, including refilling consumable materials included in the backpack, ensuring equity and engagement.

**Tip:** Identifying a person who champions STEM on your campus helps with ensuring success on your campus. This person delivers professional development and/ or leads a team in choosing the NASA activity that best integrates into your existing curriculum. The team can then organize classroom bins, deliver bins, and refill supplies when needed.

| ***What FAMA did…*** |
|---|
| We worked with school district academic coaches to identify NASA activities that aligned well with their standards and curriculum. Academic coaches also helped us identify the right timing to introduce the activity. Through our partnership, we also identified a champion in the school district that was dedicated to STEM education. |

## Materials and Budget

The estimated projected cost for the Backpack initiative program is calculated for a single participating classroom, as shown in Table 3. Backpacks are an optimal way for students to transport materials from school to home. An inexpensive backpack or drawstring sport sack can be selected, and a NASA patch can be applied if desired. Additional costs, such as the consumables and printing vary depending on the activities chosen and type advertising for participation. In most cases, the Backpack initiative activity is an extension of the NASA activity and acts as an invitation to make improvements or gather additional data at home to the design completed in the classroom.

**Table 3: Backpack Initiative Single-Classroom Budget**

| Backpack Initiative Budget | | | | |
|---|---|---|---|---|
| **Single-Classroom Estimated Cost for Elementary Classroom** | | | | |
| Description | Details/Notes | Unit Cost | Quantity | Total |
| Backpacks | Can be purchased inexpensively from online companies | $12.00 | 2 | $24.00 |
| Backpack contents | An estimated cost of a typical NASA activity | $10.00 | 2 | $20.00 |
| 112-quart storage bin | Can be any size storage bin. | $34.00 | 1 | $34.00 |
| Storage bin contents | Materials are for entire class activity. | $30.00 | 1 | $30.00 |
| | | | Total Cost | $108.00 |

**Example of Materials for a Typical NASA Activity:**

- 1 piece of stiff paper or cardboard (approximately 4/5 in./ 10 x 13 cm)
- 1 small paper or plastic cup
- 3 index cards (3 x 5/ 8 x 13 cm)
- 2 regular marshmallows
- 10 miniature marshmallows
- 3 rubber bands

- 8 plastic straws
- Scissors
- Tape

***Food items may be substituted for nonconsumable materials, such as marbles, cotton balls, or Styrofoam peanuts instead of marshmallows.**

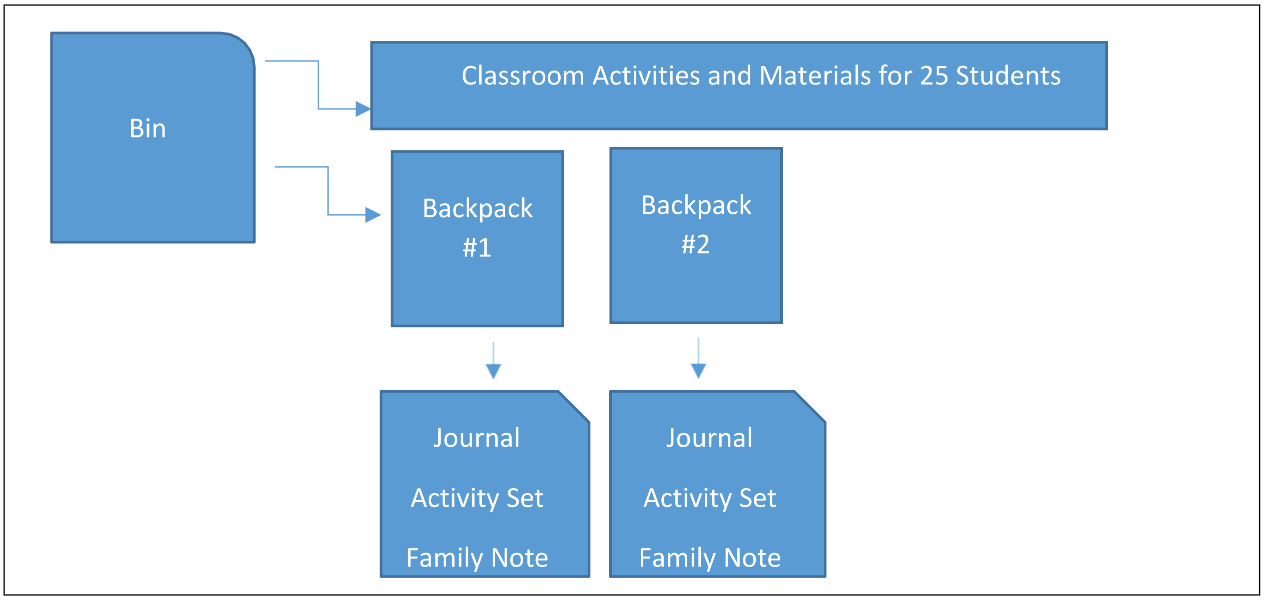



*Figure 21. Bin components/backpack components*

## Evaluating Impact

Evaluating the impact of this program can be accomplished through both quantitative and qualitative methods. A simple survey can be created. Also, evidence can be noted, such as the level of contribution from the families based on what they write in the journals.

The teacher can also make note of what students do and say when they share their designs through presentations to the class. This type engagement invites students to share their strengths through teamwork, and failure becomes part of the process to reach success. They engage in conversations, learn to negotiate, practice patience, and learn about cooperation.

***What FAMA did…***

According to teacher leaders in the school district, students practicing the engineering design process for the last 2 years have begun to exhibit an approach to problem solving that has eliminated the fear of "failure." Students look for several ways to problem solve the task dismissing the "one right answer or one right way." Teacher leaders are reporting students transferring this approach to problem solving in other academic areas.

> *"Students who have had the integration of engineering in their education are just thinking and problem solving at a much higher level than those students who have not,"* commented the science academic coach.

> "*While walking down the halls [at a local elementary school] a student ran up to me and excitedly exclaimed: 'I brought it!'…Let's test it!', "together we tested the spacecraft … the astronauts' marbles made a soft landing, surviving the fall. The young fourth grader looked straight up at me and stated in a serious tone, 'send it to NASA."*

## Scaling It Up and Making It Sustainable

We have found the Backpack initiative program to be most effective when a teacher has at least one other collaborating teacher also participating with his/her classroom. Once teachers have experience with this program, it can easily be scaled to include an entire grade level and can also be carried out at various schools in the school district. The good news is that this program can be kept fresh, because there is a tremendous supply of exciting and challenging NASA activities.

## References


Diefes-Dux, H. (2015). British Journal of Educational Technology. *Introducing engineering in elementary education: a 5-year study of teachers and students*. Vol46 No 5. Doi:10.1111/bjet.12319

Gay, G. (2010). *Culturally responsive teaching: Theory, research, and practice* (2nd ed.). New York: Teachers College Press.

Henderson, A. T., and Mapp, K. L. (2002). *A new wave of evidence: The impact of school, family, and community connections on student achievement*. Austin, TX: Southwest Educational Development Laboratory.

Martinez Ortiz, A., Rodríguez Amaya, L., Warshauer, H.K., Garcia Torres, S., Scanlon, E. and Pruett, M. (2017). Proceedings from 2016 American Society of Engineering Education annual meeting: *They choose to attend academic summer camps? A mixed methods study exploring motivation for and the impact of an academic summer pre-engineering camp upon middle school students in a Latino community.* Columbus, OH: American Society of Engineering Education.

National Academy of Engineering and National Research Council (2009). *Engineering in K-12 education: understanding the status and improving the prospectus*. Washington, DC: National Academies Press.

Rodriguez-Amaya, L., and Ramirez-Sanchez, M. (2016 ). Proceedings from 2016 Aeronautical International Conference: *Engaging Latino Families in STEM Education: Improving Parental Awareness and Confidence*. Mexico City, Mexico: Aeronautical International Conference.

Xue, Y. (2015, May). STEM crisis or STEM surplus? Yes and yes. Retrieved from https://www.bls.gov/OPUB/MLR/2015/ARTICLE/STEM-CRISIS-OR-STEM-SURPLUS-YES-AND-YES.HTM

# Appendices

# Appendix-1

## SELECT ACTIVITY ALIGNMENT TO STANDARDS

**NGSS alignment to the NASA activity: Touchdown**

| **Performance Expectation** | **Connections to NASA Backpack Activities: Touchdown** |
|---|---|
| 3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. | • Design and build a spacecraft to keep their astronauts safe/from falling out of the cup when landing |
| **Science and Engineering Practice** | |
| Asking Questions and Defining Problems<br>Planning and Carrying out Investigations<br>Constructing Explanations and Designing Solutions | • Demonstrate safe practices in testing the model<br>• Collect data to improve the spacecraft<br>• Consider the landing pad and measure the height of drop |
| **Disciplinary Core Ideas** | |
| Defining and Delimiting Engineering problems<br>Developing Possible Solutions<br>Optimizing the Design Solution | • Using everyday recyclable materials such as cardboard, pipe cleaners, tape, paper cup, design a safe, open cup that will absorb the shock and not throw astronauts (glass marbles) out<br>• Redesign after 3 trials |
| **Crosscutting Concepts** | |
| Influence of Engineering, Technology, and Science on Society and the Natural World | • Use models to draw and explain performance on the different natural surfaces when they take home for improvements.<br>• Record findings in class journal |

**NGSS alignment to the NASA activity: Packing for the Moon/Mars**

| **Performance Expectation** | **Connections to NASA Backpack Activities: Packing for the Moon/Mars** |
| --- | --- |
| 3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. | • To build a biosphere that is a balanced, self-enclosed living system able to run efficiently over a long period of time. |
| **Science and Engineering Practice** | |
| Asking Questions and Defining Problems<br>Planning and Carrying out Investigations<br>Constructing Explanations and Designing Solutions | • Understand that animals and plants interact and depend on each other in an ecosystem. |
| **Disciplinary Core Ideas** | |
| Defining and Delimiting Engineering problems<br>Developing Possible Solutions<br>Optimizing the Design Solution | • A biosphere is an enclosed system made of living and nonliving parts. |
| **Crosscutting Concepts** | |
| Influence of Engineering, Technology, and Science on Society and the Natural World | • Write about, illustrate and explain design. Defend choice of soil type, animals and plants with evidence.<br>• Document changes over time |

# Appendix-2

## NASA Backpack Fact Sheet

1. Each classroom gets 2 backpacks. Backpacks have same activity in them and circulate throughout the class during the month/weeks that you are focused on these TEKS.
2. Students take backpacks home for 3 days. Mon-Wed and then Wed to Fri.
3. Backpack has materials, list, including article/book and journal.
4. All materials will be in a tub brought to your school. Tub will be labeled. One tub per activity, per grade level, per school. In addition, backpacks will be handed to you ready to go.
5. Backpacks must be collected and returned on specific date to be refilled with new activity. TX State students will re-stock backpacks with new activity.
6. Teachers must hold on to class journals so students can continue to write.
7. We need to know the Science person at each school in 4th and 5th. This person will be responsible for distributing and gathering the materials and backpacks. Please make sure you have a “point” person at each school for 4th and 5th.
8. Should you need extra materials or have any questions please email Sara Torres or Maria Thompson.
9. To motivate students to return backpacks on time, please be creative in finding a way for students to share their findings.

<u>4th grade Back Packs</u>

ID Tag (School/teacher/grade)
Touch Down
Letter to parents
ActivitySheet
Book
Article
materials list
materials
journal and pencil

ID Tag (School/teacher/grade)
Lune Biosphere “Gardeners”
Letter to parents
Activity Sheet
Article 1
materials list
materials
journal and pencil

<u>5th Grade Back Packs</u>

ID Tag (School/teacher/grade)
Touchdown
Letter to parents
Activity Sheet
materials list
Materials
Journal and pencil

ID Tag (School/teacher/grade)
Lunar Biosphere “Water & Ice”
Letter to parents
Activity Sheet
Article 1 (moon)
Article 2 (mars)
journal and pencil

# Appendix-3

## Sample Parent Letter

Dear Parents,

You are invited to participate in the backpack activity with your child.

Your child has received this backpack as part of the Future Aerospace and Mathematicians Academy (FAMA). This initiative, a collaboration between Texas State University, the San Marcos Consolidated School District and the San Marcos Community, has been funded by NASA. The goal is to extend your child's learning in Science, Technology, Engineering and Math (STEM) education in a fun way!

The **ENGINEERING** Process
When faced with a challenge or problem engineers:

**ASK:** What is the problem? What do we know that can help us solve this?

**IMAGINE:** Design or draw out a possible solution. (draw in the notebook)

**PLAN:** choose the best design, material and get ready to work.

**CREATE:** Build your plan. Test it. Observe it. How did it work?

**IMPROVE:** Modify your design to make it better. Test it out again. *

Students: Please respond to this question in your journals. Remember to write the date and your name on the journal page.

**If you had more time and materials, what might you add to your design?**

Please make sure that materials that have a sticker or label on them are returned to the backpack, once the activity is complete. Bring your design with you to school and be ready to share.

Parents, we encourage you to work with your child and then share the experiences in the journal by drawing and writing alongside them. The information in this journal will circulate throughout the classroom.

Thank you for taking the time to explore with your child.

We hope you had a wonderful experience.

The FAMA Team

Sample of Survey

*Adapted from <u>Family Engineering</u> 2011

BackPack Survey sheet.

My child enjoyed the activities ________yes __________no

I was able to participate or read with my child _______yes ________no

If not, please state a reason:

_______too busy _______not enough time _______did not understand

_______did not interest me

Materials were included and in good condition ________yes__________no

If not, what was missing? ______________________________________________

Thank you for your time

# Appendix-4

## NASA ACTIVITIES IN ENGLISH AND SPANISH

Mass vs. Weight Stretching Mass

https://www.nasa.gov/pdf/591749main_MVW_Stretching_Mass.pdf

Mass vs. Weight Air Powered Mass

https://www.nasa.gov/pdf/591744main_MVW_Air_Powered_Mass.pdf

A NASA/Design Squad Challenge Touchdown

https://www.nasa.gov/pdf/418011main_OTM_Touchdown.pdf

https://www.jpl.nasa.gov/edu/teach/activity/touchdown/

A NASA/Design Squad Challenge On Target

https://www.nasa.gov/pdf/418005main_OTM_On_Target.pdf

https://www.jpl.nasa.gov/edu/teach/activity/on-target/

A NASA/Design Squad Challenge Down to the Core

http://pbskids.org/designsquad/pdf/parentseducators/DSN_NASA_MissionSolarSystem_DowntotheCore.pdf

A NASA/Design Squad Challenge Roving on the Moon

https://www.jpl.nasa.gov/edu/teach/activity/roving-on-the-moon/

https://www.nasa.gov/pdf/418009main_OTM_Roving.pdf

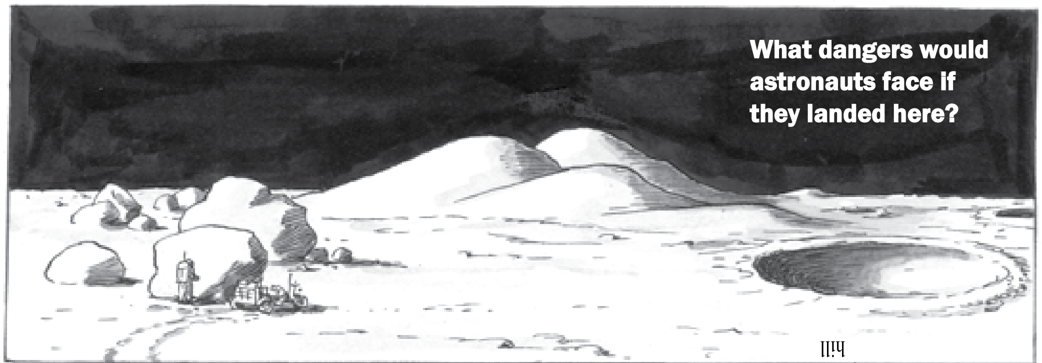
# Appendix-5

## NASA LESSONS INCLUDING CULTURALLY RESPONSIVE TEACHING IDEAS

a nasa/design squad challenge

# touchdown

**Landing on the moon is tricky. First, since a spacecraft can go as fast as 18,000 miles per hour (29,000 km/hour) on its way to the moon, it needs to slow way down. Then it needs to land gently. That lander has astronauts inside, not crash-test dummies. Easy does it!**




Answer: hitting a boulder, crater, or hill

## we challenge You to...

...design and build a shock-absorbing system that will protect two "astronauts" when they land.

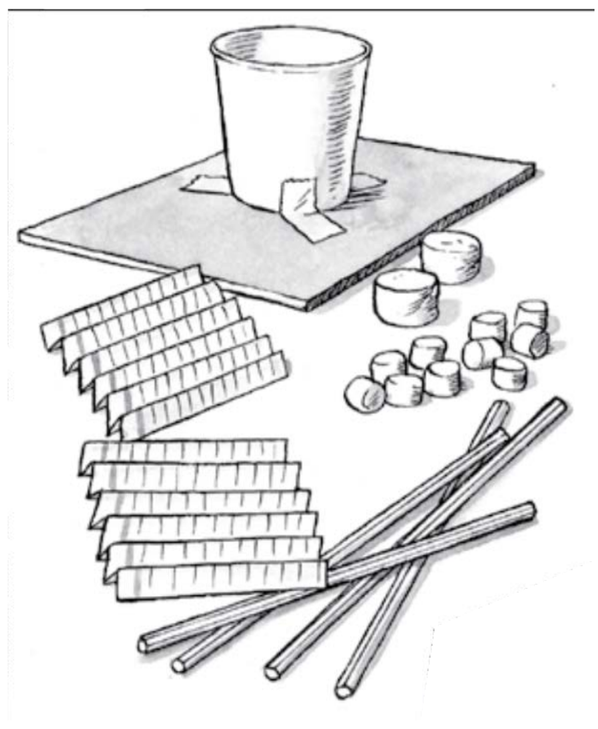
## BrainstorM and design

Think about how to build a spacecraft that can absorb the shock of a landing.

- What kind of shock absorber can you make from these materials that can help soften a landing?
- How will you make sure the lander doesn't tip over as it falls through the air?

## Build

1. **First, design a shock-absorbing system.** Think springs and cushions.
2. **Then, put your spacecraft together.** Attach the shock absorbers to the cardboard platform.
3. **Finally, add a cabin for the astronauts.** Tape the cup to the platform. Put two astronauts (the large marshmallows) in it. (NOTE: The cup has to stay open—no lids!)



**A lander under construction**

### Materials (per lander)

- 1 piece of stiff paper or cardboard (approximately 4 x 5 in/10 x 13 cm)
- 1 small paper or plastic cup
- 3 index cards (3 x 5 in/8 x 13 cm)
- 2 regular marshmallows
- 10 miniature marshmallows
- 3 rubber bands
- 8 plastic straws
- scissors
- tape

## test, evaluate, and redesign

Ready to test? Drop your lander from a height of one foot (30 cm). If the “astronauts” bounce out, figure out ways to improve your design. Study any problems and redesign. For example, if your spacecraft:

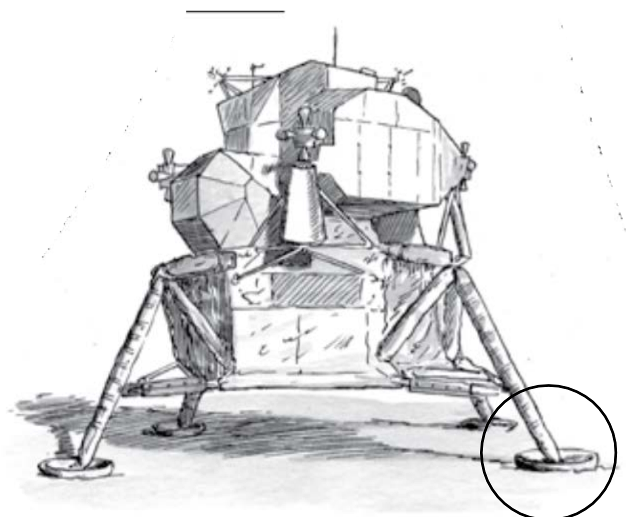
- **tips over as it falls through the air**—Make sure it’s level when you release it. Also check that the cup is centered on the cardboard. Finally, check that the weight is evenly distributed.
- **bounces the astronauts out of the cup**—Add soft pads or change the number or position of the shock absorbers. Also, make the springs less springy so they don’t bounce the astronauts out.

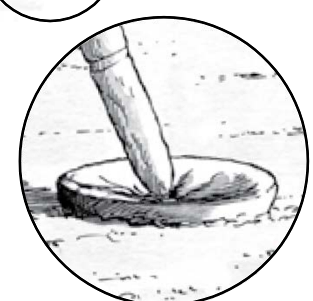
**Check out NASA’s moon missions at moon.msfc.nasa.gov.**

## the coolest JoB at nasa

When people asked Cathy Peddie what she wanted to do when she grew up, she would point at the sky and say, “I want to work up there!” Now an engineer at NASA, she manages the Lunar Reconnaissance Orbiter (LRO) project. She calls it “the coolest job at NASA.” LRO will orbit the moon for at least a year and collect information to help NASA prepare for having people live and work there. Hear her describe the mission at: **learners.gsfc.nasa.gov/mediaviewer/LRO**.

Only 12 people have ever visited the moon. But someday soon NASA plans to have teams of astronauts living there for six months at a time.





## Buried alive?

The first people who landed on the moon took a big risk. That’s because the moon is covered with a thick layer of fine dust. No one knew how deep or soft this layer was. Would a spacecraft sink out of sight when it landed? Now we know—the layer is firm. In the picture, you can see that Apollo 11’s lander pads sank only about 2 inches (5 cm) into the dust. What a relief! This helped NASA figure out the kinds of shock absorbers and landing systems its spacecraft need.

**Watch DESIGN SQUAD on PBS or online at pbs.org/designsquad.**

Major funding for *Design Squad* provided by Corporation for Public Broadcasting (A private corporation funded by the American people), intel Education

Additional funding for *Design Squad* provided by NCEES National Council of Examiners for Engineering and Surveying, Noyce Foundation, Northrop Grumman Foundation, IEEE



This NASA/*Design Squad* challenge was produced through the support of the National Aeronautics and Space Administration (NASA).

UN RETO NASA/ DESIGN SQUAD

# ANOTACIÓN

Aterrizar en la Luna es engañoso. Primeramente porque un vehículo espacial puede ir tan rápido como a 18,000 millas por hora (29,000 km/hr) de ida a la Luna, y necesita bajar considerablemente la velocidad. Después necesita aterrizar suavemente. Esta aeronave no lleva maniquies de prueba lleva astronautas reales.

MATERIALES (por pieza)

- Una pieza de paperl corrugado o cartón (aproximadamente 4 x 5 pulgandas/ 10 x 13 cm)
- Un vaso pequeño de plástico o papel
- 3 tarjetas (3x5 pulgadas / 8x13 cm)
- 2 malvaviscos regulares
- 10 malvaviscos miniatura
- 3 bandas elásticas
- 8 popotes de plastico
- tijeras
- cinta adhesiva

## TE RETAMOS A...

….. diseñar y construír un sistema de absorción de impacto que pueda proteger dos “ astronautas” al momento del aterrizaje.

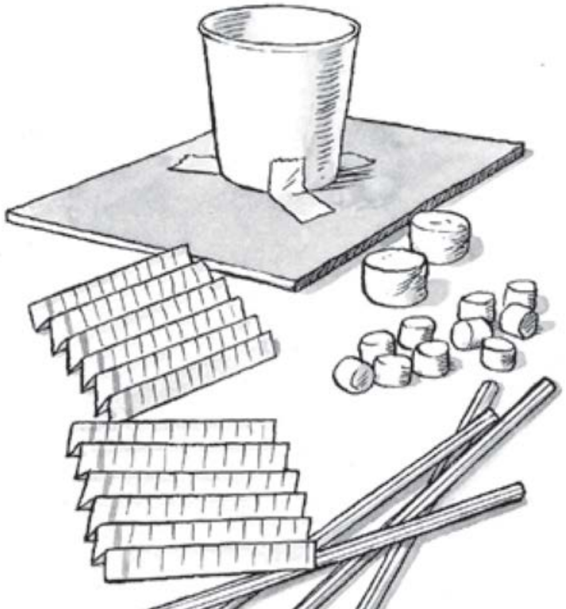
## LLUVIA DE IDEAS Y DISEÑO

Piensa en cómo construir una nave espacial que pueda absorber el impacto de un aterrizaje.

