National Aeronautics and
Space Administration

21CCLC NASA STEM Challenge

Spaced Out Sports

Facilitation Guide

FACILITATOR'S WELCOME

Dear 21CCLC STEM Facilitators,

Welcome to this year's 2014-2015 STEM Engineering Design Challenge Team! As part of this team, you will play an integral part in helping today's students become tomorrow's scientists, technicians, engineers, and mathematicians. Engineering Design Challenges, like the one included in this Facilitator's Guide. Through the Engineering Design Challenge (EDC), students will participate in authentic learning experiences that allow them to develop valuable skills through rigorous and engaging science, technology, engineering, and mathematics (STEM) content.

As a 21CCLC STEM facilitator, you are helping your students use their creativity, curiosity, analytical thinking as they utilize the **Engineering Design Process (EDP)**. Solving problems utilizing the EDP will be a key to the success of NASA's future engineering workforce.

Through the design challenge, ***Spaced-Out Sports***, students will work in small teams of no more than four students to design a sports game using Newton's Laws of Motion that could be used by the astronauts, while they are in space. It should be an entertaining activity that might also be included in the astronauts' physical fitness program.

The major real-world concepts of this challenge are:

1. **Measuring**
2. **Repeatability and Reliability**
3. **Newton's Laws of Motion**

This Facilitator's Guide is designed to provide the facilitator with important information to use in planning and conducting the challenge. It includes simple explanations of relevant background information, clear step-by-step instructions, reflective data sheets, and concise rubrics for evaluation of student performance. You will be expected to use all of the included materials you're your students. You can adapt the timeline to fit classroom schedule.

NASA supports educators and facilitators, like you, who play a key role in preparing students for careers in STEM fields through engaging content. Thank you for helping us share this learning experience with your students.

Engineering Design Challenge Team

US Department of Education
NASA Office of Education

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This challenge was adapted and content modified from "Spaced-Out Sports" EG-2011-04-00001-SSC.

INTRODUCTION

FACILITATOR'S OVERVIEW

The US Department of Education and NASA's Office of Education have worked together to create an **Engineering Design Challenge (EDC)** that teaches students about using the **Engineering Design Process (EDP).**

The EDC serves as an authentic standards-based investigation. It allows students to engage in the process of solving problems in a manner that today's scientists and engineers are utilizing. This EDC provides students with opportunities to gain tangible skills that are essential in STEM careers.

This guide is organized as follows:

1. Introductory Materials – Establishes a common basic level of understanding about the Engineering Design Process and its relation to this challenge. The introductory materials also includes an alignment to Next Generation Science Standards and the Common Core State Standards for Mathematics, as well as background information highlighting NASA's science and research related to physical fitness in space that relates, Space-out Sports.
2. Facilitator Pages – Provides instructions for facilitators to use throughout the design challenge. Also, included in this section are tools for you to use to assess student understanding throughout all steps of the challenge.
3. Student Challenge Journal – Contains prompts and tools to guide students through the cycle of steps in the Engineering Design Process, while documenting their work through each step.
4. Support Materials – Consists of information to supplement, enhance, and build on the EDC.

These user-friendly sections are provided to help you support your students as they work in teams to complete the EDC. At the conclusion of the EDC, your students will be required to articulate the steps taken in the Engineering Design Process in a video each team will create. Good luck as you help create the next generation of STEM professionals!

For more information, and to access the Help Desk, visit the NASA STEM Challenges website at http://y4y.ed.gov/stemchallenge/nasa.

THE BASICS OF ENGINEERING DESIGN

What is an Engineer? Engineers are at the heart of every Engineering Design Challenge. Engineers are people who design and build things that we use every day. The video at the link below will explain the role of an engineer and can be shared with your students: http://youtu.be/wE-z_TJyzil. After viewing the video ask the students as a class to describe what an engineer does.

Figure 1: Aerospace Engineer Chris Randall tests rocket parts and life support systems to ensure they work as planned. (NASA)

Figure 2: Simulation System Engineer Debbie Martinez works on developing a general aviation flight simulation software. (NASA)

What is an Engineering Design Challenge? An Engineering Design Challenge is developed to assist students to understand the Engineering Design Process. The students are presented with a challenge problem and, using the process, they participate in teams to complete activities and experiments to develop solutions to the original problem. These challenges facilitate teamwork, problem solving, and brainstorming ideas very similar to what real-world engineers encounter in their careers.

Engineering Design Process

What is the Engineering Design Process? The engineering design process is a cycle of steps that lead to the development of a new product or system. The cycle is repeated to continuously refine and improve the product. In this design challenge, students are to complete each step and document their work as they develop and test their design. To accomplish this task, the students need to perform each of the steps in the Engineering Design Process and repeat the cycle, as many times as time and resources allow, to develop the best end product. Some steps (for example, Researching the Need or Problem) will only need to be briefly revisited as a checkup that teams are still on track. Some steps (for example, Test and Evaluate the Solution) will need to be completely redone.

THE ENGINEERING DESIGN PROCESS

STEP 1: Identify the Need or Problem – Students, working in teams; state the challenge problem in their own words. Example: How can I design a __________ that will __________?