- ¿Qué tipo de absorción de impacto puedes construir con estos materiales demodo que puedas ayudar a tener un mejor aterrizaje?
- ¿Cómo asegurarías que la nave no se vuelque mientras cae por el aire?

## CONSTRUCCÍON

1. Primeramente, diseña un sistema de absorción de impacto. Piensa en resortes o cojines.
2. Enseguida, arma la nave. Une el sistema a la plataforma de cartón.
3. Finalmente, agrega una cabina para los astronautas. Pega el vaso a la plataforma. Coloca dos astronautas (los malvaviscos grandes). (NOTA: ¡El vaso deberá estar sin tapa!).



la areonave en construcción

## PRUEBA, EVALUACIÓN Y REDISEÑO

¿Listo a provar? Deja caer la nave desde una altura de un pie (30 cm). Si los “astronautas” se balancean, piensa en cómo mejorar tu diseño. Estudia cualquier problema y rediseña, por ejemplo, si tu nave:

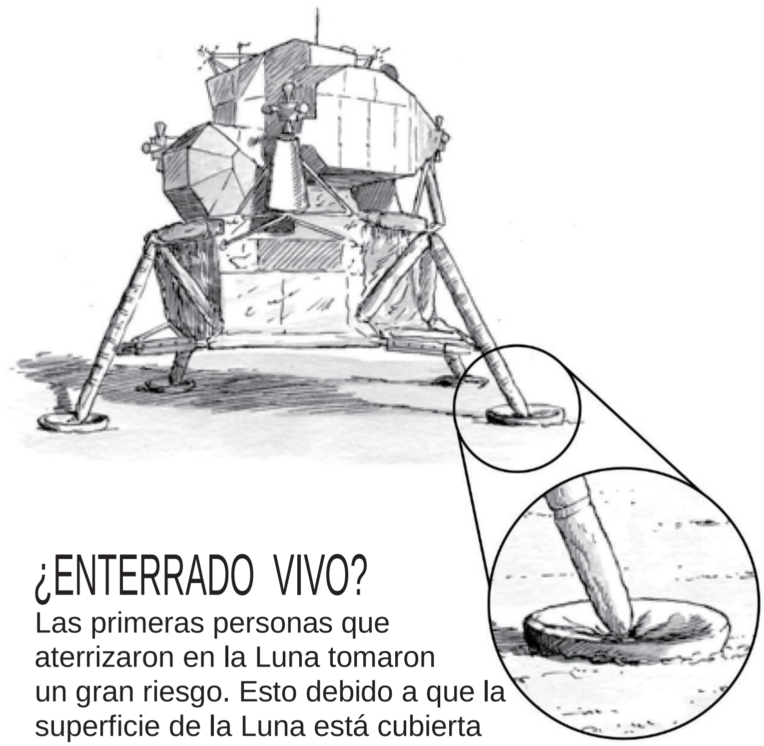
- Se voltea mientras cae en el aire — Asegúrate que esté nivelado al momento de soltarlo. También asegúrate que el vaso esté centrado con respecto a la pieza de cartón. Finalmente revisa que el peso esté distribuído en partes iguales.
- Expulsa a los astronautas fuera del vaso — Añade cojines suaves o cambia el número o la posición de las piezas que absorve-impacto. También haz los resortes menos potentes de modo que no expulsen a los astronautas.

disfruta las misiones lunares de la NASA en moon.msfc.nasa.gov.

## EL MEJOR TRABAJO EN LA NASA

Cuando las personas le preguntaban a Cathy Peddie que quería ser de grande, ella apuntaba al cielo y decía: “¡Yo quiero trabajar allá arriba!” Ahora como ingenireo de la NASA, es encargada del proyecto Módulo Orbital de Reconocimiento Lunar (Lunar Reconnaissance Orbiter, LRO). Ella lo llama “ el mejor trabajo en la NASA”. LRO estará orbitando la Luna por lo menos un año y estará recolectando información para ayudar a la NASA a prepararse en llevar a personas a vivir y trabajar allá. Escucha su explicación en: **learners.gsfc.nasa.gov/ mediaviewer/ LRO**

Solamente 12 personas han visitado la Luna. Pero un día muy cercano la NASA planea tener equipos de astronautas viviendo ahí por seis meses cada vez.



## ¿ENTERRADO VIVO?

Las primeras personas que aterrizaron en la Luna tomaron un gran riesgo. Esto debido a que la superficie de la Luna está cubierta con una capa gruesa de fino polvo. Nadie sabía que tan profundo o suave era ésta capa. ¿Se hundirá la nave espacial al momento del aterrizaje? Hoy en día sabemos que la capa es firme. En la foto, puedes apreciar que los cojines de aterrizaje del Apollo 11 se sumergieron solamente 2 pulgadas (5 cm) en el polvo. ¡Qué alivio! Esto ayudó a la NASA a encontrar los perfectos sistemas de absorción de impacto y aterrizaje que las aeronaves necesitan.

**sigue DESIGN SQUAD en PBS o en linea en pbs.org/ designsquad.**

**Major funding for *Design Squad* provided by**

Corporation for Public Broadcasting — A private corporation funded by the American people

intel Education

**Additional funding for *Design Squad* provided by**

NCEES National Council of Examiners for Engineering and Surveying

NOYCE FOUNDATION

NORTHROP GRUMMAN Foundation

IEEE

a nasa/design squad Challenge

# On TargeT

**Thanks to NASA, the moon is getting a new crater! NASA is sending a spacecraft hurtling into the moon's surface. Why? To see if there's water below the surface. This collision will send up a plume of dust and gas over 6 miles (10 km) high. To tell if there's any water, scientists will look for ice crystals and water vapor in this plume.**

## We Challenge YOu TO...

...modify a paper cup so it can zip down a line and drop a marble onto a target.

## BrainsTOrM and design

Think about how you might design a way to carry and launch a marble:

- How will you modify the cup so it can carry a marble down a zip line and also drop it onto a target?
- How will you remotely release the marble from the cup?
- When do you need to launch the marble so that it will hit the target?

## Build

1. **First, set up a zip line.** Tie 6 feet (1.8 m) of the smooth line to two objects (e.g., two chairs or a table and chair). Make sure it's stretched tight and that one end is about 20 inches (50 cm) below the other.
2. **Next, figure out how to modify the cup to carry the marble down the zip line.** Will it travel inside the cup? Outside the cup on a platform? Underneath?
3. **Then, add a remote release.** Decide how you will tip the cup at just the right instant to launch the marble toward the target.
4. **Finally, clip the cup to the zip line.** Figure out how to hook the cup onto the zip line so it slides easily.

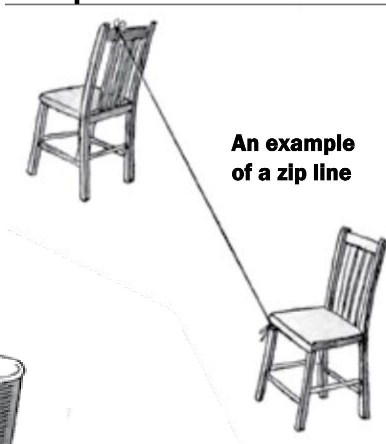
## TesT, evaluaTe, and redesign

Ready for a test run? Place the target near the end of the zip line. Send down the cup and try to hit the target with the marble, using the remote release. How close did you get? See a way to improve your design? Engineers improve their designs by testing them. The steps they follow are called the design process. Try your idea and build an improved version. For example, if your cup:

- **goes slowly**—*Check that the zip line is steep enough. Also, make sure the cup slides freely.*

### MaTerials (per zip line)

- 9 feet (3m) of smooth line (e.g., fishing line or kite string)
- index card
- marble
- masking tape
- paper clip
- 1 medium-sized paper cup
- scissors
- target drawn on a piece of paper



**An example of a zip line**

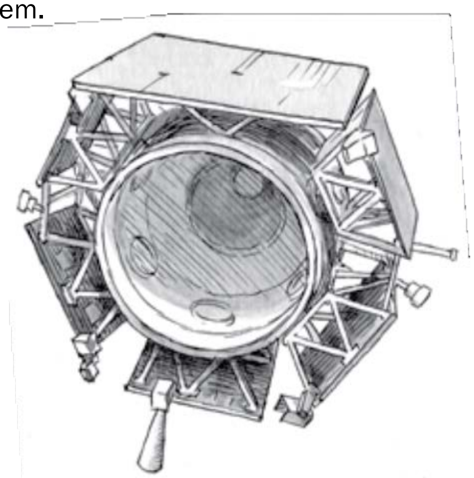
**Materials to make a zip line, carrier, and target**

- **can't keep the marble in**—*Roll a small tube of tape to keep the marble from falling out accidentally. Also, adjust the tilt of the cup so it doesn't tip the marble out.*
- **doesn't let the marble out**—*Roll small tubes of tape and build a chute to funnel the marble toward the opening. If necessary, adjust the tilt of the cup so the marble can roll out more easily.*
- **misses the target**—*Since the marble is already moving forward along the zip line, it keeps moving forward as it falls. Make sure to take this forward motion into account as you choose a release point.*

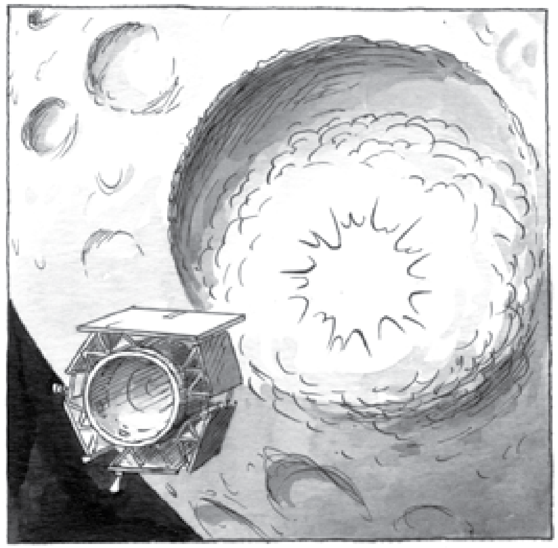
**Check out NASA's moon missions at moon.msfc.nasa.gov.**

## "running arOund in The WOOds helped Me The MOsT."

As a kid, Tony Colaprete loved nature, ecology, and running around in the woods. He liked thinking about how, in one way or another, everything is connected. He brings that kind of thinking to his job as a planetary scientist and as the top scientist for NASA's LCROSS mission. To learn about how other planets work, he builds computer models and designs instruments. These help him understand the many interesting connections between the different planets in our solar system. And the more Tony discovers, the more we learn about how our world—Earth—fits within our solar system.



**NASA's Lunar Crater Observation and Sensing Satellite (LCROSS) will hit the moon, raising a tall plume of dust and gas and hopefully revealing the presence of water.**



## lOOk OuT BelOW!

NASA wants to make a deep hole on the moon to see if there's ice in the soil. But instead of beginning to dig at the surface, NASA is getting a head start. It will dig its hole at the bottom of a crater that's already about one mile (2 km) deep—and it won't dig, exactly. Instead, NASA will plunge a spacecraft named LCROSS into the crater. Scientists expect the collision will make a hole that's 80 ft. (24.4 m) across and 15 ft. (4.6 m) deep. The chances of finding ice at the bottom of this deep, dark, cold place are much better than finding it at the moon's surface, where the sun shines brightly on the soil, vaporizing any ice.

**Watch DESIGN SQUAD on PBS or online at pbs.org/designsquad.**

**Major funding for *Design Squad* provided by**

Corporation for Public Broadcasting

A private corporation funded by the American people

intel Education

**Additional funding for *Design Squad* provided by**

NCEES National Council of Examiners for Engineering and Surveying

NOYCE FOUNDATION

NORTHROP GRUMMAN Foundation

IEEE



This NASA/*Design Squad* challenge was produced through the support of the National Aeronautics and Space Administration (NASA).

UN RETO NASA/ DESIGN SQUAD

# EN EL BLANCO

Gracias a la NASA, ¡la Luna tendrá un nuevo cráter! La NASA esta enviando una nave espacial a la superficie lunar. ¿Por qué?, para ver si existe agua debajo de la superficie. Este impacto enviará una nube de polvo y gas mas ayá de 6 millas (10km) de altura. Para saber si existe agua los científicos esperan encontrar cristales de hielo y vapor de agua en esta nube de polvo.

## TE RETAMOS A...

…modificar un vaso de papel de tal modo que pueda deslizarse hacia abajo y lanzar una canica dando en el blanco.

## LLUVIA DE IDEAS Y DISEÑO

Piensa como podrías transportar y lanzar una canica:

- ¿Cómo modificarías el vaso de manera que pueda transportar una canica hacia abajo por el cordón guía y al mismo tiempo llegar al blanco?
- ¿Cómo podrías controlar la expulsión de la canica del vaso?
- ¿Cuándo necesitas lanzar la canica para que ésta de en el blanco?

## CONSTRUCCÍON

1. Primero, ten listo el cordón guía. Ata 6 pies (1.8 m) de cordón flexible a dos objetos (por ejemplo: dos sillas o una silla y una mesa). Asegúrate que el cordón guía esté derecho y firme y que uno de los extremos esté alrededor de 20 pulgadas (50 cm) por debajo del otro extremo.
2. Siguiente, piensa como modificar el vaso para que transporte la canica por el cordón guía hacia abajo.
3. Entonces, agrega un liberador controlado.Decide como inclinarás el vaso en el momento preciso para lanzar la canica contra el blanco.
4. Finalmente, sujeta el vaso en el cordón guía usando el sujetador de papeles (clip). Encuentra la manera de enganchar el vaso al cordón guía de manera que se deslice fácilmente.

## PRUEBA, EVALUACION, Y REDISEÑO

¿Listo para correr una prueba? Coloca el blanco cerca del extremo del cordón guía. Envia el vaso hacia abajo y trata de dar en el blanco con la canica, usando el liberador controlado. ¿Que tan cerca llegaste?, ¿Vez alguna manera de mejorar tu diseño? Los ingenieros mejoran sus diseños realizando pruebas con ellos. Los pasos que ellos siguen son llamados diseños de proceso. Prueba tu idea y construye una versión mejorada. Por ejemplo, si tu vaso:

- **se mueve lento** — Revisa que el cordón guía esté suficientemente inclinado. Al mismo tiempo, revisa que el vaso se deslize libremente.

MATERIALES (por cada cordón guía / tiroleta)

- 9 pies (3m) de cordón flexible (por ejemplo: cordón para pescar o cordón para papalote)
- tarjeta
- canicas
- cinta adhesiva
- sujeta papeles
- 1 vaso de papel mediano
- tijeras
- blanco dibujado en un papel

Ejemplo de cordón guia/ tiroleta

Materiales para hacer un cordón guia, trasportador y el blanco

- **No puedes mantener la canica dentro** — rueda un tuvo pequeño de cinta para prevenir que la canica caiga por accidente. Al mismo tiempo, ajusta la inclinación del vaso de manera que no empuje la canica hacia afuera.
- **No deja salir la canica** — rueda unos tuvos pequeños de cinta y construye una rampa para hacer pasar la canica en dirección a la apertura. Si es necesario, ajusta la inclinación del vaso de manera que la canica pueda rodar mejor.
- **No dar en el blanco** — Como la canica está moviéndose hacia adelante por el cordón guía, seguirá moviéndose mientras caiga. Asegúrate de tomar éste movimiento hacia adelante en cuenta al momento de escoger el punto de liberarla.

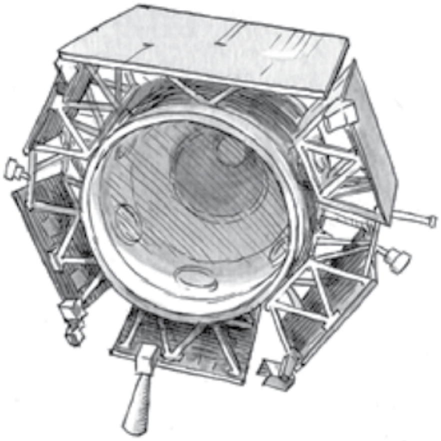
disfruta las misiones lunares de la NASA en moon.msfc.nasa.gov.

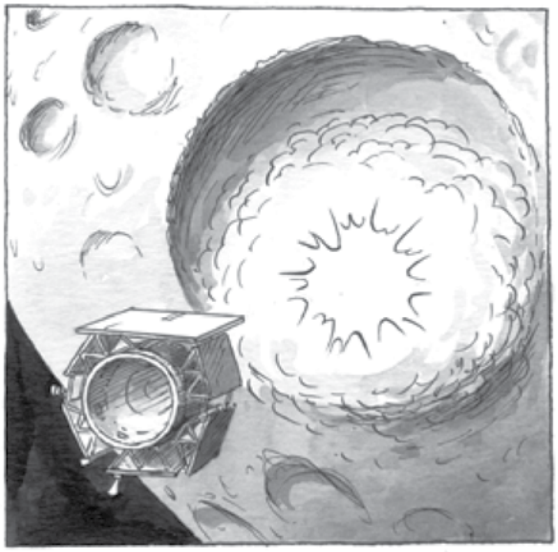
## "CORRER ALREDEDOR DEL BOSQUE, FUÉ LO QUE MÁS ME AYUDÓ"

De niño, Tony Colaprete amaba la naturaleza, la ecología y correr alrededor del bosque. A El le gustaba pensar en cómo, de un modo u otro, todo está conectado. El trajo consigo ese tipo de pensamiento a su trabajo como científico planetario y como uno de los mejores científicos de la misión LCROSS de la NASA. Para aprender como otros planetas tranbajan, El construyó modelos computarizados y diseñó instrumentos. Esto lo ayudó a entender las múltiples conecciones interesantes entre los diferentes planetas de nuestro sistema solar.

Y entre El más descubría, nosotros aprendemos más acerca de como nuestro mundo — la Tierra — encaja con nuestro sistema solar.

El Lunar Crater Observation and Sensing Satellite (LCROSS) de la NASA golpeará la Luna, levantando una nube de polvo y gas y con suerte revelando la presencia de agua.





## CUIDADO ABAJO!

La NASA quiere hacer un orificio profundo en la Luna para ver si existe hielo. Pero en lugar de comenzar a excavar en la superficie, la NASA está tomando ventaja. Excavará el orificio en lo profundo de un cráter que ya está alrededor de una milla (2 km) de profundidad — y no excavará exactamente. En lugar de eso, la NASA sumergirá una nave espacial llamada LCROSS dentro del cráter. Los científicos esperan que el impacto provoque un orificio de 80 pies ( 24.4 m) de ancho y 15 pies (4.6) de profundidad. Las posibilidades de encontrar hielo en lo más profundo de este obscuro y frío lugar son mayores que encontrarlo en la superficie de la Luna, donde el Sol brilla y resplandece y evaporiza cualquier hielo.

**sigue DESIGN SQUAD en PBS o en linea en pbs.org/ designsquad.**

Major funding for *Design Squad* provided by
Corporation for Public Broadcasting — A private corporation funded by the American people
Intel Education

Additional funding for *Design Squad* provided by
NCEES National Council of Examiners for Engineering and Surveying
NOYCE FOUNDATION
NORTHROP GRUMMAN Foundation
IEEE


This NASA/*Design Squad* challenge was produced through the support of the National Aeronautics and Space Administration (NASA).

A NASA/DESIGN SQUAD CHALLENGE

# ROVING ON THE MOON

**Can you imagine driving an all-terrain vehicle (ATV} on the moon? NASA can. It's building a fleet of ATVs (called rovers). Some can be driven by astronauts. Others are remote-controlled. All of them can handle the moon's dusty, rugged terrain. Talk about off-road adventure!**

as built on T\i

## ViE CHAllENG.E YOU TO...

. . .design and build a rubber band-powered rover that can scramble across the floor.

## BUILD

1. **First, you have to make the body.** Fold the cardboard into thirds. Each part will be about 2 inches (5 cm) across. Fold along (not across) the corrugation (the tubes inside a piece of cardboard).
2. **Then, make the front wheels.** On the two 5-inch (13-cm) cardboard squares, draw diagonal lines from corner to corner. Poke a small hole in the center (that's where the lines cross). On the body, poke one hole close to the end of each side for the axle. Make sure the holes are directly across from each other and are big enough for the pencil to spin freely.
3. **Now attach the front wheels.** Slide the pencil through the body's axle holes. Push a wheel onto each end. Secure with tape.
4. **Next, make the rear wheels.** Tape the straw under the back end of the rover. Slip a candy onto each end. Bend and tape the axle to stop the candies from coming off.
5. **Finally, attach the rubber band.** Loop one end around the pencil. Cut small slits into the back end of the body. Slide the free end of the rubber bands into the slits.

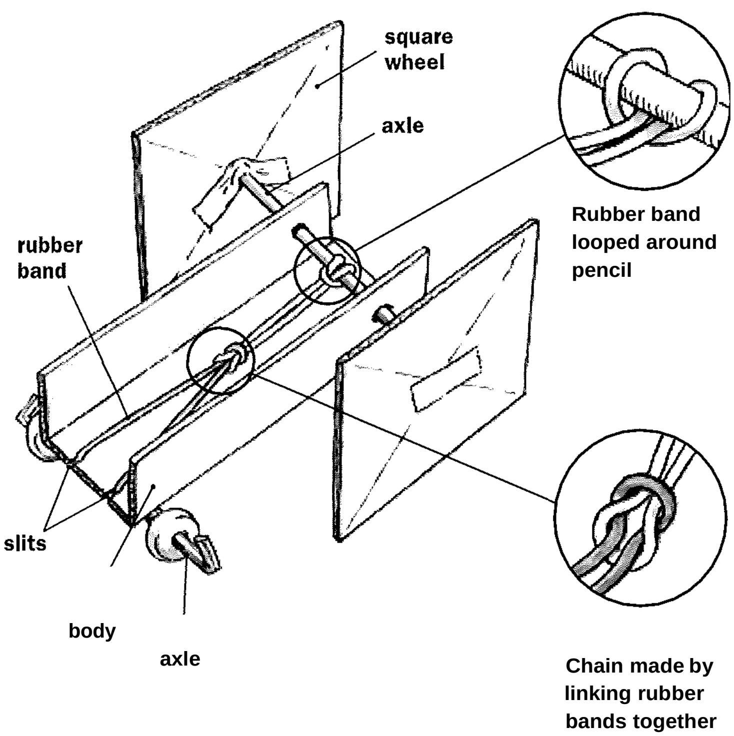
### MATERIALS (per *rover)*

- corrugated cardboard body (6-inch/15-cm square)
- 2 corrugated cardboard wheels (5-inch/13-cm square)
- 1 sharpened round pencil
- 2 rubber bands
- ruler
- tape
- 2 round candies (the hard, white, mint ones with a hole in the middle)
- 1 plastic drinking straw
- scissors

## TEST, EVALUATE, AND REDESIGN

Test your rover. Wind up the wheels, set the rover down, and let it go. Did everything work? Can you make your rover go farther? Engineers improve their designs by testing them. This is called the design process. Try redesigning the wheel setup or rubber band system. For example, if:

- **the wheels don't turn freely-** *Check that the pencil turns freely in the holes.* A/so, *make sure the wheels are firmly attached and are parallel to the* sides.

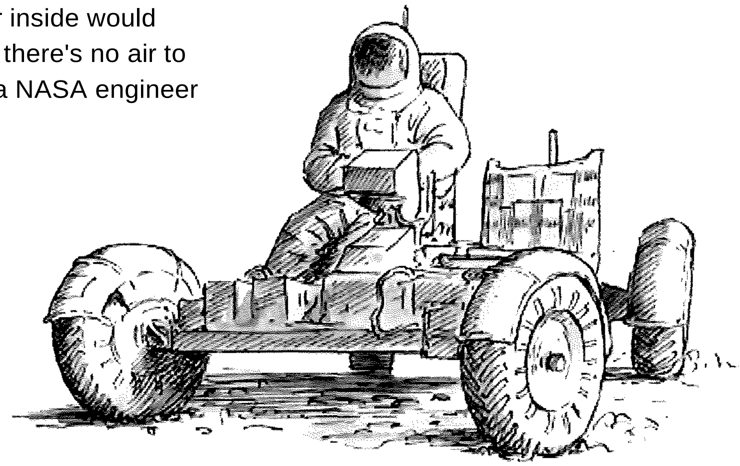


- **the rover doesn't go *far-Wind*** *up the wheels more. Try wheels of different sizes or shapes. Or, add another rubber band or use* a *rubber-band chain.*
- **the wheels spin *out-Add*** *weight above the square wheels; put more wheels on the pencil; use bigger wheels; or cut open* a *rubber band and use only* a *single strand of elastic.*
- **the rover won't travel in a straight** line-Check *that the pencil is straight and the front wheels are the* same *size.*

**Check out NASA's moon missions at moon.msfc.nasa.gov.**

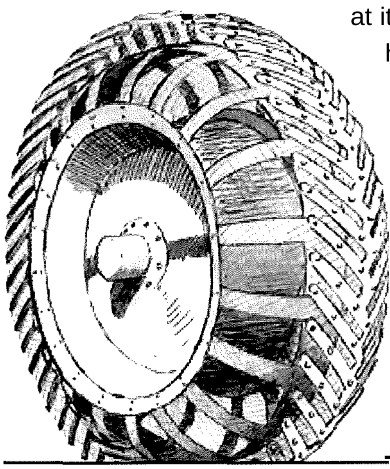
## CUSTOM Vt.'HEELS

The moon doesn't have an atmosphere-there's no air there! So air-filled tires like the ones on a bike or car would explode-the air inside would push through the tire to escape into outer space (where there's no air to push back against the walls of the tire). Imagine you're a NASA engineer who has to design a tire that:



- works in space, where there's no atmosphere
- withstands extreme hot and cold temperatures-on the moon, they range from roughly 250° to -250° Fahrenheit (121° to -157° Celsius)
- weighs 12 pounds (5.5 kg), which is half the weight of an average car tire
- won't get clogged with the fine dust that covers the moon

Despite these challenges, engineers designed a tire that worked perfectly when it was used on the moon. It's made of thin bands of springy metal. That helps it be lightweight, have good traction, and work at any temperature the moon can throw at it. Plus, it flexes when it hits a rock, and it doesn't need to be pumped up. Dependability is important. There's no roadside service when you're on the moon, 250,000 miles (400,000 km) from home.



## RIDE IN "STYLE"?

A rover may not be the hottest-looking vehicle around, but with a price tag of over ten million dollars, it's one of the most expensive. And it sure is convenient to bring along. Rovers can be folded and stored in a landing module the size of a small room. Look at the picture of the rover. Which features are also found on cars designed for use on Earth?

**·s10AJU0:> l!IU!Aaais pue '(sAe:> awos) eAawe:, 'AAaneq 'euuaiue 'si1aq ieas 'sieas •,oiow 's,apua1 's1aaqM 's1sse11O :sAaMsuv**

**The farthest trip anyone has ever taken on the moon with a rover is 2.8 miles (4.5 km).**

**Watch DESIGN SQUAD on PBS or online at pbs.org/designsquad.** **Ci)PBS.**

[redacted]

Major funding for *Design Squad* provided by Corporation

Additional funding for Design *Squad* provided by

+.IEEE

by Iha AmarJcon peopkJ UCa (On

UN RETO NASA/DESIGN SQUAD

# EXPLORANDO LA LUNA EN UN ROVER

**i,Te puedes imaginar manejando un vehiculo todo-terreno en la Luna? La NASA si puede. Esta construyendo una flotilla de vehiculos todo-terreno(sigtas en ingtes ATVs, llamados rovers) Algunos pueden ser manejados por astronautas. Otros son a control remoto. Todos ellos pueden soportar el terreno polvoso, irregular y accidentado de la Luna. iHabla acerca de la aventura todo-terreno!**

asbuilt onT\.

## TE RETAMOS A...

......Disenar y construir un vehfculo rover impulsado par bandas elasticas que se pueda mover en el suelo.

## CONSTRUCCION

1. **Primero, tienes que construir la carroceria.** Dobla el papel carton en tres partes. Cada parte sera aproximadamente de 2 pulgadas (5cm) de ancho. Dobla a lo largo (no a lo ancho) del corrugado.
2. **En seguida, has las ruedas frontales.** En las dos piezas cuadradas de carton de 5 pulgadas (13 cm), dibuja lfneas diagonales de esquina a esquina. Marca un pequeno agujero en el centro (En donde se cruzan las lfneas). Sabre el cuerpo, marca un agujero cerca del lado de cada eje. Asegurate que las agujeros esten directamente enfrente uno del otro y sean suficientemente grandes para que el lapiz pueda girar libremente.
3. **Ahora conecta las ruedas delanteras.** Desliza el lapiz atraves de las agujeros de las ejes de la carrocerfa. Empuja una rueda en cada extrema. Aseguralas con cinta.
4. **Siguiente, has las ruedas traseras.** Pega el popote en la parte trasera del vehfculo (rover). Desliza un dulce en cada estremo. Dobla y asegura el eje para evitar que las dulces se salgan.
5. **Finalmente, coloca la banda elastica.** Enlaza un extrema alrededor del lapiz. Haz un pequeno carte en la parte trasera de la carrocerfa. Pasa la parte libre de la banda elastica par la ranura del carte.

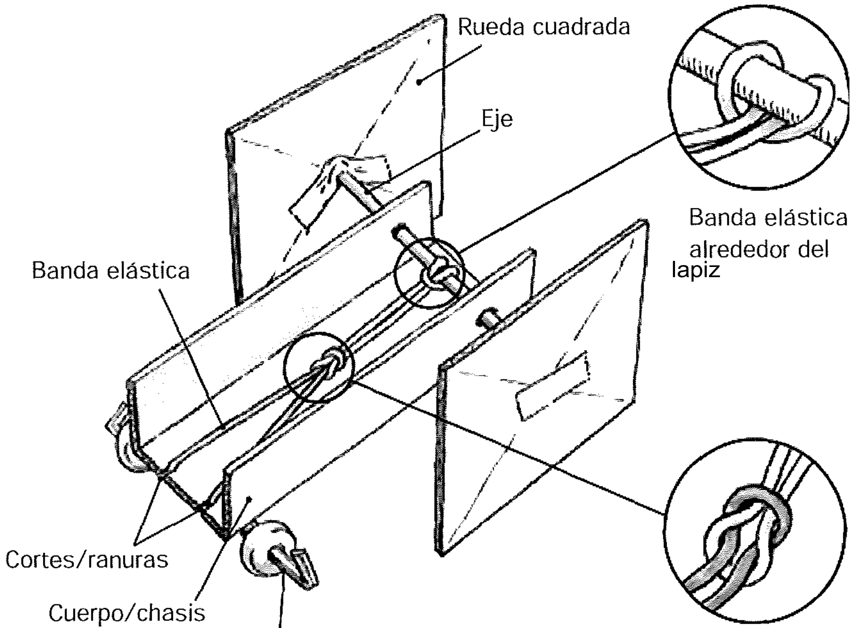
**MATERIALES** (por pieza)

- carton corrugado para la carrocerfa (6 pulgadas/ 1 5 cm cuadrados)
- 2 llantas de carton corrugado (5 pulgada/ 13 cm cuadrados)
- 1 lapiz redondo
- 2 bandas elasticas o ligas
- regla
- cinta adhesiva
- 2 dulces redondos (mentas redondas con agujero en el centro)
- 1 popote de plastico
- tijeras

## PRUEBA, EVALUACION V REDISENO

Prueba tu vehfculo rover. Da cuerda a las ruedas, coloca el rover abajo y dejalo ir. LFunciono todo? LPodrfas hacer que tu vehfculo viajara mas lejos?. Los ingenieros mejoran sus disenos hacienda pruebas con ellos. Esto se llama diseno de proyecto. lntenta redisenar el sistema de ruedas o el de las bandas elasticas. Par ejemplo, si:

- **las ruedas no giran libremente** - Revisa que el lapiz gire libremente en las agujeros.Tambien asegurate que las ruedas esten firmemente sujetas y sean paralelas a las lados.



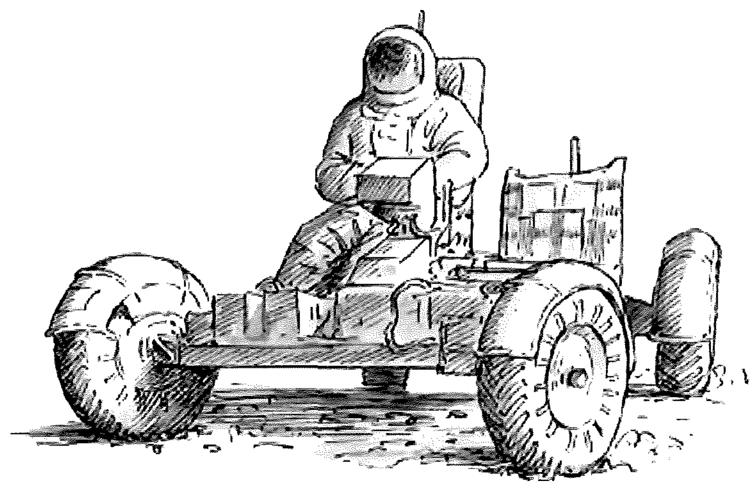

Cadena fabricada con la union de bandas elasticas

- **El vehiculo no llega lejos** - Da mas cuerda a las ruedas. Intenta con diferente tamano y forma. 0 agrega otra liga elastica o utiliza una cadena de ellas.
- **¿la ruedas derrapan?** - Agrega peso sobre las ruedas cuadradas, coloca mas ruedas en el lapiz, utiliza ruedas mas grandes, o troza la banda elastica y utiliza solo una hebra.
- **El vehiculo no circula en linea recta** - Revisa que el lapiz este derecho y que las ruedas frontales sean de la misma medida.

**disfruta las misiones lunares de la NASA en moon.msfc.nasa.gov.**

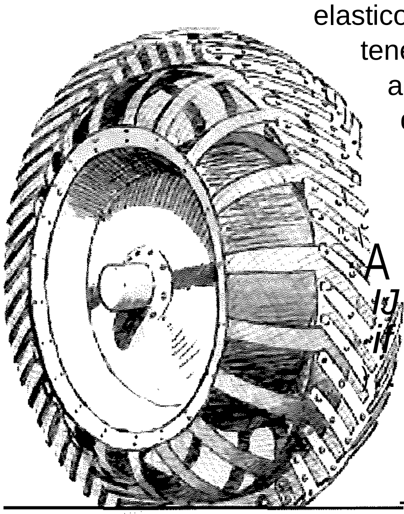
## RUEDAS A LA ORDEN

La Luna no tiene atsmosfera - jno hay aire! Asi que las ruedas convencionales (llenas con aire) como las que se utilizan en una bicicleta o un auto expoltarf an --- el aire de adentro tratarfa de escapar hacia el espacio exterior (donde no existe aire que empuje en contra de las paredes de la llanta). Imagina que eres un ingeniero de la NASA que tiene que disenar una llanta que:



- trabaje en el espacio exterior, donde no existe una atmosfera.
- Soporte temperaturas extremas - en la Luna, el promedio de estas temperaturas extremas es de 250 a -250 grados Fahrenheit (121 a -157 grados Celsius)
- pese 12 libras (5.5 kg.) que es la mitad del peso de una llanta de carro promedio.
- Nose atasca con la arena fina que cubre la Luna.

A pesar de estos retos, los ingenieros disenaron una llanta que trabajo perfectamente cuando fue usada en la Luna. Esta echa de bandas delgadas de metal elastico. Eso ayuda a ser ligero, tener buena traccion y trabajar a cualquier temperatura que pudiera existir en la Luna. Ademas se flecciona al golpear una roca y no necesita ser inflada. La autonomfa es importante. No existe asistencia en carretera cuando estas en la Luna a 250,000 millas (400,00 km) de casa.



## MANEJA "CON ESTILO"

El vehfculo rover puede no ser el vehfculo mas atractivo alrededor, pero con un precio de mas de diez millones de dolares, es uno de los mas costosos. Y de seguro es conveniente traerlo. Los vehfculos rovers pueden ser doblados y almacenados en un modulo del tamano de una pequena habitacion. Fijate en la foto del vehfculo rover. LOue caracterfsticas se pueden encontrar en los vehfculos usados en la Tierra?

·u91:i:iaJ!P ap sa10J1uo:, K (so1apow sou 1e)mw :, 'eJJa1eq 'eua1ue 'pep
·!Jnias ap sauoJn}UJ:t 'so1uaise 'Jo1ow 'esuaJap 'se1ue11 'siseq3 :se1sandsau

El viaje mas largo que alguien
una ha sido de 2.8 millas (4

**sigue DESIGN SQUAD en PBS o en linea enpbs.org/designsquad.**

Major funding for Design Squad provided by
Ill Corporation
Iii forPubllc
Aprlval&c:.:::: 0 : .:
by the American people
lintel/
c UCattOn
Additional funding for Design Squad provided by
,"I I m t ., '"
tor [1 lnt-c-1b ;,,1vl ufl..:>ybIg
J IATION NOR '!,'!_ R :. +.IEEE

This NASA/Design Squad challenge was produced through the support of the National Aeronautics and Space Administration (NASA).

Para más información acerca de la misión y programas educaccionales de la NASA, visita nasa.gov.

UN RETO NASA/ DESIGN SQUAD

# EXPLORANDO LA LUNA EN UN ROVER

¿Te puedes imaginar manejando un vehículo todo-terreno en la Luna? La NASA si puede. Está construyendo una flotilla de vehículos todo-terreno(siglas en inglés ATVs, llamados rovers) Algunos pueden ser manejados por astronautas. Otros son a control remoto. Todos ellos pueden soportar el terreno polvoso, irregular y accidentado de la Luna. ¡Habla acerca de la aventura todo-terreno!

## TE RETAMOS A...

…...Diseñar y construir un vehículo rover impulsado por bandas elásticas que se pueda mover en el suelo.

## CONSTRUCCÍON

1. Primero, tienes que construir la carrocería. Dobla el papel cartón en tres partes. Cada parte será aproximadamente de 2 pulgadas (5cm) de ancho. Dobla a lo largo (no a lo ancho) del corrugado.
2. En seguida, has las ruedas frontales. En las dos piezas cuadradas de cartón de 5 pulgadas (13 cm), dibuja líneas diagonales de esquina a esquina. Marca un pequeño agujero en el centro (En donde se cruzan las líneas). Sobre el cuerpo, marca un agujero cerca del lado de cada eje. Asegúrate que los agujeros estén directamente enfrente uno del otro y sean suficientemente grandes para que el lápiz pueda girar libremente.
3. Ahora conecta las ruedas delanteras. Desliza el lápiz através de los agujeros de los ejes de la carrocería. Empuja una rueda en cada extremo. Aseguralas con cinta.
4. Siguiente, has las ruedas traseras. Pega el popote en la parte trasera del vehículo (rover). Desliza un dulce en cada estremo. Dobla y asegura el eje para evitar que los dulces se salgan.
5. Finalmente, coloca la banda elástica. Enlaza un extremo alrededor del lápiz. Haz un pequeño corte en la parte trasera de la carrocería. Pasa la parte libre de la banda elástica por la ranura del corte.

MATERIALES (por pieza)

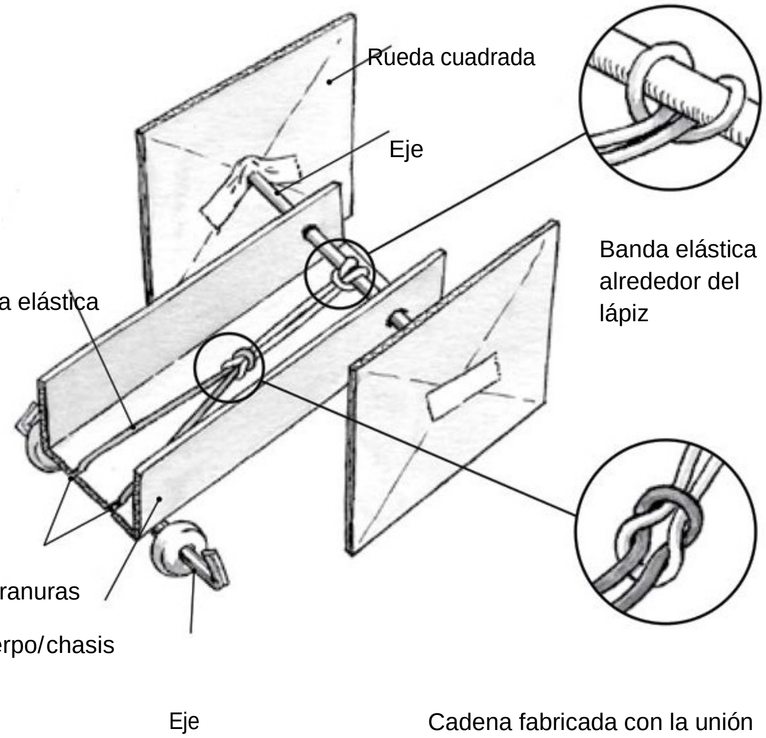
- cartón corrugado para la carrocería (6 pulgadas/ 15 cm cuadrados)
- 2 llantas de cartón corrugado (5 pulgada/ 13 cm cuadrados)
- 1 lápiz redondo
- 2 bandas elásticas o ligas
- regla
- cinta adhesiva
- 2 dulces redondos (mentas redondas con agujero en el centro)
- 1 popote de plástico
- tijeras

## PRUEBA, EVALUACIÓN Y REDISEÑO

Prueba tu vehículo rover. Da cuerda a las ruedas, coloca el rover abajo y déjalo ir. ¿Funcionó todo? ¿Podrías hacer que tu vehículo viajara más lejos?. Los ingenieros mejoran sus diseños haciendo pruebas con ellos. Esto se llama diseño de proyecto. Intenta rediseñar el sistema de ruedas o el de las bandas elásticas. Por ejemplo, si:

- las ruedas no giran libremente — Revisa que el lápiz gire libremente en los agujeros.También asegúrate que las ruedas estén firmemente sujetas y

  sean paralelas a los lados.



de bandas elásticas

- El vehículo no llega lejos — Da más cuerda a las ruedas. Intenta con diferente tamaño y forma. O agrega otra liga elástica o utiliza una cadena de ellas.
- ¿La ruedas derrapan? — Agrega peso sobre las ruedas cuadradas, coloca más ruedas en el lápiz, utiliza ruedas más grandes, o troza la banda elástica y utiliza sólo una hebra.
- El vehículo no circula en línea recta — Revisa que el lápiz esté derecho y que las ruedas frontales sean de la misma medida.

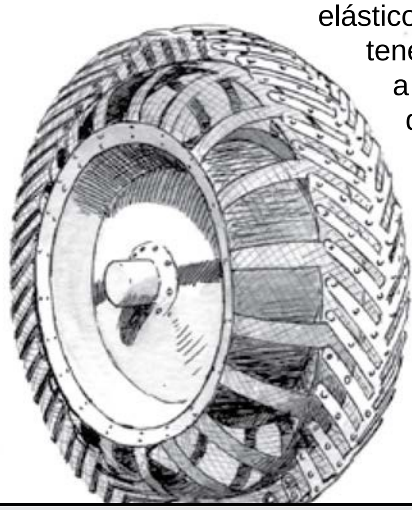
disfruta las misiones lunares de la NASA en moon.msfc.nasa.gov.

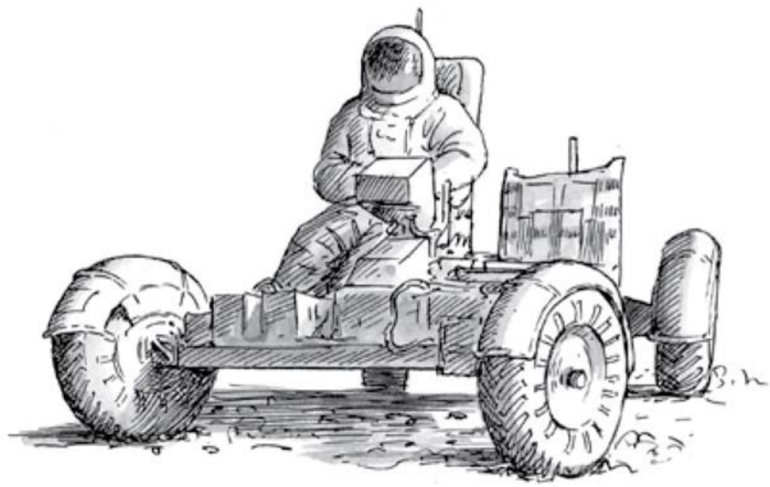
## RUEDAS A LA ORDEN

La Luna no tiene atsmósfera — ¡no hay aire! Asi que las ruedas convencionales (llenas con aire) como las que se utilizan en una bicicleta o un auto expoltarían --- el aire de adentro trataría de escapar hacia el espacio exterior (donde no existe aire que empuje en contra de las paredes de la llanta). Imagina que eres un ingeniero de la NASA que tiene que diseñar una llanta que:

- trabaje en el espacio exterior, donde no existe una atmósfera.
- Soporte temperaturas extremas — en la Luna, el promedio de éstas temperaturas extremas es de 250 a -250 grados Fahrenheit (121 a -157 grados Celsius)
- pese 12 libras (5.5 kg.) que es la mitad del peso de una llanta de carro promedio.
- No se atasca con la arena fina que cubre la Luna.

A pesar de estos retos, los ingenieros diseñaron una llanta que trabajó perfectamente cuando fué usada en la Luna. Está echa de bandas delgadas de metal elástico. Eso ayuda a ser ligero, tener buena tracción y trabajar a cualquier temperatura que pudiera existir en la Luna. Además se flecciona al golpear una roca y no necesita ser inflada. La autonomía es importante. No existe asistencia en carretera cuando estás en la Luna a 250,000 millas (400,00 km) de casa.





## MANEJA "CON ESTILO"

El vehículo rover puede no ser el vehículo más atractivo alrededor, pero con un precio de más de diez millones de dólares, es uno de los más costosos. Y de seguro es conveniente traerlo. Los vehículos rovers pueden ser doblados y almacenados en un módulo del tamaño de una pequeña habitación. Fijáte en la foto del vehículo rover. ¿Que características se pueden encontrar en los vehículos usados en la Tierra?

Respuestas: Chasis, llantas, defensa, motor, asientos, dad, antena, batería, cámara (algunos modelos) y controles de dirección.

El viaje más largo que alguien ha realizado en la Luna ha sido de 2.8 millas (4.5 km)

This NASA/*Design Squad* challenge was produced through the support of the National Aeronautics and Space Administration (NASA).

**Para más información acerca de la misión y programas educaccionales de la NASA, visita nasa.gov.**

# DOWN TO THE CORE

## LEADER NOTES

Photo credit: NASA

**CHALLENGE:** Design and build a device that can take a core sample from a potato.

**LEARNING GOALS:** *Science:* Potential and kinetic energy, force (i.e., Newton's 2nd Law); *NASA:* Tools that sample the composition of planets, moons, and asteroids; *Engineering*: Design process

**NASA CONNECTION:** Many NASA spacecraft collect rock and soil samples to learn about a planet's, moon's, or asteroid's chemistry, potential to support life, and geologic history.

## GET READY AHEAD OF TIME

- If possible, make a few different kinds of corers to stimulate kids' thinking.
- **Cut potato slices.** Slice potatoes for kids' testing. Slices should be 1 centimeter (½ inch) thick.
- **Get the videos.** Go to pbskids.org/designsquad/links/solarsystem. Download the *Down to the Core,* Allison Bolinger, and NASA videos. Be prepared to project them. If you're unable to show videos, review the handout's overview and steps and tell kids about the NASA work described in the overview and in Step 1.
- **Photocopy.** Copy the handout and performance assessment rubric.

## MATERIALS (per corer)

- 12 craft sticks
- 4 flexible plastic straws
- 6 small (i.e., ¾-inch) or 4 medium (i.e., 1-inch) binder clips
- 8 rubber bands
- 2 potato slices (1 cm [½ inch] thick)
- Tape (any kind)
- Optional: 1 paper cup (6-ounce or larger)
- Optional: 1 sharp pencil for poking holes in the cup
- Optional: a wide straw that the flexible straw fits into

**In *Down to the Core*, kids design and build a device that drives a straw into a potato to take a core sample.**

## 1 INTRODUCE THE CHALLENGE (10 minutes)

**Set the stage**

- Ask: What are some examples of people taking samples? (*Cooks sample the food they prepare. Scientists studying what the climate was like in the past take cores from ice and trees. Doctors sample human tissue to detect diseases like cancer. Geologists sample rock to locate oil and mineral deposits.)*
- Tell kids the challenge and show them the *Down to the Core* video.

**Relate it to NASA missions**

Show the *Curiosity* rover animation. At 4:25 in the clip, point out the rover's sampling and analysis techniques. Tell kids that rock and soil samples reveal a lot about a planet's, moon's, or asteroid's chemistry, potential to support life, and geologic history.

Kids can add binder clips to the plunger. When pulled back against the rubber bands, the added weight (i.e., mass) gives the plunger more potential energy, enabling it to do more work.

## 2 BRAINSTORM AND DESIGN (10 minutes)

**Identify the problem.** Have kids state the problem in their own words (e.g., build a tool that can cut out a piece of potato).

**Demonstrate the activity's sampling technique.** Pick up a slice of potato and drive a straw through it. Show kids how the straw cut a sample out of the potato. Tell them that when NASA can't send a person into space to collect samples, it has to be done mechanically.

**Show kids different kinds of coring devices.** If you made sample corers, show kids your collection. This will give them ideas for frames (cup, craft sticks, cardboard), ways to hold the frame together (rubber bands, tape, binder clips), ways to connect the straw and crosspiece (tape, rubber bands, clamping), and how to connect the plunger (i.e., the straw connected to the crosspiece) to the frame. If you don't have samples, review the ideas on the handout.

Kids can use a wide straw as an outer casing to stabilize the thin straw sliding up and down inside. This is similar to how the outer casing in a push-pop ice cream treat stabilizes the flimsy ice cream.

**Review the corer's key components**

- What does the potato slice represent? *(The surface of a planet, moon, or asteroid)*
- What part will do the cutting? *(The straw)*
- What will you use to drive the straw into the potato? *(Rubber bands)*
- How will you hold the rubber bands and plunger? *(With a frame)*

## 3 BUILD, TEST, EVALUATE, AND REDESIGN (30 minutes)

**If any of these issues come up, ask questions to get kids thinking about how they might solve them.**

- **If the straw tip bends or breaks…** Have kids snip off the deformed end or use a new straw.
- **If the straw won't penetrate the slice…** Tell kids to add rubber bands to increase the force of the plunger. Or suggest that they add some binder clips to the plunger to increase its weight (i.e., mass). With more weight there is more potential energy when the plunger is pulled back against the rubber bands, enabling the straw to do more work.
- **If the straw bounces off the potato…** Have kids make a guide for the straw. For example, kids can run the straw through a hole poked in the bottom of a paper cup, similar to how the barrel of a clickable ballpoint pen keeps the tip steady. (See photos.)

When kids stretch the rubber bands, they build up potential energy. When they release the plunger, this potential energy changes to kinetic energy. When the straw hits the potato, the kinetic energy changes to mechanical energy and does work.

## 4 DISCUSS WHAT HAPPENED (10 minutes)

**Emphasize key elements in today's challenge by asking:**

- **Engineering:** What features helped your coring tool be effective? (*Answers will vary.*)
- **Science:** Your coring tool turns potential (stored) energy into kinetic (motion) energy. Explain how it does this. (*When kids stretch the rubber bands, they build up potential [stored] energy. When they release the rubber bands, the potential energy changes to kinetic [motion] energy. When the straw hits the potato, the kinetic energy changes to mechanical energy and does work. With more potential energy, the straw can penetrate more deeply and do more work.*)
- **NASA:** Why are NASA scientists interested in sampling planets, moons, and asteroids? (*Rock and soil samples reveal a lot about a planet's, moon's, or asteroid's chemistry, potential to support life, and geologic history. NOTE: Surface materials can change when they are exposed to wind and water or can mix with other materials [e.g., soil]. For the most reliable analysis, scientists want to get samples from below the surface.*)
- **Career:** Show kids the engineer profile featuring Allison Bolinger. One day, astronauts will visit asteroids and other planets and moons. As a spacewalk flight controller and trainer, Allison gets astronauts ready to work outside a spacecraft. They need to know how to use their tools while floating weightlessly in a bulky spacesuit. Download the profile sheet for fun facts, discussion prompts, and extension ideas.

## EXTEND THE CHALLENGE

- **Build a spaceship.** Have kids add space-related components to their coring tools. For example, duct tape can represent solar panels. Kids can add rockets, fins, radio dishes, and other instruments to represent spacecraft components.
- **Add a way to easily remove the sample from the straw.** Have kids figure out how to push or blow a sample out of the straw.

## CURRICULUM CONNECTIONS

**Use *Down to the Core* to engage, explain, and extend student understanding of the following topics:**

- **Potential, kinetic, and mechanical energy.** In this challenge, kids store energy (called potential energy) by stretching rubber bands. When they release the straw, this potential energy turns into motion (kinetic) energy and moves the straw forward. The straw's kinetic energy is then converted to mechanical energy when the straw penetrates the potato.
- **Newton's 2nd Law.** Adding weight (i.e., mass) to the plunger gives it more potential energy when you pull the plunger back against the rubber bands. More potential energy enables the plunger to do more work. This demonstrates Newton's 2nd Law—force equals mass times acceleration. Since acceleration is roughly the same for each trial, force is directly related to mass.

# DOWN TO THE CORE

**To find water, interesting minerals, or even life, you have to dig into a planet, moon, or asteroid. When NASA can't send a person to collect samples, they send spacecraft with tools that can take samples.**

## WE CHALLENGE YOU TO...

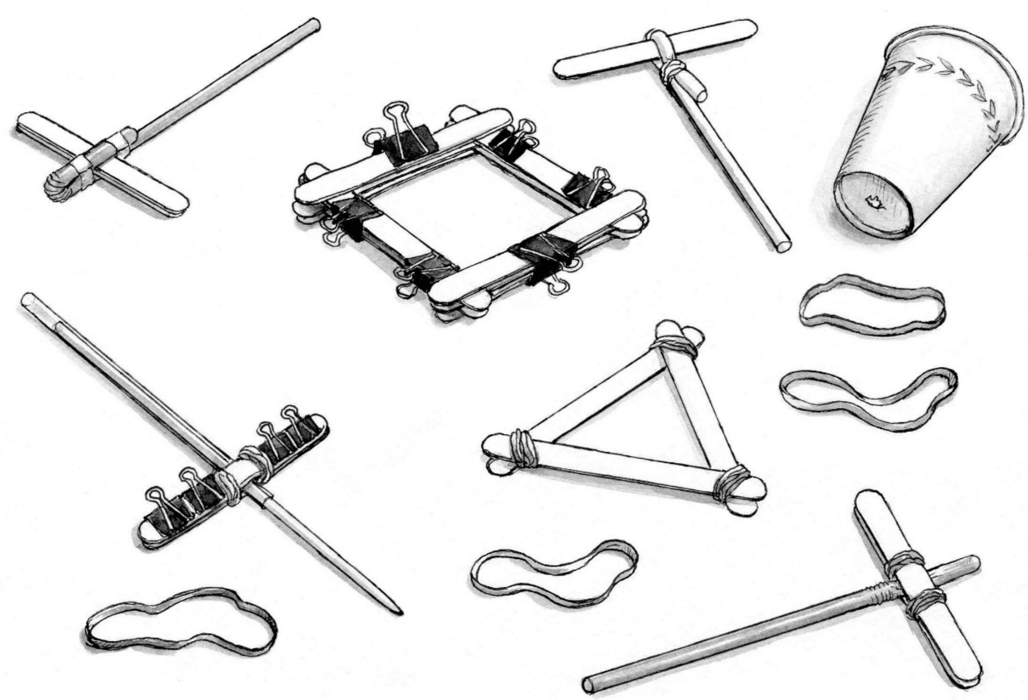
...design and build a tool that can take a core sample from a potato.

## 1. IDENTIFY THE PROBLEM AND BRAINSTORM

- What will you use to drive the straw into the potato (i.e., the "asteroid")?
- What kind of frame can you make to hold the rubber bands and straw?

## 2. DESIGN AND BUILD

Below are some ideas for coring tools. Invent your own design or improve on one of these.



## MATERIALS (per corer)

- 12 craft sticks
- 4 flexible plastic straws
- 6 small (i.e., ¾-inch) binder clips
- 8 rubber bands
- 2 potato slices (1 centimeter [½-inch] thick)
- Tape (any kind)
- Optional: a wide straw that the flexible straw can fit into
- Optional: 1 paper cup (6-ounce or larger)
- Optional: 1 sharp pencil

## WORDS TO USE

- **potential energy:** *Stored energy*
- **kinetic energy:** *Motion energy*
- **asteroid:** *One of the many small, rocky bodies that orbit the sun and lie between Mars and Jupiter. They range in size from less than a kilometer (half a mile) to nearly 800 kilometers (500 miles).*

## 3. TEST, EVALUATE, AND REDESIGN

- **If the straw tip bends or breaks…** Snip off the broken end or use a new straw.
- **If the straw doesn't go into the potato…** Try adding more rubber bands. Also, boost the plunger's force by adding weight, such as binder clips.
- **If the straw bounces off the potato…** Make a guide for the straw.

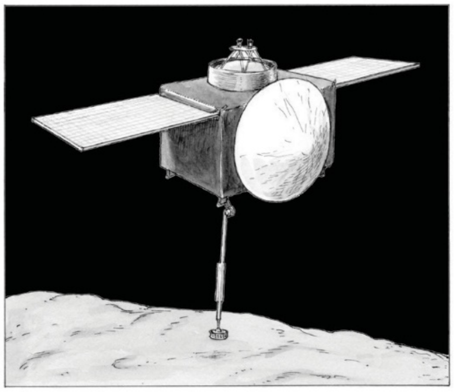
**Check out NASA's missions at nasa.gov**

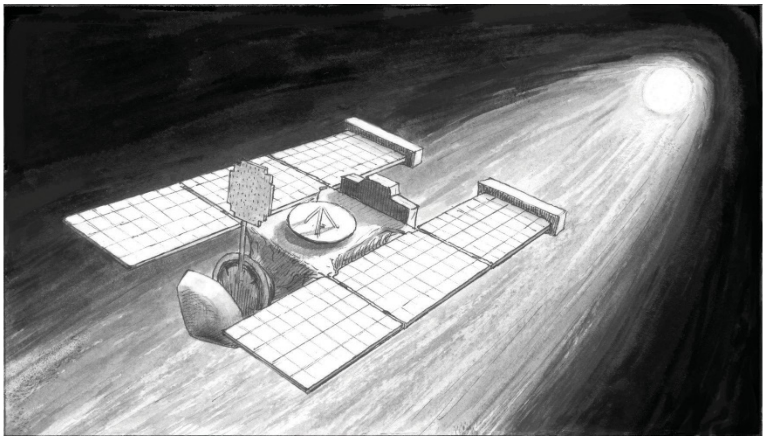
## 4. TRY THIS NEXT!

- Invent an easy way to remove the sample from the straw.
- Make your coring tool into a spaceship. Add rockets, fins, solar panels, radio dishes, and other spaceship components.

## NASA EXPLORES SPACE

*Osiris Rex* will collect samples from asteroids. It uses a tool similar to your corer. Scientists study asteroids to learn about what the solar system was like when it formed five billion years ago. *Osiris Rex* will launch in 2016, with samples returning to Earth in 2023. Think about becoming a NASA scientist, and you could do research with these samples!





The *Stardust* spacecraft collected dust grains from the gases coming off a comet called Wild 2. *Stardust* then returned to Earth, delivering thousands of comet grains.

**Visit the *Design Squad Nation* website at pbskids.org/designsquad.**

MAJOR FUNDING

PROJECT FUNDING

ADDITIONAL FUNDING

*Design Squad Nation* is produced by WGBH Boston. Major funding is provided by the National Science Foundation. Project funding is provided by Northrop Grumman Foundation and S.D. Bechtel, Jr. Foundation. Additional funding is provided by United Engineering Foundation (ASCE, ASME, AIChE, IEEE, AIME). This *Design Squad Nation* material is based upon work supported by the National Science Foundation under Grant No. EEC-1129342. 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.  This NASA/Design Squad Nation challenge was produced through the support of the National Aeronautics and Space Administration under Grant No. <NNX12AB47G> issued through the Science Mission Directorate.

# DESIGN CHALLENGE PERFORMANCE ASSESSMENT RUBRIC

**Challenge name:** ______________________________

**Names of team members:** ______________________________

______________________________

| | | | | |
|---|---|---|---|---|
| **Identifying the problem(s) and brainstorming solutions** | Showed a clear understanding of the problem(s) to solve. Independently brainstormed solutions. | Needed some teacher direction to define the problem(s) and brainstorm possible solutions. | Needed lots of teacher direction to define the problem(s). Little if any independent brainstorming. | **Points:** |
| **Working as a team member** | Worked well together. All team members participated and stayed on task. | Some team members were occasionally off task. | Most team members were often off task and not cooperating or participating fully. | **Points:** |
| **Using the design process** | Team brainstormed many design ideas and tested and improved the design. Final design complete or nearly complete and shows creative problem solving. | Some team members were occasionally off task. | Team brainstormed few design ideas and did little testing or redesigning. Final design lacks clear design idea(s). | **Points:** |
| **Processing the science and engineering** | Team gave a strong presentation of its solution to the challenge and showed clear understanding of the science concepts and design process. | Team gave a basic presentation of its solution to the challenge and showed basic understanding of the science concepts and design process. | Team gave a weak presentation of its solution to the challenge and showed little understanding of the science concepts and design process. | **Points:** |
| | | | | **Total Points:** |

**Visit the *Design Squad Nation* website at pbskids.org/designsquad.**

MAJOR FUNDING PROJECT FUNDING ADDITIONAL FUNDING

*Design Squad Nation* is produced by WGBH Boston. Major funding is provided by the National Science Foundation. Project funding is provided by Northrop Grumman Foundation and S.D. Bechtel, Jr. Foundation. Additional funding is provided by United Engineering Foundation (ASCE, ASME, AIChE, IEEE, AIME). This *Design Squad Nation* material is based upon work supported by the National Science Foundation under Grant No. EEC-1129342. 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.  This NASA/Design Squad Nation challenge was produced through the support of the National Aeronautics and Space Administration under Grant No. <NNX12AB47G> issued through the Science Mission Directorate.

# HASTA EL NÚCLEO

Para encontrar agua, minerales interesantes, o incluso vida, tienes que excavar en un planeta, la Luna o un asteroide. Cuando la NASA no puede enviar a personas a recolectar muestras, envían aeronaves con herramientas especiales que puedan tomar éstas muestras.

## TE RETAMOS A.....

…. Diseñar y construír una herramienta que pueda tomar una muestra del centro de una papa.

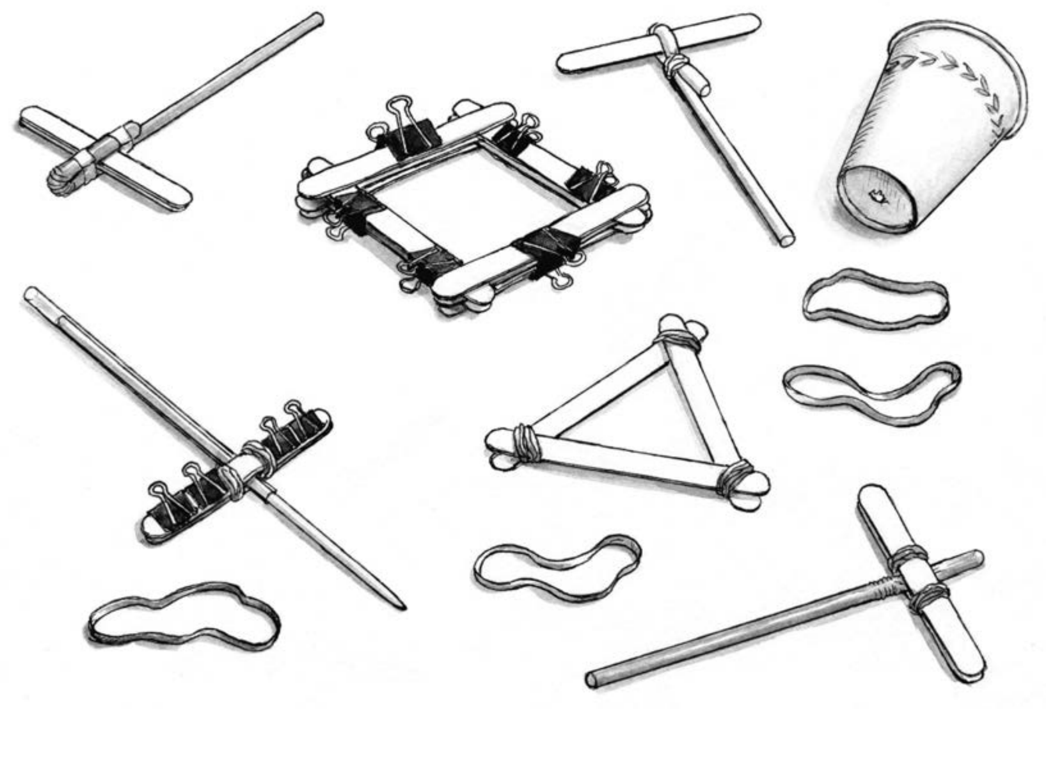
## 1. IDENTIFICANDO EL PROBLEMA Y LLUVIA DE IDEAS

¿Qué usarías para introducir el popote dentro de la papa (el asteroide)?

¿Que tipo de armazón harías para sujetar las bandas elásticas y el popote?

## 2. DISEÑO Y CONTRUCCIÓN

Debajo encontrarás algunas ideas de herramietas. Inventa tu propio diseño o mejora cualquiera de éstos.



### MATERIALES (por pieza)

- 12 palitos de madera
- 4 popotes flexibles de plástico
- 6 pequeños (¾ de pulgada) sujetadores de papel
- 8 bandas elásticas
- 2 rebanadas de papa (1 cm, ½ pulgada, de grosor)
- Cinta adhesiva (de cualquier)
- opcional: un popote ancho de manera que el popote flexible pueda caber dentro
- opcional: un vaso de papel ( 6-onzas o más grande)
- opcional: un sacapuntas

### PALABRAS A USAR

- Energía Potencial: Energía acumulada
- Energía Kinética: Energía en movimiento
- Asteroide: Uno de los muchos cuerpos rocosos pequeños que orbitan en el sol y se encuentran entre Júpiter y Marte. Su medida promedio va desde menos de un kilómetro (media milla) hasta cerca de 800 kilómetros (500 millas).

## 3. PRUEBA, EVALUACIÓN Y REDISEÑO

- Si el popote se quiebra o dobla… Corta el pedazo quebrado o utiliza un nuevo popote.
- Si el popote no perfora la papa… Trata de añadir mas bandas elásticas. También añade peso por ejemplo, algunos sujeta papeles.
- Si el popote se sale de la papa… Haz una guía para el popote.

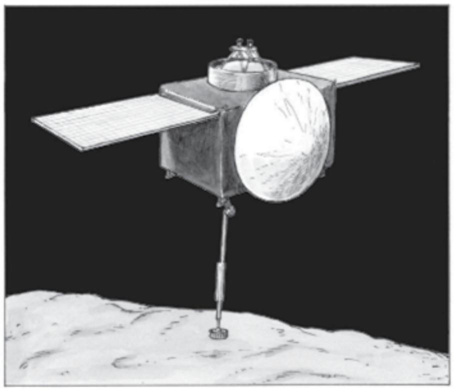
## 4. ¡TRATA ESTO!

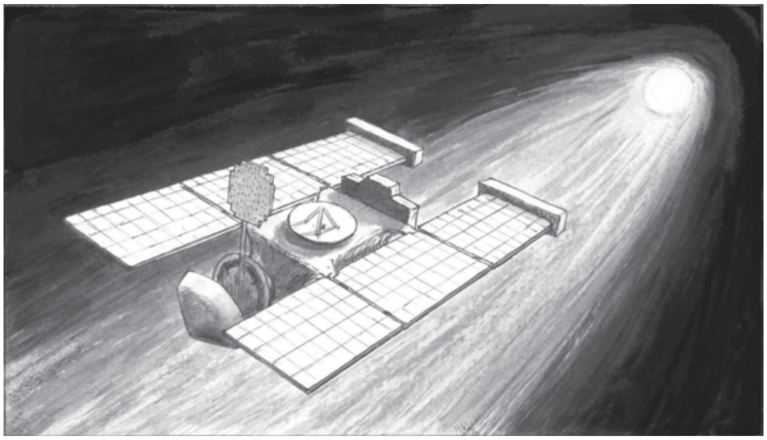
- Inventa algo fácil para extraer la muestra del popote.
- Transforma tu herrmaienta en una nave espacial. Agrega cohetes, estabilizadores, páneles solares, y otros componentes de naves espaciales.

disfruta las misiones de la NASA en moon.msfc.nasa.gov.

## LA NASA EXPLORA EL ESPACIO

Osiris Rex recolectará muestras de asteroides. Usa herramientas similares que la nuestra. Los científicos estudian los asteoides para conocer más acerca del Sistema Solar cuando éste se formó millones de años atrás. Osiris Rex será lanzado en el 2016, con las muestras regresando a la Tierra en el 2023. Piensa en cómo convertirte en un científico de la NASA, y en como podrías hacer investigaciones con estas muestras!





La nave Stardust recolectó muestras de granos de polvo de entre los gases que provenían de un cometa llamado Wild 2. Después Stardust regresó a la Tierra entregando miles de granos del cometa.

Sigue Design Squad Nation en línea en pbs.org/ designsquad.

MAJOR FUNDING PROJECT FUNDING ADDITIONAL FUNDING

Design Squad Nation is produced by WGBH Boston. Major funding is provided by the National Science Foundation. Project funding is provided by Northrop Grumman Foundation and S .D. Bechtel, Jr. Foundation. Additional funding is provided by United Engineering Foundation (ASCE, ASME, AIChE, IEEE, AIME). This Design Squad Nation material is based upon work supported by the National Science Foundation under Grant No. EEC-1129342. 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.  This NASA/ Design Squad Nation challenge was produced through the support of the National Aeronautics and Space Administration under Grant No. <NNX12AB47G> is sued through the Science Mission Directorate.

National Aeronautics and Space Administration

# *Mass vs. Weight*
# Stretching Mass

## Objective

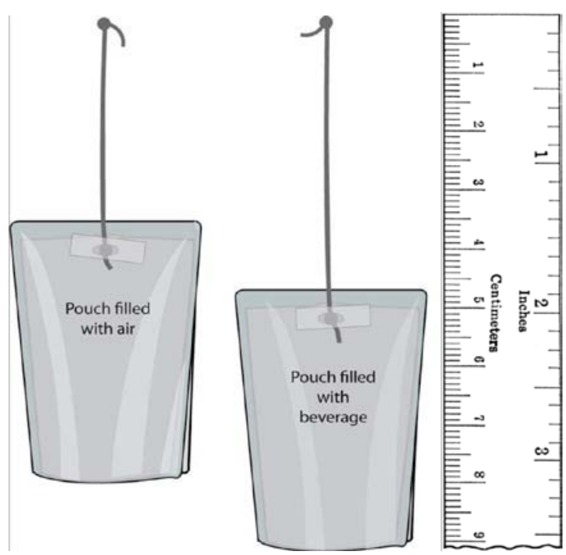
To investigate the difference between "mass" and "weight" in the normal gravity environment on Earth vs. the microgravity environment of space.

## Description

Teams of two students each measure the force gravity exerts on objects of different mass by suspending them on elastic strings made from cut rubber bands and measuring the distance the band stretches. Students compare their results to that of a similar experiment done on the International Space Station (ISS) and discuss their conclusions.

## Materials (per student team)

- **Two size 19 rubber bands (common size found in classrooms)**
- **Full (liquid-filled) foil drink pouch (identical size)**
- **Empty (air-filled) foil drink pouch (identical size)**
- **Mass scale**
- **Scissors**
- **30 cm ruler**
- **Cellophane tape (any classroom tape will work)**
- **50 Pennies**
- **Copies of the Student Data Sheets**
- ***Mass vs. Weight* "Stretching Mass" video clip**



## Management

The rubber bands used in this activity should be cut to make straight elastic "strings". Tie a knot at the same distance from each end of the string to create better grip for taping onto the drink pouch and for students to hold in their hands. Also, inflate the empty drink pouch by inserting the drink straw and blowing into it. Remove the straw and cover the hole with a piece of tape. Check each team to ensure their procedures are consistent.

## Background

For background information, refer to the *Mass vs. Weight Introduction*.

## Procedure

1. Lead a discussion of *gravity* and *microgravity* with the students before beginning this activity. Also discuss *"How can weight be measured in space?"*
2. Using a beam balance or digital scale, have students measure the masses of an empty (air-filled) drink pouch and a full (liquid-filled) drink pouch and record the measurements on Student Data Sheet 1.
3. Tape one end of the elastic string (rubberband) to the top of the air-filled drink pouch. Do the same for the liquid-filled drink pouch. Tape in same spot on each pouch.
4. Have one student hold the knot on the opposite end of the elastic string attached to the air-filled drink pouch and suspend vertically toward the floor. In the other hand, have the student do the same with the liquid-filled drink pouch.
5. Have the second student measure how much each drink pouch stretches the elastic string. Ensure the measurements are from the same points, preferably from their hand to the top of the drink pouch.
6. Have students record their measurements on the Data Sheets as they complete each part of the experiment.
7. When students have completed steps 1-6 on their data sheets, have them view the *Mass vs. Weight* "Stretching Mass" video clip. Have them complete step 7 and discuss their conclusions based on the comparison of the normal gravity and microgravity outcomes of this experiment.

## Assessment

1. Discuss the difference in the definitions of "mass" and "weight" and discuss the question, *"What is being measured by the stretch of the elastic string?"*
2. Review students' *Stretching Mass* data sheets.

## Extensions

1. Have students repeat the measurement steps by varying the mass of the empty pouch.
   Have them cut a slot in the top of the pouch and insert pennies. Place pennies in the pouch in multiples of 10 (each penny has a mass of 2.5g) and measure how far 10, 20, 30, 40 and 50 pennies stretch the rubber band. Have the students design and construct a graph to plot their data.
2. Place an unknown quantity of pennies in the student's pouches. Have them use their developed graphs to determine how many pennies are in the pouches based on the stretch of the elastic strings.

## Standards

**National Science Education Standards**

Unifying Concept and Processes
- Evidence, models, and explanation
- Change, constancy, and measurement

Science as Inquiry
- Abilities necessary to do scientific inquiry

Physical Science
- Motions and Forces

History and Nature of Science
- Science as a human endeavor

**Principles and Standards for School Mathematics**

(refer to *Mass vs. Weight* "Introduction" for complete standards)

Number and Operations
- Understand numbers
- Understand meanings
- Compute fluently

Measurement
- Understand measureable attributes
- Apply appropriate techniques

Data Analysis and Probability
- Formulate questions
- Develop and evaluate inferences
- Understand and apply

Process Standards
- Problem Solving
- Communication
- Connections
- Representation

Name: ____________________________________

MASS VS WEIGHT

## *Stretching Mass Activity*
## Student Data Sheet 1

1. Measure the mass (in grams) of both an empty (air-filled) drink pouch and a full (liquid-filled) drink pouch. Record your data below.
   **empty drink pouch** =__________g **full drink pouch** =__________g

2. Predict what will happen when you suspend an air-filled drink pouch attached to a rubber band held in your hand:

   ______________________________________________________________________

   ______________________________________________________________________

   Predict what will happen when you suspend a liquid-filled drink pouch attached to a rubber band held in your hand:

   ______________________________________________________________________

   ______________________________________________________________________

   Carefully cut a rubber band in one place to make an elastic string. Take an empty drink pouch (air-filled) and tape one end of the string to the top part of the pouch. Do the same for a full (liquid-filled) drink pouch. Hold the other end of each string in your hand and let the drink pouches suspend freely. Answer the questions below.

3. Have your partner measure how far (in centimeters), from your hand, the empty drink pouch stretches the string, and record your answer below. Mark your measurement on the ruler on Student Data Sheet 2:

4. Measure how far (in centimeters), from your hand, the full drink pouch stretched the string and record your answer below. Graph your measurement on the rulers on Student Data Sheet 2:

   **empty drink pouch** =_______cm **full drink pouch**=_______cm **difference** =______cm

5. Describe what happened and explain the results from your experiment with the empty and full drink pouches: (use the back of the paper if needed)

   ______________________________________________________________________

   ______________________________________________________________________

   ______________________________________________________________________

6. Predict what will happen if astronauts did the same experiment onboard the International Space Station (ISS) in a microgravity environment. (use the back of the paper if needed)

   ______________________________________________________________________

   ______________________________________________________________________

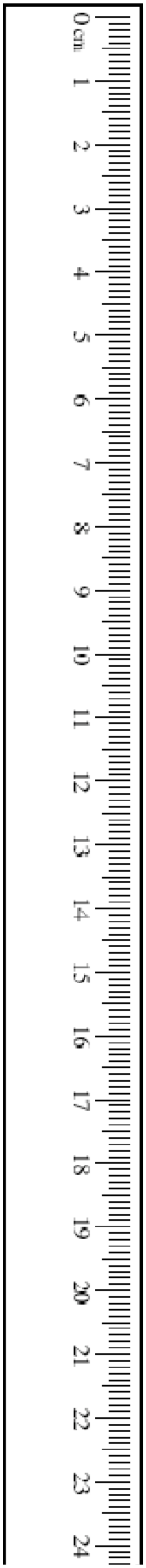
7. Watch the *Mass vs. Weight* “Stretching Mass” video clip. How did your prediction compare to the astronaut’s experiment on the ISS? (use the back of the paper if needed)

   ______________________________________________________________________

DATA

MASS VS WEIGHT

Name: ______________________________

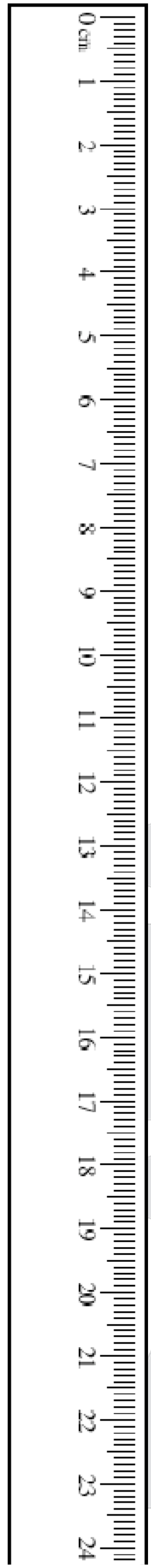



## *Stretching Mass Activity*
## Student Data Sheet 2

Graph your measurements from Student Data Sheet 1 on the rulers by shading in the amount of your measurements.

**EMPTY (air-filled) DRINK POUCH**

**FULL (liquid-filled) DRINK POUCH**

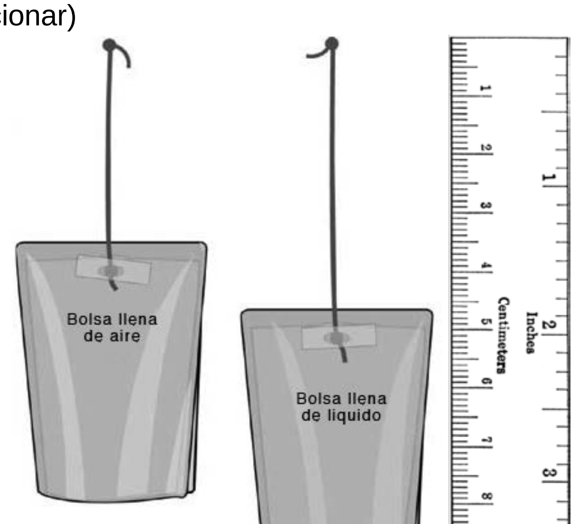


# *MASA VS. PESO*
# MASA ESTIRANDO

## Objetivo
Investigar la diferencia entre “masa” y “peso” en el medio hambiente gravitacional normal en la Tierra contra la microgravedad del medio hambiente del Espacio.

## Descripcion
Equipo de dos estudiantes, cada uno midirá la fuerza de gravedad que se ejerce en objetos de diferente masa suspendiéndolos en cordones elásticos fabricados con ligas cortadas y midiendo la distancia que la liga se extiende. Los estudiantes comparán sus resultados a los resultados de los experimentos realizados en la Estacion Espacial Internacional (ISS, International Space Station) y dicutirán sus conclusiones.

## Materiales (por equipo)
- Dos ligas elasticas de medida 19 ( medida comun encontrada en los salones escolares)
- Bolsa de bebida de aluminio (llena de líquido)
- Bolsa de bebida de aluminio (llena de aire)
- Báscula
- Tijeras
- Regla de 30 centimetros
- Cinta de celofán (cualquier cinta adhesiva puede funcionar)
- 50 penies
- Copias de las Hojas de Datos del Estudiante
- Video Masa contra Peso “ Masa Estirando”




MASA VS PESO

Nombre:______________________________

## Actividad de Masa Estirando

## Datos del Estudiante Hoja 1

1. Mide la masa (en gramos) de las dos bolsas de bebidas una vacía (llena de aire) y una llena (llena de líquido).Registra los datos obtenidos
   bolsa de bebida vacía =________g                    bolsa de bebida llena =_______g

2. Predice qué pasaría al suspender una bolsa de bebida llena de aire conectada a una cinta elástica (liga) sugetándola con tu mano:

   ______________________________________________________________________________

   ______________________________________________________________________________

   Predice qué pasaría al suspender una bolsa de bebida llena de líquido conectada a una cinta elástica (liga) sugetándola con tu mano:

   ______________________________________________________________________________

   ______________________________________________________________________________

   Con cuidado corta un pedazo de la cinta elástica (liga) para hacer un cordón elástico. Toma una bolsa de bebida vacía (llena de aire) y con cinta adhesiva pega una parte del cordón a la parte superior de la bolsa de bebida. Haz lo mismo con la bolsa de bebida llena (llena de líquido). Sujeta el otro extremo de cada cordón en tu mano y deja que las bolsas de bebidas se suspendan libremente. Contesta las siguientes preguntas.

3. Has que tu compañero mida que tan lejos (en centímetros), desde tu mano, la bolsita de bebida vacía estira el cordón, y reporta los resultados enseguida. Marca tus medidas en la regla en la Datos del Estudiante Hoja 2:

4. Mide que tan lejos (en centímetros), desde tu mano, la bolsa de bebida llena estira el cordón y reporta los resultados enseguida. Grafica tus medidas en las reglas en la Datos del Estudiante, Hoja 2:
   bolsa de bebida vacía =____cm          bolsa de bebida llena =___cm          diferencia =___cm

5. Decribe que pasó y explica los resultados de tu experimento con la bolsa de bebida vacía y la llena: (utiliza la parte trasera del papel si es necesario)

   ______________________________________________________________________________

   ______________________________________________________________________________

6. Predice que pasaría si los astronautas hicieran el mismo experimento a bordo de la Estación Espacial Internacional (ISS) en un medio hambiente con microgravedad (utiliza la parte trasera del papel si es necesario)

   ______________________________________________________________________________

   ______________________________________________________________________________

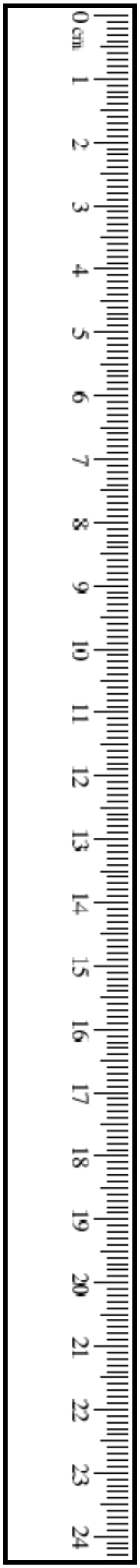
7. Ve el video de la Masa contra Peso “Masa Esrtirando”. ¿Cómo se compara tu predicción con los experimentos de los astronautas en la Estación Espacial Internacional (ISS)?

   ______________________________________________________________________________

   ______________________________________________________________________________

MASA VS
**PESO**

Nombre:______________________________

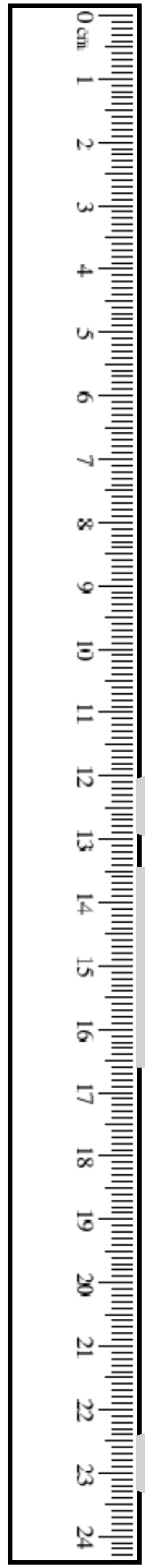



## Actividad de Masa Estirando
## Datos del Estudiante Hoja 2

Grafica tus medidas de Datos del Estudiante Hoja 1 marcando tus medidas en las reglas.

**BOLSA DE BEBIDA VACIA (llena deaire)**

**BOLSA DE BEBIDA LLENA (llena de liquido)**



National Aeronautics and Space Administration

mass vs weight

# *Mass vs. Weight*
# Air Powered Mass

## Objective

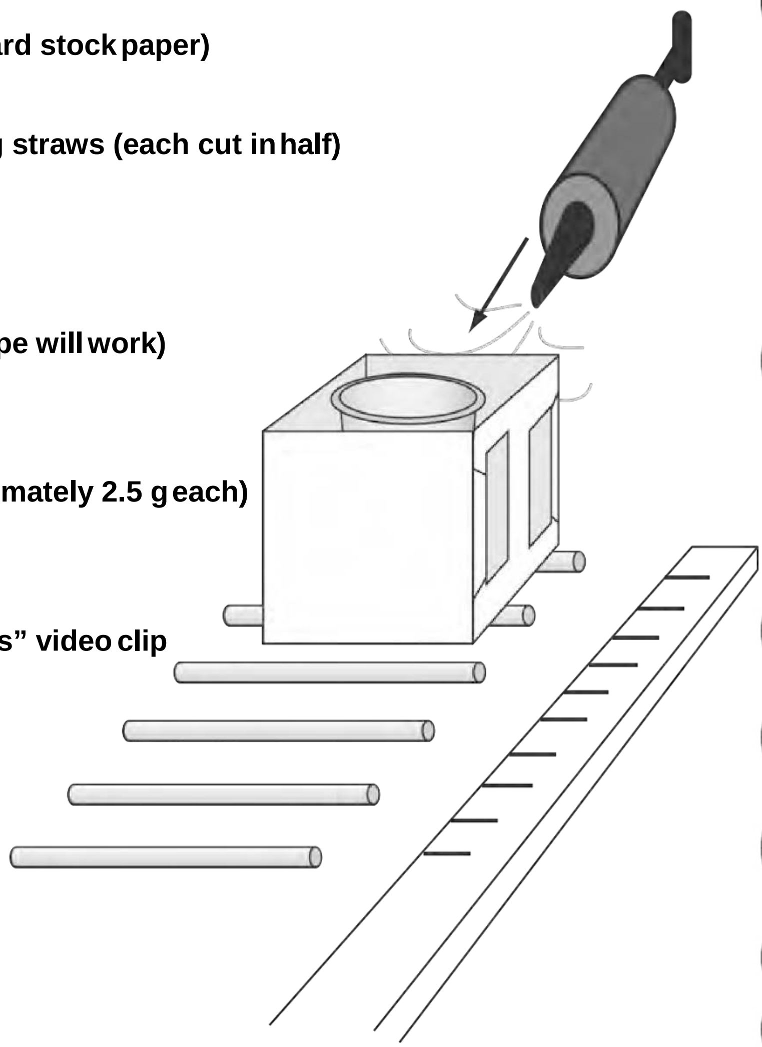
To investigate Newton's Second Law of motion, $F = ma$, by measuring how objects of different mass are accelerated by a constant force.

## Description

Student teams build a **mass car** and measure its movement in relation to the amounts of mass it carries as it is propelled by a uniform air blast. Following data collection, students graph and discuss their results and compare it to the video of a similar experiment performed on the International Space Station.

## Materials (per student team)

- **Mass Car Template (copied onto card stock paper)**
- **4 oz paper or plastic drinking cup**
- **15 non-flexible, solid color drinking straws (each cut in half)**
- **Party balloon air pump**
- **Mass scale**
- **Scissors**
- **Cellophane tape (any classroom tape will work)**
- **Meter stick**
- **Graphing paper**
- **15 pennies (or flat washers approximately 2.5 g each)**
- **Safety goggles**
- **Copies of the Student Data Sheets**
- ***Mass vs. Weight* "Air Powered Mass" video clip**



## Management

Prepare your students for the experiment by reviewing the importance of controlling variables in experiments. In this investigation, there are many variables (e.g. spacing and straightness of the straws, placement of the car, uniform air blast from the pump, etc.). This activity requires a smooth uncarpeted floor or long, level table for a rolling surface. Designate areas for each team to set-up their experiment. Check each student team to make sure they are being consistent in setting up the mass car and placing the straws. Demonstrate how to "load" the mass in the car. The cup, with pennies inside, must be placed on the shaded circle. Also ensure that the students target the blast of air in the same spot on the car to minimize variables. In place of pennies, washers that have approximately the same mass as a penny (2.5g) can be used.

## Background

For background information, refer to the *Newton's Laws of Motion Introduction* brief.

## Procedure

1. Copy the Mass Car Template onto card stock paper. Provide each student team with a template and have them construct the Mass Car.
2. Provide each student team with a Mass Car Experiment Procedures sheet. Have them read the written directions on how to conduct the experiment and how to record their data on the Student Data Sheet. Be sure students ***practice safety***, ***wear goggles*** and ***stay alert*** during this experiment.
3. At the completion of the experiment, have students discuss their observations and conclusions. *How did the movement of the mass car change when you increased its mass? How does Newton's second law of motion apply to this investigation?* With a constant propelling force, the acceleration of the car is reduced when the mass is increased, *F=ma*. *Would the results be the same if you did the same experiment in the microgravity environment on-board the ISS?*
4. View the *Mass vs. Weight* "Air Powered Mass" video clip and have students relate the ISS experiment results to their own results.

## Assessment

1. Review student Mass Car data and graph sheets.
2. Discuss with the students what would happen if more tests were performed and mass was continuously added.
3. Discuss the variables in the experiment (i.e. The angle of the air gun, force of air etc.) and how these variables can be controlled.

## Extensions

1. Students compare each team's data and determine the mean, median, and mode of the class test results.
2. Using gathered data, place an unknown amount of mass in the mass car and instruct students to determine the unknown amount of mass.
3. Discuss with students other examples of Newton's second law of motion at work. (e.g. a semi truck requires much more engine force to accelerate from a stop light as does a passenger car.)
4. For a more durable experiment set-up, short lengths of wooden dowels can be used in place of straws for the Mass Car to travel over. The dowels need to be uniform in length and diameter and sanded smooth.

## Standards

**National Science Education Standards**

Unifying Concept and Processes
- Evidence, models, and explanation
- Change, constancy, and measurement

Science as Inquiry
- Abilities necessary to do scientific inquiry

Physical Science
- Motions and Forces

History and Nature of Science
- Science as a human endeavor

**Principles and Standards for School Mathematics**

(refer to *Mass vs. Weight* "Introduction" for complete standards)

Number and Operations
- Understand numbers
- Understand meanings
- Compute fluently

Measurement
- Understand measureable attributes
- Apply appropriate techniques

Data Analysis and Probability
- Formulate questions
- Select and use methods
- Develop and evaluate inferences
- Understand and apply

Process Standards
- Problem Solving
- Communication
- Connections
- Representation

Name: ___________________________________



***Air Powered Mass***
**Student Team Experiment Procedures**

***PRACTICE SAFETY – WEAR GOGGLES – STAY ALERT***

1. Construct the Mass Car using the provided template.

2. Cut fifteen standard straight straws in half to make 30 shorter straw pieces.

3. Place a meter stick on a smooth floor or tabletop. Put one straw next to the end of the meter stick. Place the second straw parallel to the first at the 2-centimeter mark. Continue placing all the other straws 2 centimeters apart. Be sure the straws are not touching the meter stick. The straws should be parallel to each other like the wooden ties of railroad tracks.

4. Set the Mass Car on the straws with the back of the car even with the 0 centimeter straw.

5. Carefully place an empty cup on top of the shaded circle inside the box of the mass car. Measure the mass of the mass car and empty cup. Record mass on the chart on Student Data Sheet

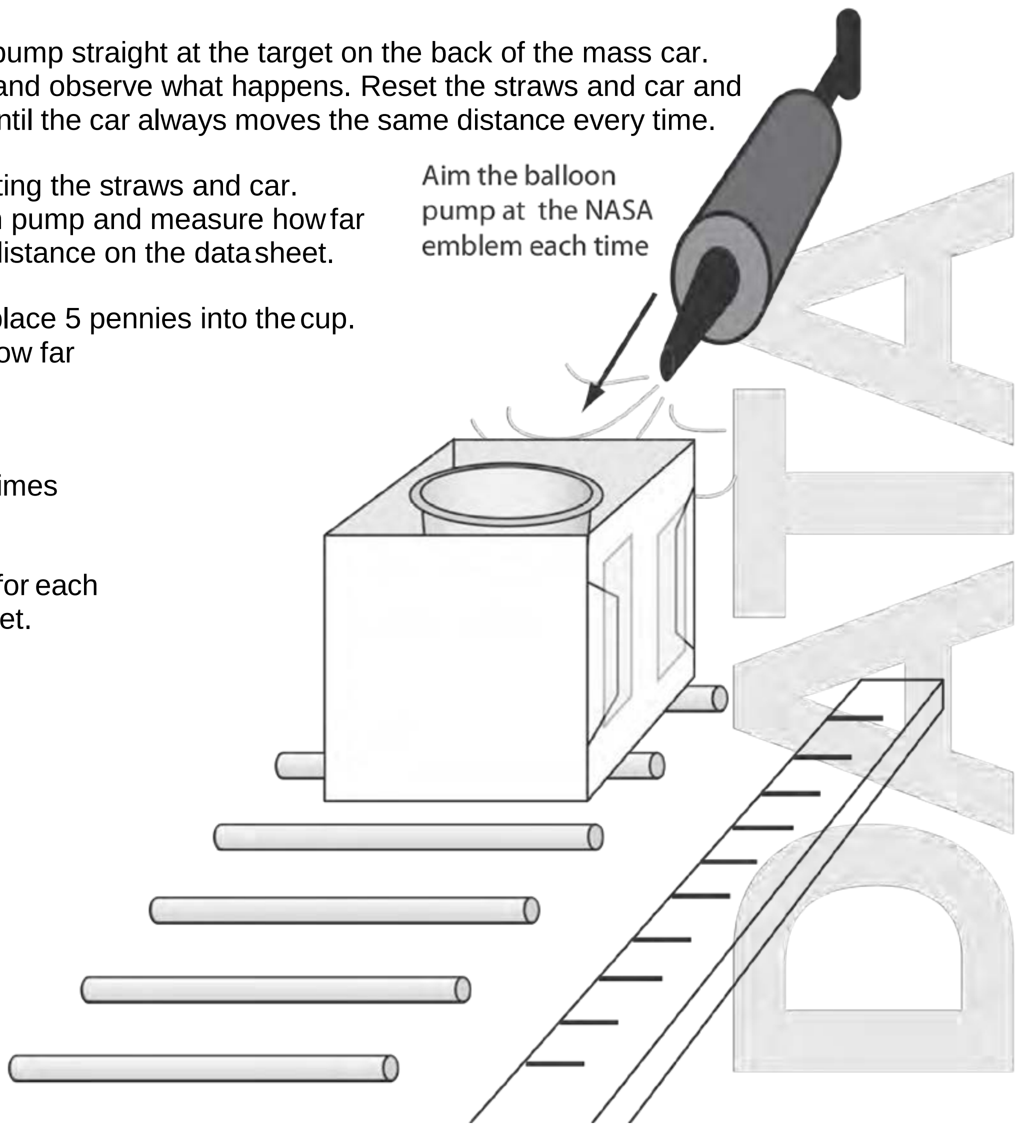
6. Aim the nozzle of the balloon pump straight at the target on the back of the mass car. Shoot a blast of air at the car and observe what happens. Reset the straws and car and propel it again several times until the car always moves the same distance every time.

7. Begin the experiment by resetting the straws and car. Propel the car with the balloon pump and measure how far the car traveled. Record the distance on the data sheet.

8. Reset the straws and car but place 5 pennies into the cup. Propel the car and measure how far it goes with the extra mass. Record your data.

9. Repeat experiment two more times with 10 and then 15 pennies.

10. Record and graph your data for each test on the Student Data Sheet.

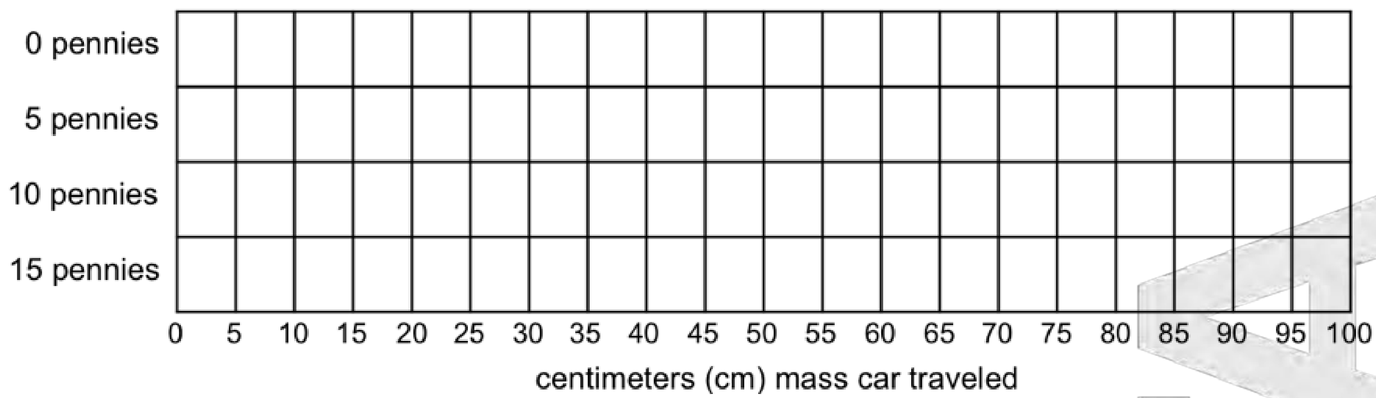


Name: ______________________________________

***Air Powered Mass***
***Student Data Sheet***

| Items | Total Mass (g) | Distance Mass Car Traveled (cm) | | | |
|---|---|---|---|---|---|
| | | Test 1 | Test 2 | Test 3 | Average |
| Car + Cup + 0 pennies | | | | | |
| Car + Cup + 5 pennies | | | | | |
| Car + Cup + 10 pennies | | | | | |
| Car + Cup + 15 pennies | | | | | |

1. Plot the bar graph showing the average distance of the three tests for each mass:




2. Plot the data on graph paper as a line graph. Give the graph a title and label the axes. Include the units.

3. Examine the data and the graphs. How does the mass affect the distance the mass car traveled?

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

4. How can Newton's Laws of Motion explain the data results?

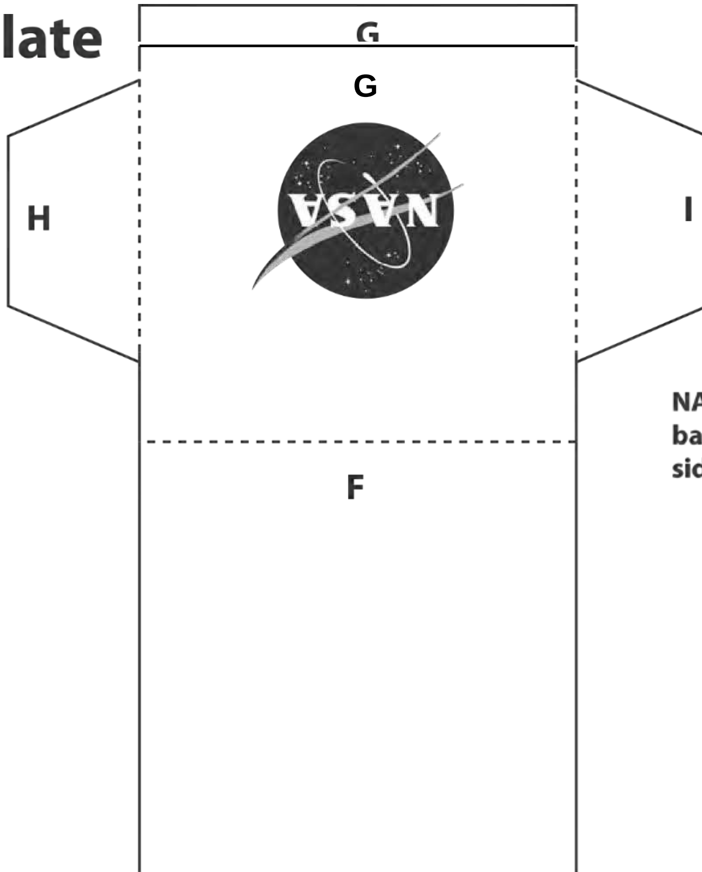
______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

5. How would this experiment work on the International Space Station? (Use the back of the sheet if needed)

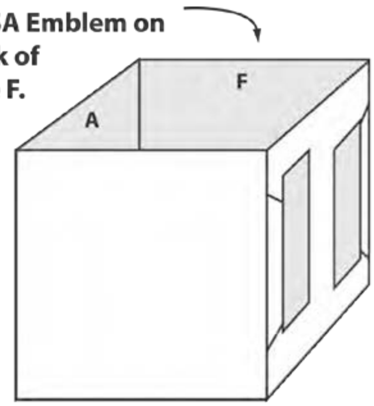
# Mass Car Template



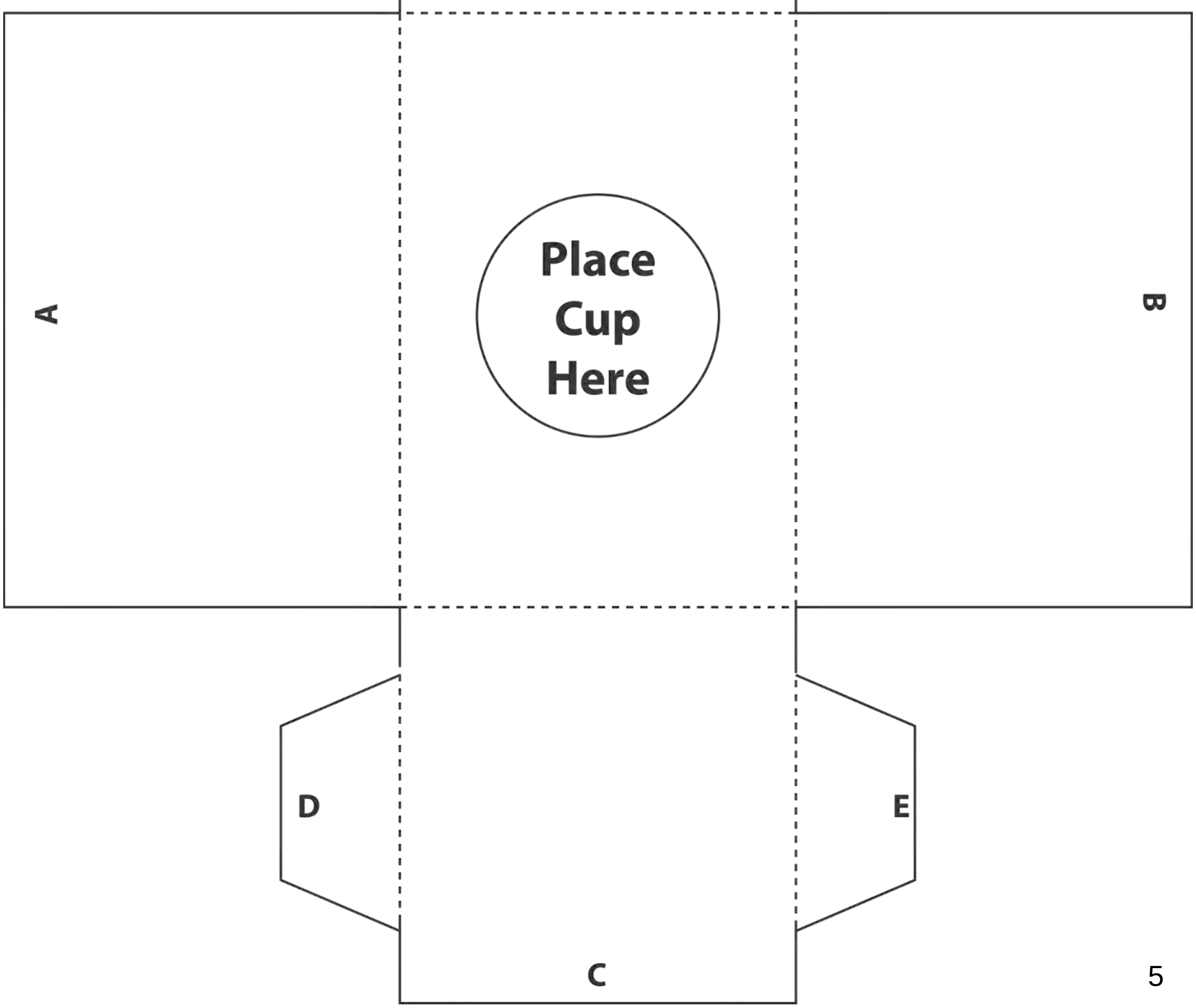

**Instructions:**

1. Cut on solid lines.
2. Fold on dashed lines.
3. Fold up sides A and B.
4. Fold up side C.
5. Fold tabs D and E around sides A and B. Tape them.
6. Fold up side F.
7. Fold down side G.
8. Fold tabs H and I around sides A and B. Tape them.

The Box is ready.




Box Folded and Taped



# Newton's Laws of Motion Introduction

Excerpt from *Rockets: Educator Guide With Activities in Science, Technology, Engineering and Mathematics* (EG-2008-05-060-KSC)

In his master work entitled *Philosophia Naturalis Principia Mathematica* (usually referred to as *Principia*), Isaac Newton stated his laws of motion. For the most part, the laws were known intuitively by rocketeers, but their statement in clear form elevated rocketry to a science. Practical application of Newton's laws makes the difference between failure and success. The laws relate force and direction to all forms of motion.

**In simple language, Newton's Laws of Motion:**

**First Law**
Objects at rest remain at rest and objects in motion remain in motion in a straight line unless acted upon by an unbalanced force.

**Second Law**
Force equals mass times acceleration ($f = ma$).

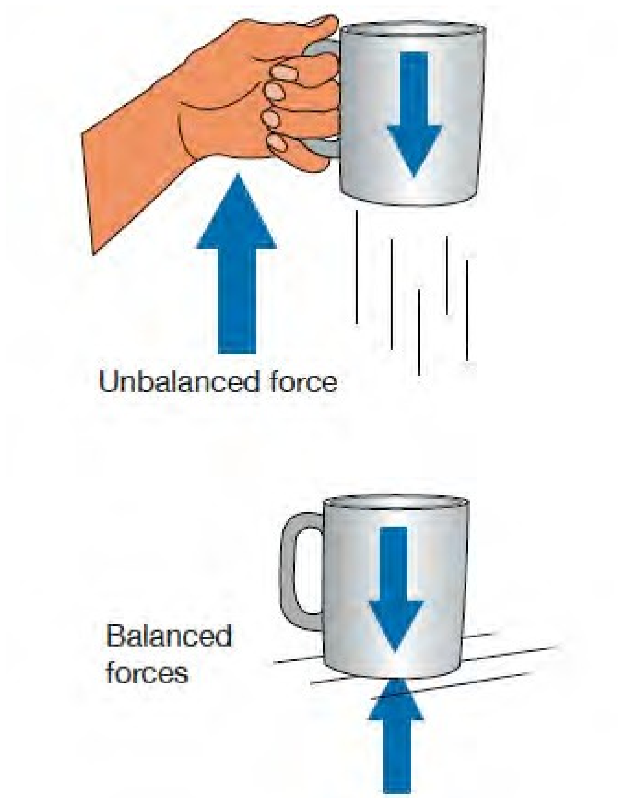
**Third Law**
For every action there is an equal and opposite reaction.

Before looking at each of these laws in detail, a few terms should be explained.

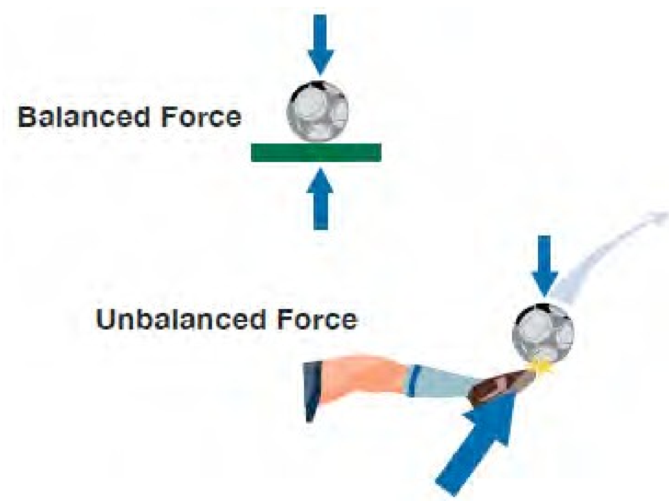
*Rest* and *Motion*, as they are used in the first law, can be confusing. Both terms are relative. They mean rest or motion in relation to surroundings. You are at rest when sitting in a chair. It doesn't matter if the chair is in the cabin of a jet plane on a cross-country flight. You are still considered to be at rest because the airplane cabin is moving along with you. If you get up from your seat on the airplane and walk down the aisle, you are in relative motion because you are changing your position inside the cabin.

*Force* is a push or a pull exerted on an object. Force can be exerted in many ways, such as muscle power, movement of air, and electromagnetism, to name a few. In the case of rockets, force is usually exerted by burning rocket propellants that expand explosively.

*Unbalanced Force* refers to the sum total or net force exerted on an object. The forces on a coffee cup sitting on a desk, for example, are in balance. Gravity is exerting a downward force on the cup. At the same time, the structure of the desk exerts an upward force, preventing the cup from falling. The two forces are in balance. Reach over and pick up the cup. In doing so, you unbalance the forces on the cup. The weight you feel is the force of gravity acting on the mass of the cup. To move the cup upward, you have to exert a force greater than the force of gravity. If you hold the cup steady, the force of gravity and the muscle force you are exerting are in balance.

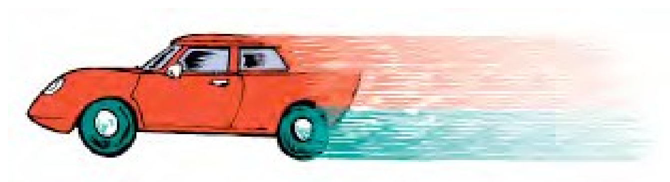


Unbalanced force also refers to other motions. The forces on a soccer ball at rest on the playing field are balanced. Give the ball a good kick, and the forces become unbalanced. Gradually, air drag (a force) slows the ball, and gravity causes it to bounce on the field. When the ball stops bouncing and rolling, the forces are in balance again. Take the soccer ball into deep space, far away from any star or other significant gravitational field, and give it a kick. The kick is an unbalanced force exerted on the ball that gets it moving. Once the ball is no longer in contact with the foot, the forces on the ball become balanced again, and the ball will travel in a straight line forever. How can you tell if forces are balanced or unbalanced? If the soccer ball is at rest, the forces are balanced. If the ball is moving at a constant speed and in a straight line, the forces are balanced. If the ball is accelerating or changing its direction, the forces are unbalanced.

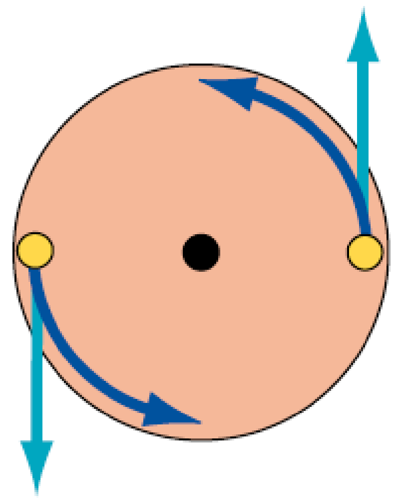



*Mass* is the amount of matter contained in an object. The object does not have to be solid. It could be the amount of air contained in a balloon or the amount of water in a glass. The important thing about mass is that unless you alter it in some way, it remains the same whether the object is on Earth, in Earth orbit, or on the Moon. Mass just refers to the quantity of matter contained in the object. (Mass and weight are often confused. They are not the same thing. Weight is a force and is the product of mass times the acceleration of gravity.)

*Acceleration* relates to motion. It means a change in motion. Usually, change refers to increasing speed, like what occurs when you step on the accelerator pedal of a car. Acceleration also means changing direction.



This is what happens on a carousel. Even though the carousel is turning at a constant rate, the continual change in direction of the horses and riders (circular motion) is an acceleration.



Top view of two riders on a carousel. The carousel platform exerts unbalanced forces on the riders, preventing them from going in straight lines. Instead, the platform continually accelerates the riders in a counterclockwise direction.

*Action* is the result of a force. A cannon fires, and the cannon ball flies through the air. The movement of the cannon ball is an action. Release air from an inflated balloon. The air shoots out the nozzle. That is also an action. Step off a boat onto a pier. That, too, is an action.

*Reaction* is related to action. When the cannon fires, and the cannon ball flies through the air, the cannon itself recoils backward. That is a reaction. When the air rushes out of the balloon, the balloon shoots the other way, another reaction. Stepping off a boat onto a pier causes a reaction. Unless the boat is held in some way, it moves in the opposite direction. (Note: The boat example is a great demonstration of the action/reaction principle, providing you are not the one stepping off the boat!)

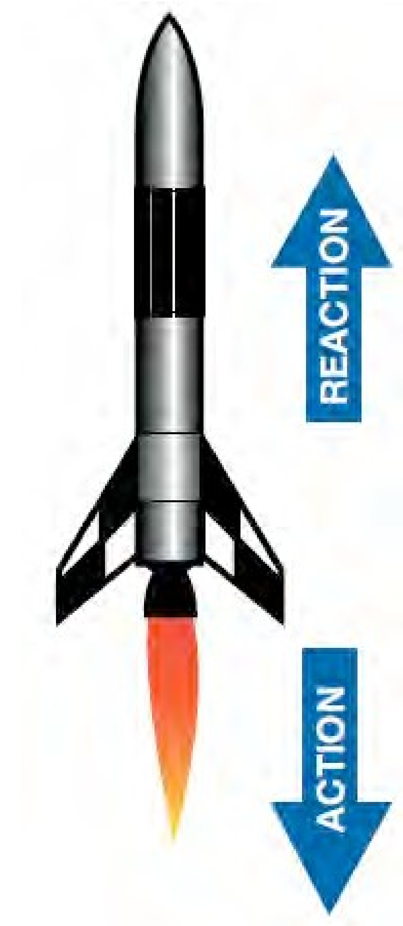
**Newton's First Law**

This law is sometimes referred to as Galileo's law of inertia because Galileo discovered the principle of inertia. This law simply points out that an object at rest, such as a rocket on a launch pad, needs the exertion of an unbalanced force to cause it to lift off. The amount of the thrust (force) produced by the rocket engines has to be greater than the force of gravity holding it down. As long as the thrust of the engines continues, the rocket accelerates. When the rocket runs out of propellant, the forces become unbalanced again. This time, gravity takes over and causes the rocket to fall back to Earth. Following its "landing," the rocket is at rest again, and the forces are in balance. There is one very interesting part of this law that has enormous implications for spaceflight. When a rocket reaches space, atmospheric drag (friction) is greatly reduced or eliminated. Within the atmosphere, drag is an important unbalancing force. That force is virtually absent in space. A rocket traveling away from Earth at a speed greater than 11.186 kilometers per second (6.95 miles per second) or 40,270 kilometers per hour (25,023 mph) will eventually escape Earth's gravity. It will slow down, but Earth's gravity will never slow it down enough to cause it to fall back to Earth. Ultimately, the rocket (actually its payload) will travel to the stars. No additional rocket thrust will be needed. Its inertia will cause it to continue to travel outward. Four spacecraft are actually doing that as you read this. *Pioneers 10* and *11* and *Voyagers 1* and *2* are on journeys to the stars!

**Newton's Third Law**

(It is useful to jump to the third law and come back to the second law later.) This is the law of motion with which many people are familiar. It is the principle of action and reaction. In the case of rockets, the action is the force produced by the expulsion of gas, smoke, and flames from the nozzle end of a rocket engine. The reaction force propels the rocket in the opposite direction.

When a rocket lifts off, the combustion products from the burning propellants accelerate rapidly out of the engine. The rocket, on the other hand, slowly accelerates skyward. It would appear that something is wrong here if the action and reaction are supposed to be equal. They are equal, but the mass of the gas, smoke, and flames being propelled by the engine is much less than the mass of the rocket being propelled in the opposite direction. Even though the force is equal on both, the effects are different. Newton's first law, the law of inertia, explains why. The law states that it takes a force to change the motion of an object. The greater the mass, the greater the force required to move it.




**Newton's Second Law**

The second law relates force, acceleration, and mass. The law is often written as the equation:

$$f = m\,a$$

The force or thrust produced by a rocket engine is directly proportional to the mass of the gas and particles produced by burning rocket propellant times the acceleration of those combustion products out the back of the engine. This law only applies to what is actually traveling out of the engine at the moment and not the mass of the rocket propellant contained in the rocket that will be consumed later.

The implication of this law for rocketry is that the more propellant (m) you consume at any moment and the greater the acceleration (a) of the combustion products out of the nozzle, the greater the thrust (f)

*MASA CONTRA PESO*

# MASA A PRESION DE AIRE

## Objetivo

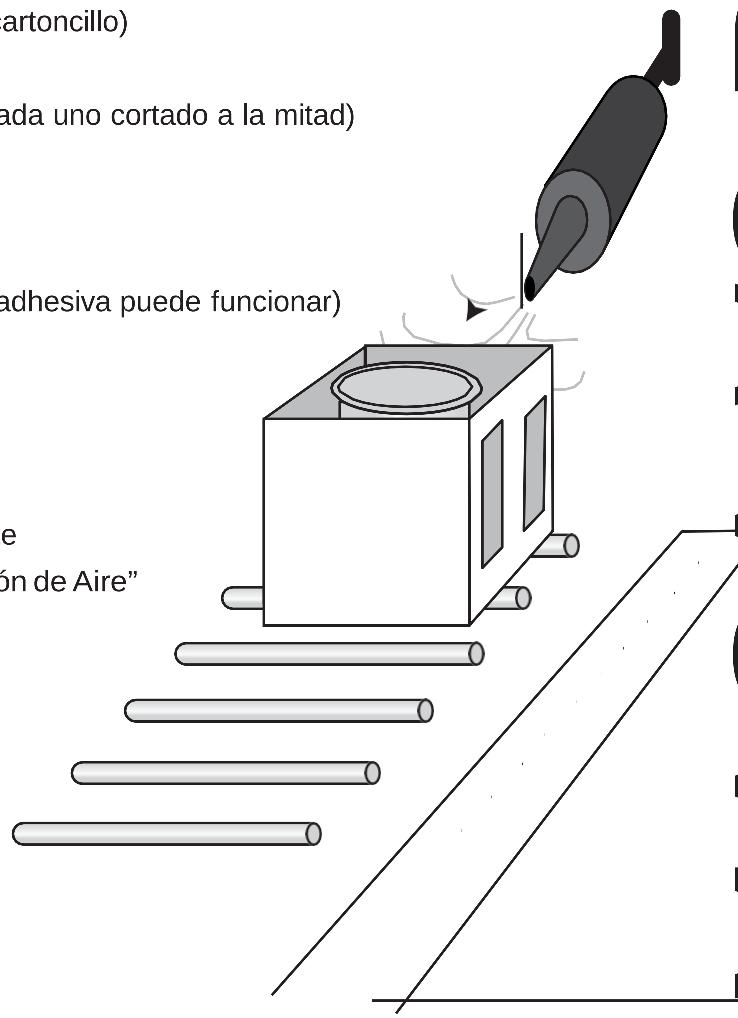
Investigar la Segunda Ley de Newton, la ley del movimiento, F=ma, midiendo cómo los objetos de diferente masa son acelerados por una fuerza constante.

## Descripción

Los equipos construirán un carro masa y medirán su movimiento en relación a la cantidad de masa que carga mientras es impulsado por una ráfaga de aire uniforme. Siguiendo la recolección de datos, los estudiantes graficarán y discutirán sus resultados y los compararán con el video de un experimento similar realizado en la Estación Espacial Internacional.

## Materiales

- Plantilla del carro masa (copia en el papel cartoncillo)
- Vaso de papel o plástico de 4 onzas
- 15 popotes, de un sólo color no flexibles (cada uno cortado a la mitad)
- Bomba de aire para inflar globos
- Báscula
- Tijeras
- Cinta adhesiva de celofán ( cualquier cinta adhesiva puede funcionar)
- Regla de un metro
- Papel cuadriculado
- 15 penies
- Lentes de seguridad
- Copias de las Hojas de Datos del Estudiante
- Video de Masa contra Peso “ Masa a Presión de Aire”



MASA VS PESO

Nombre:______________________________



## Masa a Presión de Aire

## Procedimientos del Experimento del Equipo de Estudiantes

**PRACITA LA SEGURIDAD– UTILIZA LENTES PROTECTORES – PERMANECE ALERTA**

1 Construye el carro-masa usando la plantilla adjunta

2. Corta quince popotes de medida regular por la mitad para hacer 30 piezas pequeñas de popote.

3. Coloca la regla de un metro en piso liso o en la superficie de la mesa.Coloca un popote cerca del extremo de la regla de metro. Coloca el segundo popote paralelo al primero en la marca de 2 centímetros.Continúa colocando los popotes restantes dos centímetros aparte cada uno.Asegúrate que los popotes no toquen el metro.

   Los popotes deben estar paralelos entre sí como los durmientes de madera de las vías del ferrocarril.

4. Coloca el carro masa sobre los popotes con la parte trasera del carro alineado con el popote de cero centímetros.

5. Cuidadosamente coloca un vaso vacío encima de la marca circular dentro de la caja del carro masa.

   Mide la masa del carro masa y el vaso vacío. Registra la masa en la tabla de la Hoja de Datos del Estudiante.

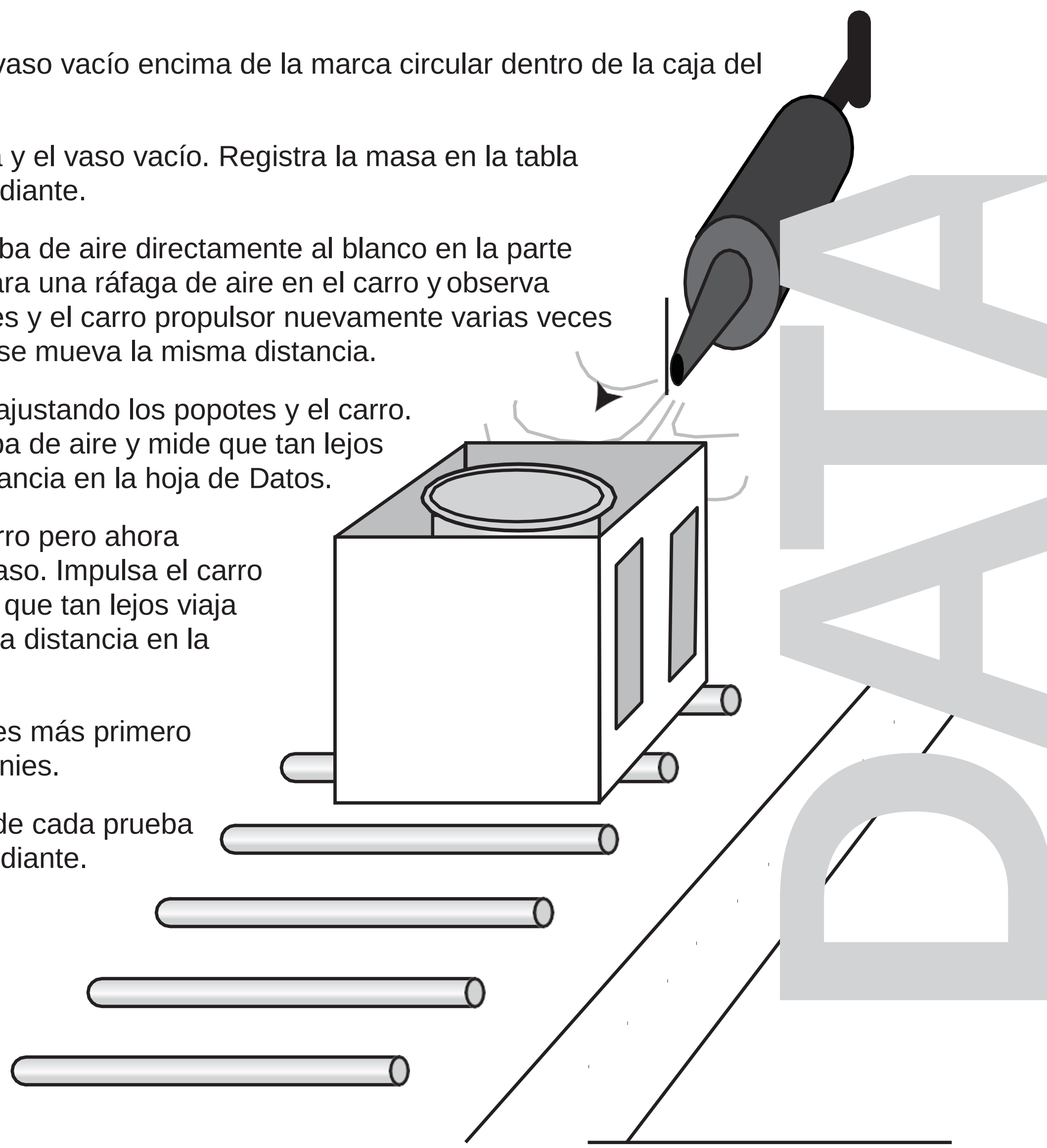
6. Apunta la boquilla de la bomba de aire directamente al blanco en la parte trasera del carro masa.Dispara una ráfaga de aire en el carro y observa que pasa.Reinicia los popotes y el carro propulsor nuevamente varias veces hasta que cada vez el carro se mueva la misma distancia.

7. Comienza el experimento reajustando los popotes y el carro. Impulsa el carro con la bomba de aire y mide que tan lejos viajó el carro.Registra la distancia en la hoja de Datos.

8. Reajusta los popotes y el carro pero ahora coloca 5 penies dentro del vaso. Impulsa el carro con la bomba de aire y mide que tan lejos viaja con la masa extra. Registra la distancia en la hoja de datos.

9. Repite el experimento 2 veces más primero con 10 y después con 15 penies.

10. Registra y grafica tus datos de cada prueba en la Hoja de Datos del Estudiante.



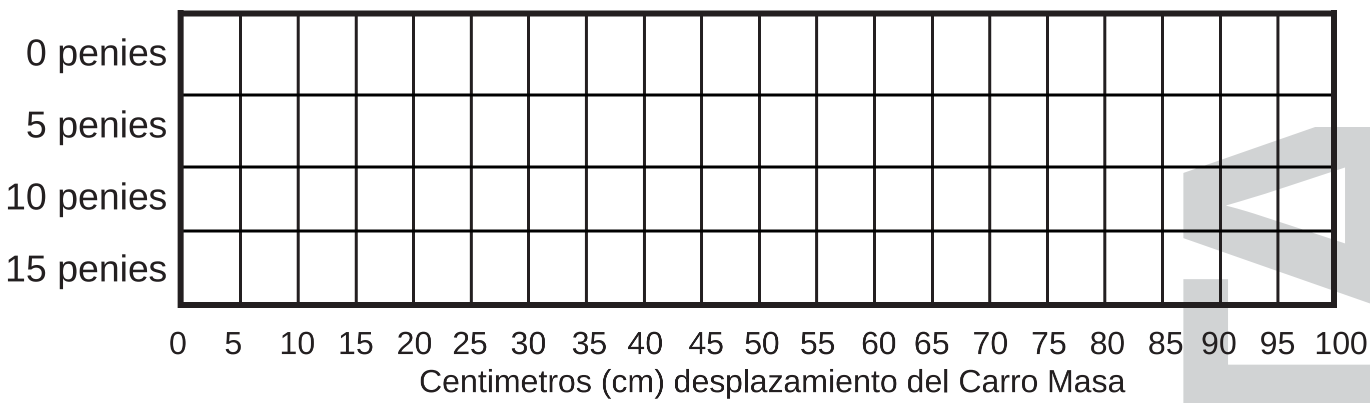
Nombre:______________________________

MASA VS
**PESO**

## Masa a Presión de Aire
## Hoja de Datos del Estudiante

| Objetos | Masa Total(g) | Distancia del Carro Masa (cm) | | | |
|---|---|---|---|---|---|
| | | Prueba 1 | Prueba 2 | Prueba 3 | Promedio |
| Carro + Vaso + 0 penies | | | | | |
| Carro+ Vaso + 5 penies | | | | | |
| Carro + Vaso + 10 penies | | | | | |
| Carro + Vaso + 15 penies | | | | | |

1. Marca la gráfica de Barras mostrando la distancia promedio de las tres pruebas de cada masa.




2. Marca los datos en el papel cuadrícula como gráfica línear. Nombra la gráfica y marca los ejes. Incluye las unidades.

3. Examina los datos y las gráficas ¿Cómo la masa afecta la distancia viajada del carro masa?

______________________________________________________________

______________________________________________________________

______________________________________________________________

4. ¿Cómo puede explicar los resultados la Ley Del Movimiento de Newton?

______________________________________________________________

______________________________________________________________

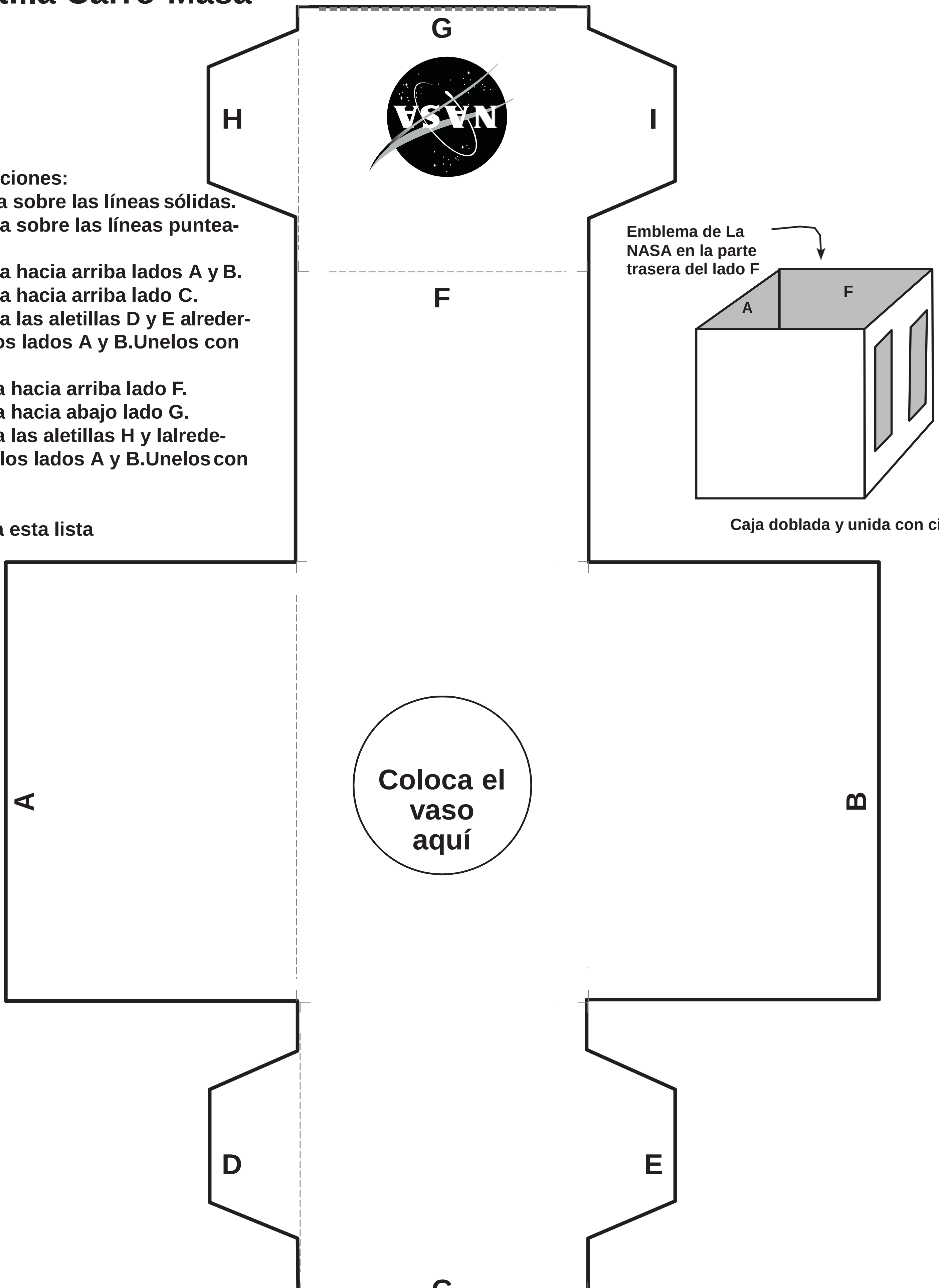
______________________________________________________________

5. ¿Cómo trabajaría este experimento en la Estación Espacial Internacional? (Si es necesario usa la parte trasera de la hoja)

# Plantilla Carro Masa

**Instrucciones:**
1. Corta sobre las líneas sólidas.
2. Dobla sobre las líneas puntea-das.
3. Dobla hacia arriba lados A y B.
4. Dobla hacia arriba lado C.
5. Dobla las aletillas D y E alreder-or de los lados A y B.Unelos con cinta.
6. Dobla hacia arriba lado F.
7. Dobla hacia abajo lado G.
8. Dobla las aletillas H y Ialrede-dor de los lados A y B.Unelos con cinta.

La Caja esta lista




Emblema de La NASA en la parte trasera del lado F

Caja doblada y unida con cinta

| Lesson Update and CRT Addendum | |
|---|---|
| **Lesson/Activity Title: Packing Up for the Moon** | **ID: 1-94** |
| **Product Number: EP-2007-08-93-MSFC** | **Grade: MS** |
| **URL for Lesson: http://lroc.sese.asu.edu/files/EducatorGuides/PackingupforMoon1Guide.pdf** | |
| **Subject: Plant growth, photosynthesis, transpiration, cellular respiration, energy transformation, comparison of Earth and moon, role of plants in ecosystems** | |
| **Summary: Students will explore the role of plants in ecosystems, determine the biological requirements for plant growth, and discover the conversion of matter and energy through natural processes. Students will also use mathematical concepts (ratios and percentages) to compare and contrast the Earth and its moon.** | |
| **Materials for lesson: No extensive materials beyond common classroom technology.** | |

| Review and Recommendations | |
|---|---|
| **ALIGNMENT TO STANDARDS** | |
| **NGSS** | **MS-LS1-6, MS-LS1-7, MS-LS2-1, MS-LS2-2, MS-LS2-3, MS-LS-4, MS-LS2-5, MS-ESS1-3** |
| **Common Core State Standards in Mathematics** | **6. RP, 7.RP** |
| **State Standards: Science TEKS** | **5.9(D), 6.11(C), 7.5(A), 8.11(C)** |
| **State Standards: Math TEKS** | **6.5(B), 7.4(D)** |
| **CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS** | |
| **5E Lesson/Description** | |
| **1. Engage** | -Tease with NASA slamming LCROSS into Cabeus crater in 2009. Why? What could that have to do with growing plants on the moon? (see link in Additional Resources) |
| **2. Explore** | Teacher could let students survey local area and determine types of plants their family uses (food, medicine..). |
| **3. Explain** | Teacher can facilitate a discussion of which milestones have been reached and which have not yet, including the |

| | |
|---|---|
| | possibility of students' future participation in achieving those goals. |
| **4. Expand/Enhance** | Lesson could be taught in collaboration with social studies lesson on original moon landing.<br>Cultures that favor plant-based diet could be explored in greater depth.<br><br>In urban areas, parallels could be drawn to growing plants/food in containers/patios/greenhouses/other urban spaces where lack of access to soil/water and temperature must be considered.<br><br>Students could do this lesson as a wrap up for an ecosystem unit. Students could build a model of the Lunar Base that includes all of the things they have just learned are required in an ecosystem as a hands on summative assessment. The assessment itself could be as simple as a gallery walk or the student creations could be modular and put together into a large lunar "village" that gets presented to the school or parents. |
| **5. Evaluate** | -Students can build scale models of Lunar Base Plant Growth Chamber using available materials.<br>-Students could share their family or culture's experience with growing plants for food/medicine and relate that positively or negatively to recreation of the same model in a lunar environment. |

**Additional Resources:**

**www.nasa.gov/mission_pages/LCROSS/main/prelim_water_results.html**

**http://www.nasa.gov/topics/moonmars/features/moon20090924.html**

**http://www.cnbc.com/2016/08/03/moon-express-and-the-trillion-dollar-race-to-harvest-the-moon.html**

**http://sservi.nasa.gov/articles/nasa-looking-to-mine-water-on-the-moon-and-mars/**

**http://sservi.nasa.gov/wp-content/uploads/2015/11/Pendleton_IAU.pdf**

| Lesson Update and CRT Addendum | |
|---|---|
| **Lesson/Activity Title: Follow the Water** | **ID: 5-478** |
| **Subject: Water in the environment, water and life** | **Grade: MS** |
| **URL: https://www.nasa.gov/pdf/168049main_Follow_the_Water.pdf** | |
| **Summary: This lesson covers a broad understanding of water, its effect on and importance to ecosystems and the environment. Included is water in the solar system and the role of water in the search for extraterrestrial life.** | |
| **Materials for Lesson: Lesson has detailed materials list for each activity.** | |

| Review and Recommendations | |
|---|---|
| **ALIGNMENT TO STANDARDS** | |
| **NGSS** | **MS-LS1-1, MS-LS1-3, MS-LS2-1, MS-LS2-3, MS-LS2-4, MS-ESS2-1, MS-ESS2-2, MS-ESS2-4, MS-ESS3-2, MS-ETS1-2, MS-ETS1-3, MS-ETS-4** |
| **Common Core State Standards in Mathematics** | |
| **State Standards: Science TEKS** | **7.9(A), 8.11(A)** |
| **State Standards: Math TEKS** | |
| **CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS** | |
| **5E Lesson/Description** | |
| **1. Engage** | Teacher should prepare information about the sources of water and watershed areas in their local area and use that to engage and make the lesson more concrete for students. Further, students should be allowed to share any water related special cultural relationship they may have. |
| **2. Explore** | While beginning the larger explorations, teacher should spend specific time with the included vocabulary for students (i.e., adhesion, aquifer, brackish…). |
| **3. Explain** | Students are asked to provide written narratives. Use this opportunity to create a dialogue or discussion with students. Allow them to answer in the manner in which they are most comfortable. Be open to visual narratives as well. |

| | |
|---|---|
| **4. Expand/Enhance** | Local water resource data can be analyzed to add more relevance and bring mathematics into the lesson (i.e., increased amount of water treated during rain/precipitation events, water output to sewage input and treatment).<br>Teacher can collaborate with Social Science teacher if curriculum topics can be aligned. |
| **5. Evaluate** | Teachers are given several suggestions for evaluation. Create a pre and post assessment. Check in with students throughout the process. |

**Additional Resources:**

## Lesson Update and CRT Addendum

| | |
|---|---|
| **Lesson/Activity Title: Food for Thought: Extension: Burning Question- Which Foods to Take to Mars?** | **ID: 7-705** |
| **Product Number: EG-2011-08-00005-SSC** | **Grade: MS** |
| **URL for Lesson: https://www.nasa.gov/pdf/591741main_Food-For-Thought.pdf** | |
| **Subject: Energy conversion, caloric density versus nutrition** | |
| **Summary: This extension has students measure the amount of energy contained in various foods and determine the foods suitability for inclusion on a mission to Mars.** | |
| **Materials for Lesson: Lesson has detailed materials list for each activity.** | |

## Review and Recommendations

| | |
|---|---|
| **ALIGNMENT TO STANDARDS** | |
| **NGSS** | **MS-PS1-6, MS-PS3-4, MS-LS1-7, MS-LS2-1, MS-LS2-3, MS-LS2-4, MS-ESS2-1** |
| **Common Core State Standards in Mathematics** | |
| **State Standards: Science TEKS** | **7.5(C)** |
| **State Standards: Math TEKS** | |
| **CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS** | |
| **5E Lesson/Description** | |
| **1. Engage** | The previous activities, Mars Needs Food! should be included to put the calorimeter activity in better context. Students should also be asked to share foods they eat at home that are part of their cultures and as this lesson progresses the value of those foods inclusion in the menu for long space travel should be explored and included. In Part Two of the previous investigation (Guess Who's Coming to Dinner, step 5 on page 7) there is a specific task for students to include food for astronauts from different countries, this is an opportunity to allow students with families from other areas to take a lead role in the discussion.<br><br>Include foods taken on earlier manned space travel (Gemini and Apollo). |

| | |
|---|---|
| **2. Explore** | Adding the preceding activities gives much more opportunity to fully explore the lesson, provides depth, rigor, and the opportunity for critical thinking and student engagement. |
| **3. Explain** | While there isn't a separate vocabulary list, there is a lot of potential for vocabulary building here and having ESL students share the vocabulary equivalents in their home languages. |
| **4. Expand/Enhance** | Students could prepare and sample foods that have been preserved in various ways that may make them able to be carried on a space voyage.<br><br>The calorimeter activity is a good chance to talk about and explore the difference between junk foods and healthy alternatives.<br><br>Discuss with students the importance of various scientific disciplines in space exploration. Often students think only of engineers and "rocket scientists", but nutritionists, medical personnel, logistics managers, and all types of scientists, mathematicians, and workers are needed for the program to be successful. Use this as an analog for the need for diversity in our society in general and highlight the wonderful diversity of the students in the classroom. |
| **5. Evaluate** | Within the activities the various activities have charts and worksheets for students to organize their work. These can be used to summatively assess student work and understanding. Teacher should be using student responses and participation in discussions to formatively assess and drive the lesson. |

**Additional Resources:**

| Lesson Update and CRT Addendum | |
|---|---|
| **Lesson/Activity Title: Lunar Landing Sites** | **ID: 8-708** |
| **Product Number: EG-1997-10-116-HQ** | **Grade: MS** |
| **URL for Lesson: https://tracs.txstate.edu/access/content/group/1f661749-a288-4c82-af20-eac949ac1c67/Lesson%208/_8_%20708%20Lunar%20Landing%20Sites%20_1_.pdf** | |
| **Subject: Mass, velocity, geology, design, experimental modeling,** | |
| **Summary: Within a given background of the Moon's geological conditions, students design spacecraft, choose landing sites, and plan a lunar mission. This is a hand-on activity that culminates with oral, visual, and 3-dimensional presentations.** | |
| **Materials for Lesson: Lesson has detailed materials list for each activity.** | |

| Review and Recommendations | |
|---|---|
| **ALIGNMENT TO STANDARDS** | |
| **NGSS** | **MS-ESS1, MS-ESS2, MS-PS2-2, MS-PS2-4, MS-PS3-1, MS-PS3-2, MS-PS3-3, MS-PS3-5, MS-ETS1** |
| **Common Core State Standards in Mathematics** | **The lesson doesn't have explicit requirements that align with CC Standards, however there is ample opportunity to include graphing, statistics, and comparison throughout the activity.** |
| **State Standards: Science TEKS** | **5.5(A), 6.11(A), 7.7(A), 8.9(C)** |
| **State Standards: Math TEKS** | |
| **CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS** | |
| **5E Lesson/Description** | |
| **1. Engage** | Teacher can lead a discussion about various generations "Events" that impact culture so profoundly that everyone that experiences them, they remember exactly where they were and what they were doing at that moment. (Moon Landing, 9/11, Kennedy Assassination…) Prompt students to share any moments they may have experienced or that are important to their cultures.<br><br>Teacher can discuss with the class the rapidity with which technology grows (From Wright Brothers to Moon landing was less than 60 years. Rate has increased |

| | |
|---|---|
| | exponentially since then.) and show video of Wright Brothers flight and the Moon Landing.<br><br>Teachers should also spend time reviewing pertinent vocabulary and making connections to students' home language is applicable. |
| **2. Explore** | The primary activity is very concrete and hands-on. Opportunities are provided for multimodal learning. |
| **3. Explain** | Much of this section should come directly from the students, directed and refocused when necessary by the teacher. Students should be explaining their process and asked high order open-ended questions throughout the activity. |
| **4. Expand/Enhance** | The "Heavy Lifting" Activity or any of the other activities included in the additional resources would nicely expand or enhance this activity. |
| **5. Evaluate** | The presentations at the end provide ample opportunity for formalized summative assessment. Formative assessment can and should occur throughout the process. |

## Additional Resources:

**SLS Resources for the Classroom:**
http://www.nasa.gov/exploration/systems/sls/outreach/classroom.html
**Rocket Guide:**
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html
**Heavy Lifting Activity**
http://www.jpl.nasa.gov/edu/teach/activity/rocket-activity-heavy-lifting/
**Match Activity**
https://www.grc.nasa.gov/www/k-12/TRC/Rockets/match_rocket.html
**Thrust Equation and Other activities (on the bottom of the page by grade level)**
https://www.grc.nasa.gov/www/k-12/airplane/rockth.html
**Rocket Principles and Resource Websites:**
https://spaceflightsystems.grc.nasa.gov/education/rocket/TRCRocket/rocket_principles.html
**More Ways to Build Rockets with other Recyclable materials:**
https://spaceflightsystems.grc.nasa.gov/education/rocket/TRCRocket/RocketActivitiesHome2.html

| Lesson Update and CRT Addendum | |
|---|---|
| **Lesson/Activity Title: Mass vs. Weight: A Heavy Duty Concept** | **ID: 9-721** |
| **Product Number: EB-2010-03-00022** | **Grade: MS** |
| **URL for Lesson: [http://education.ssc.nasa.gov/massvsweight.asp](http://education.ssc.nasa.gov/massvsweight.asp)** | |
| **Subject: Mass, Weight, Gravity, Acceleration, Force** | |
| **Summary: This lesson is an exploration of the difference between weight and mass. It has video demonstrations that illustrate the effects of mass on acceleration.** | |
| **Materials for Lesson: Lesson has detailed materials list for each activity.** | |

| Review and Recommendations | |
|---|---|
| **ALIGNMENT TO STANDARDS** | |
| **NGSS** | |
| **Common Core State Standards in Mathematics** | |
| **State Standard: Science TEKS** | **5.5(A); 6.2(A); 7.2(A); 8.2(A)** |
| **State Standard: Math TEKS** | |
| **CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS** | |
| **5E Lesson/Description** | |
| **1. Engage** | **This activity has been updated and includes multiple videos of astronauts on the ISS demonstrating various concepts that illustrate the difference between mass and weight using the unique microgravity conditions on the station. The videos include classroom activities to reinforce each demonstration and concept. These should effectively engage students initially.**<br><br>**Students should be given the opportunity to share any experiences they have had with moving objects of varying masses (pushing friends on skates/bikes/shopping carts, moving furniture, rearranging their rooms…).** |
| **2. Explore** | Have a discussion with students about phenomenon that may potentially vary based on the effects of gravity, acceleration, or force on mass (paint dripping, stalactite growth…). |

| | |
|---|---|
| **3. Explain** | Students should be given the primary responsibility for explanations. They should be required to explain their foundational thinking and processes throughout the design of their experiment. |
| **4. Expand/Enhance** | Research and explore current tests being conducted and previous work done. Good science leads to more and better questions. Let students brainstorm (We know A, so what if they…). |
| **5. Evaluate** | Each build up activity can be individually assessed. A summative assessment can be created based on the final presentation of the individual or group's experimental proposal. |

**Additional Resources:**

**All found at:**

http://education.ssc.nasa.gov/Massvsweight.asp

| Lesson Update and CRT Addendum | |
|---|---|
| Lesson/Activity Title: Buzz Lightyear: Putting It All Together | ID: 11-732 |
| Product Number: | Grade: MS |
| URL for Lesson: https://www.nasa.gov/pdf/387966main_Putting_It_All_Together.pdf | |
| Subject: Newton's Laws, energy, photosynthesis, cellular respiration | |
| Summary: Students design and build a Rube Goldberg machine to put a marble in a cup. In addition to the obvious lesson in physics, teachers can use this lesson to teach biological cascade processes (photosynthesis/cell respiration). While the step-by-step procedure of the machines is helpful for giving students a hands-on analog of various processes, the teacher should make it a point to contrast the purposeful overcomplexity of the Rube Goldberg machine with the efficient processes in the natural world. | |
| Materials for Lesson: Lesson has detailed materials list for each activity. | |

| Review and Recommendations | |
|---|---|
| ALIGNMENT TO STANDARDS | |
| NGSS | MS-PS1-5, MS-PS2-1, MS-PS2-2, MS-PS3-1, MS-PS3-5, MS-LS1-6, MS-LS1-7, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3 |
| Common Core State Standards in Mathematics | |
| State Standards: Science TEKS | 5.6D; 6.8(A); 7.7(A); 8.6(A); 8.6(C) |
| State Standards: Math TEKS | 5.9 (C); |
| CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS | |
| 5E Lesson/Description | |
| 1. Engage | Show the following videos:<br>Student designed with very common materials, includes the number of tries it took to "get it right". https://www.youtube.com/watch?v=dFWHbRApS3c<br>Opening credits for "Elementary" https://www.youtube.com/watch?v=C7JT3iMzS4k |
| 2. Explore | This activity should be a part of a larger lesson. If this is for a physics or physical science class, begin with this and then "name" the laws the students have discovered on their own. Or after showing students the steps of photosynthesis and cellular respiration, they can create analogs of the processes with a small addendum to this activity. |

| | |
|---|---|
| **3. Explain** | **Some time should be taken to dispel the idea that something is science if it is terribly complicated. Rube Goldberg was an artist that was making a comment on inventions and inventors at a time of incredible scientific innovation. In truth, engineers and scientists seek out the most efficient solutions. Biological processes and systems can often seem terribly complex which is a product both of the multivariate conditions in which they must operate and the evolutionary mechanisms from which they spring.** |
| **4. Expand/Enhance** | **This activity is, of itself, an expansion or enhancement of a broader lesson.**<br><br>**For a greater mathematics component students can be tasked with graphing data related to variables in the different machines created.** |
| **5. Evaluate** | **With specific guidelines given, the evaluation should be relatively straightforward. Does the finished product have the requisite number of steps, etc.?** |

**Additional Resources: Included in the 5E steps above.**

| Lesson Update and CRT Addendum | |
|---|---|
| **Lesson/Activity Title:** Touchdown (from "On the Moon Educator Guide") | **ID: 12-725** |
| **Product Number: EG-2009-02-05-MSFC** | **Grade: 3-8** |
| **URL for Lesson: http://www.jpl.nasa.gov/edu/pdfs/touchdown.pdf** | |
| **Subject: Potential and kinetic energy, acceleration, air resistance, measurement, engineering processes.** | |
| **Summary: Students are designing and building a shock-absorbing system to protect two marshmallow "astronauts".** | |
| **Materials for lesson: There are suggested materials in the list but others can be added or substituted based on availability and level/depth of design.** | |

| Review and Recommendations | |
|---|---|
| **ALIGNMENT TO STANDARDS** | |
| **NGSS** | **3-5-ETS1-3** |
| **Common Core State Standards in Mathematics** | |
| **State Standards: Science TEKS** | **5.1(A), 5.2(D), 5.2(E), 5.4(A);6.2(B),** |
| **State Standards: Math TEKS** | |
| **CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS** | |
| **5E Lesson/Description** | |
| **1. Engage** | As written the lesson is very teacher centered. Create a dialogue with students to bring out their stories and experiences either jumping off of something or playing with something that may have landed with great force or very softly. There is wonderful opportunity to engage with students during the brainstorming sessions as well.<br>There are a lot of suggestions and students are led in very specific directions with folded card stock, for example. Removing those suggestions and letting students discover those possibilities will free them. Giving too many suggestions can lead to students just shutting down their own creative process in lieu of just taking the "easy" path of following your lead. Allow students to struggle with the problem to create their own path to a solution. |
| **2. Explore** | This activity should be all about students exploring and experimenting with possible materials, design, and construction techniques. As stated in the "Engage" section, present the problem, but allow students to explore paths to their own solutions. |

| | |
|---|---|
| | Make explicit the use of different units of measure and the different ways to estimate quantities and relationships.<br>Encourage students to draw from their own experiences and allow them to use multiple modes of communication to express or share their processes. |
| **3. Explain** | No justification or explanation is prompted by student worksheet. Teacher guide includes a section titled "Discuss what happened;" suggested questions could result in explaining (e.g., "after testing, what changes did you make to your lander?") or might not (e.g., "what forces affected your lander as it fell?") depending on teacher implementation. Use evidence to reason or support claims. |
| **4. Expand/Enhance** | • Add discussion of "fair test" and control of variables to lesson plan.<br>• Improve connection between scientific/engineering practices with engineering design ideas.<br>• Draw on physical science concepts of energy transfer and transformation to make sense of elements used in the design process.<br>• Consider making the extended challenge part of the lesson if the goal is to cover this mathematical practice.<br>• Align with grade-level content standards.<br>• Connect the standards for Mathematical Practices to the Standards for Mathematical Content for a deeper conceptual understanding.<br>• The lesson needs to include grade-level standards and suggestions on how to customize learning.<br>• Make other connections to other disciplines.<br>• Lesson should encourage multiple inputs.<br>• Expand affective domain considerations.<br>• Increase intellectual safety and create a sense of belonging,<br>• Add language objectives to each of the activities. |
| **5. Evaluate** | Incorporate a pre and post assessment of students understanding of key concepts. Collaborate with students to create a method for recording results and changes made. |

## Additional Resources:

https://tracs.txstate.edu/access/content/group/1f661749-a288-4c82-af20-eac949ac1c67/Lesson%2012/_12_%20725%20Touchdown%20_from%20%E2%80%9COn%20the%20Moon%20Educator%20Guide%E2%80%9D_.pdf

| Lesson Update and CRT Addendum | |
|---|---|
| **Lesson/Activity Title: On Target** | **ID: 13-767** |
| **Product Number:** | **Grade: 6-12** |
| **URL for Lesson:** [https://www.nasa.gov/pdf/418005main_OTM_On_Target.pdf](https://www.nasa.gov/pdf/418005main_OTM_On_Target.pdf) | |
| **Subject: Design process, Newton's First Law, acceleration, vectors, trajectory, potential and kinetic energy, measurement.** | |
| **Summary: Students are asked to design a vehicle to release a marble at a very specific point in order to hit a target.** | |
| **Materials for lesson: There are suggested materials in the activity, but teacher should allow for students to suggest others as available to personalize and increase design potential.** | |

| Review and Recommendations | |
|---|---|
| **ALIGNMENT TO STANDARDS** | |
| **NGSS** | |
| **Common Core State Standards in Mathematics** | |
| **State Standards: Science TEKS** | 6.8(A); 7.7(A); 8.6(A) |
| **State Standards: Math TEKS** | 7.12(C) |
| **CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS** | |
| **5E Lesson/Description** | |
| **1. Engage** | Elicit students' prior experiences and knowledge, (stopping suddenly in a vehicle, trying to drop something on target while moving, sports analogies…). |
| **2. Explore** | Create more open-ended questions to allow students to produce different paths to the desired results. Incorporate inferences that enable student to use prior knowledge and skills to aid in the project. Take out the specific suggestions included and create a dialogue with students to encourage the design process. Design, test, redesign, test… |
| **3. Explain** | Leave the explanation to the end of the project to allow open design process. Have students describe what happens and reason out the processes involved. |

| | |
|---|---|
| **4. Expand/Enhance** | The activity suggests some ways to "Extend the Challenge". Have students compete for accuracy, set time challenges, smaller targets… |
| **5. Evaluate** | Collaborate with students to design graphs/charts to document results and compare data. Create a rubric with students to assess their work. Give students a pre and post-test of key concepts. Have students present their results. |

## Additional Resources:

http://pbskids.org/designsquad/build/target/

| Lesson Update and CRT Addendum | |
|---|---|
| **Lesson/Activity Title: Feel the Heat** | **ID: 17-844** |
| **Product Number: EG-2009-02-05-MSFC** | **Grade: 9-12** |
| **URL for Lesson:** [https://www.nasa.gov/pdf/417998main_OTM_Feel_Heat.pdf](https://www.nasa.gov/pdf/417998main_OTM_Feel_Heat.pdf) | |
| **Subject: Heat transfer, infrared radiation, conversion of energy, measurement** | |
| **Summary: In this challenge, students follow the engineering design process to: (1) build a solar hot water heater; (2) test to see if it can raise the temperature of water; and (3) use their testing results to improve their heater and get as big a temperature change as possible.** | |
| **Materials for lesson: (per heater if making the one suggested) Aluminum foil, cardboard, adjustable lamp, black marker, black paper, 2 paper cups, 3 feet of clear plastic tubing, water container, ruler, scissors, straws, duct tape, thermometer.** | |

| Review and Recommendations | |
|---|---|
| **ALIGNMENT TO STANDARDS** | |
| **NGSS** | **HS-ESS2** |
| **Common Core State Standards in Mathematics** | Not emphasized. Could add: conversion of units of measure. |
| **State Standards: Science TEKS** | 5.6(A); 6.9(A) |
| **State Standards: Math TEKS** | Measure volume and compare temperature data collected |
| **CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS** | |
| **5E Lesson/Description** | |
| **1. Engage** | Incorporate students' prior knowledge of heat transfer: hot pavement/sand, hot surfaces in a vehicle in the summer, water in a hose left in the sun, anyone have solar heaters at home? Have you seen a roof with solar panels? Dark roof vs. lighter colored. Wearing dark clothes in the summer. |
| **2. Explore** | Allow the students to translate parts of the project in their own language and then share with other students. A suggestion here would be to allow students to apply proper uses of the solar water heating system at home and in their respective neighborhoods for people such as the poor or homeless who will need heat during winter and cold days. |

| | |
|---|---|
| | Instead of giving students the design shown, let them brainstorm and design the system from scratch and discover the benefit of longer tubes and zig-zag pattern on their own. |
| **3. Explain** | There is an opportunity for discussion that students/teachers can take advantage of once the project during the design and after the project is complete. During the brainstorming and design process, the teacher can focus students attending based on the brainstorming questions. The students or kids can exhibit their heaters and discuss how they solved any problems that came up. |
| **4. Expand/Enhance** | The teacher or facilitator can have students reflect and brainstorm ways water is heated and use their primary language to create vocabulary words.<br>The class can build a simple larger solar water heater for the classroom using the best design from the lesson scaled up. |
| **5. Evaluate** | There are no assessments associated with the lesson. A rubric designed to measure appropriate criteria should be considered.<br>Consider assessing students on their reasoning for using certain materials and provide clear rationale(s) for their designs and be ready to defend. |

**Additional Resources:**

https://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/OTM_Feel.html

| Lesson Update and CRT Addendum | |
|---|---|
| **Lesson/Activity Title: Exploring the Moon: Lunar Biosphere** | **ID: 19-702** |
| **Product Number: EG-1997-10-116-HQ** | **Grade: MS** |
| **URL for Lesson:** [https://www.nasa.gov/pdf/180588main_ETM.Lunar.Biospheres.pdf](https://www.nasa.gov/pdf/180588main_ETM.Lunar.Biospheres.pdf) | |
| **Subject: Biosphere, ecosystems, science careers, photosynthesis, graphing and data analysis** | |
| **Summary: This activity challenges students to create a working model of a lunar biosphere that is a balanced, self-enclosed living system able to run efficiently over a long period of time.** | |
| **Materials for lesson: (1) Cardboard or heavy-weight paper, (2) Cinder, gravel, sand silt, clay, (3) Data and Observation Sheets, (4) Fertilizer, (5) Lamp, (6) Markers or crayons, (7) Measuring cups & spoons, (8) String, (9) Something to use as the frame: wooden, chopsticks, other kinds of sticks, (10) vermiculite, (11) Plastic tape, (12) Plastic drinking straws, hangers, (13) Plastic 2-liter bottle, (14) Seedlings and animals (15) Team Member Information Sheets, (16) Water.** | |

| Review and Recommendations | |
|---|---|
| **ALIGNMENT TO STANDARDS** | |
| **NGSS** | ETS1; LS2 |
| **Common Core State Standards in Mathematics** | |
| **State Standards: Science TEKS** | 5.9(A), 5.9(B); 7.10(A); 8.11(B) |
| **State Standards: Math TEKS** | Measurement and ratio covered in lower grades |
| **CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS** | |
| **5E Lesson/Description** | |
| **1. Engage** | The nature of the abiotic and biotic components should be discussed. Students designing the hanging mobile "Biosphere" to assess prior knowledge will promote curiosity and elicit prior knowledge of students. Discuss the different variables one may encounter on the moon that are different than on Earth. Plants have been grown on the ISS, share videos/pictures with students of those. Ask if students have ever seen hydroponics or different growing techniques. Share what you can find about them. Ask a local grower to come in and share with the students what and how they grow. |

| | |
|---|---|
| **2. Explore** | In regard to the describing and discussing aspects, the learners could have been asked to provide such language engagements for their native peers or for other ELLs. This would also help in translating the language of science into a format that is less intimidating. This approach might also support a more in-depth understanding of the science and processes involved in the lesson.<br>Let students research and decide which plants to grow or animals to include and compare to see what creates the best results. |
| **3. Explain** | Through discussions and narratives, students can share their personal relationship with the content of this lesson. Have students share their finished projects and how they overcame any problems that came up. |
| **4. Expand/Enhance** | Take a trip to a farm or greenhouse.<br>Create an analogue of conditions on the moon (as closely as possible) and have students start from there to design working biospheres. Using what they learned. Challenge students to use as many resources that would be available in situ on the moon as possible. |
| **5. Evaluate** | A pre and post-test might help to know with more confidence what was learned. The lesson has a somewhat open-ended approach and mixtures of questions and mixed-modality response types might be considered (i.e. drawings for younger learners).<br>There might be set points where the student can get feedback as to the status of their model project's development. With established milestones, the student can have an advanced knowledge as to where they should be in regard to the lesson's progression. However, instead of have a scoring of the progress; it would be points where personal reflection and sharing can be carried out. |

**Additional Resources:**
https://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Exploring.the.Moon.html

| Lesson Update and CRT Addendum | |
|---|---|
| **Lesson/Activity Title: Lunar Colonization: Understanding the Challenge** | **ID: 20-100** |
| **Product Number: EP–2009–03–49–MSFC** | **Grade: MS** |
| **URL for Lesson: [https://www.nasa.gov/pdf/475486main_HEP_I_MS_6.pdf](https://www.nasa.gov/pdf/475486main_HEP_I_MS_6.pdf)** | |
| **Subject: Use of technology and engineering to solve problems, space exploration.** | |
| **Summary: This lesson is designed to familiarize students with space travel and exploration, the Moon and lunar colonization, and getting to the Moon: past, present, and future. It is very general and broad in scope.** | |
| **Materials for lesson: No materials needed for this lesson.** | |

| Review and Recommendations | |
|---|---|
| **ALIGNMENT TO STANDARDS** | |
| **NGSS** | **ETS1, LS2** |
| **Common Core State Standards in Mathematics** | 8.EE, 7.EE |
| **State Standards: Science TEKS** | 8.8(A) |
| **State Standards: Math TEKS** | Possibility with extension activities. |
| **CULTURAL RESPONSIVE TEACHING (CRT) RECOMMENDATIONS** | |
| **5E Lesson/Description** | |
| **1. Engage** | In addition to the suggestion made in the lesson, create discussions with students about their prior understanding of colonization. Compare and contrast colonizing the moon to what we've done on Earth. Ask if they would want to go themselves. Why or why not? |
| **2. Explore** | This lesson is all about exploration. Further, the teacher can connect students to their other "ways of knowing" (cultural, community, personal, etc.) to focus their exploration. |
| **3. Explain** | Students watch NASA videos followed by discussion. This activity can guide students toward a deeper understanding.<br>Multiple resources are given to students to help explain and understand the characteristics of the Moon and its atmosphere before they design the lunar colony. |

| | |
|---|---|
| **4. Expand/Enhance** | The teacher can challenge students to design and think about the best way to transport food from the kitchen to the dining room. Students in the rural areas can be tasked to design ways to transport food produce from farms to the grocery stores or markets without using any current technology such as cars, helicopters, etc.<br>Students can survey people in the community regarding lunar colonization and transportation plans.<br>Students can explore sustainable designs for Earth communities and determine what elements would work in a Lunar colony and what would need to be modified. |
| **5. Evaluate** | The lesson utilizes pre-test and post-test to assess student knowledge on lunar colonization. Off to the Moon KWHL Chart is used to collect information from students. Likewise, worksheet is used to evaluate students' progress towards achieving the lesson's objectives.<br>Design challenges can be presented and issues discussed. |

**Additional Resources:**

https://www.nasa.gov/pdf/475486main_HEP_I_MS_6.pdf

https://settlement.arc.nasa.gov/Basics/wwwwh.html

https://www.nasa.gov/pdf/166504main_Survival.pdf

https://sservi.nasa.gov/articles/colonizing-the-moon/