STEP 2: Research the Need or Problem – Teams use resources, from the Internet, library, or discussions with experts, to examine the how this problem is currently being solved or how similar problems are being solved.

STEP 3: Develop Possible Solutions – Team members draw on their mathematic and scientific knowledge to brainstorm all the possible ways that they might solve the problem. Out of their ideas, they choose the most promising options, and refine their solution by quickly sketching in two or three dimensions. Labels and arrows should be included to identify parts.

STEP 4: Select the Best Possible Solution(s) – Team members should share their ideas and answer questions from other team members. The team then discusses and records strengths and weaknesses from each design and determines which solution(s) best meet(s) the original need or solve(s) the original problem. This may include features from more than one design. The team writes a statement that describes why they chose the solution.

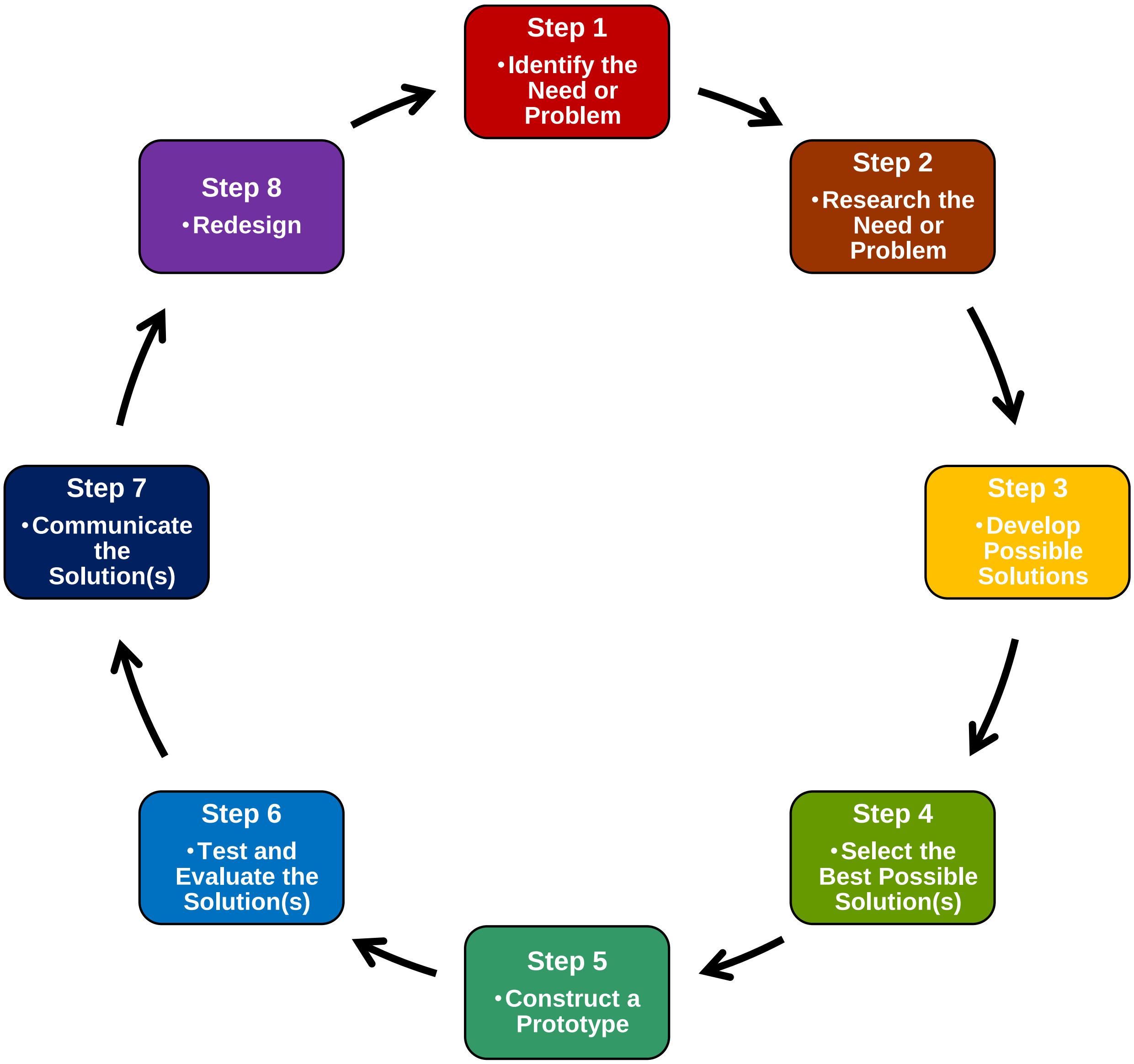
STEP 5: Construct a Prototype – Team members construct a full-size or scale model of the selected solution(s) in two or three dimensions. The facilitator helps to identify and acquire appropriate modeling materials and tools.

STEP 6: Test and Evaluate the Solution(s) – Team members test their model to determine how effective it was in solving the need or problem. Data is collected to serve as evidence of their success or need for improvement.

STEP 7: Communicate the Solution(s) – Team members record and share what was learned about their design based on testing. They make a presentation that includes how the solution(s) best solved the need or problem and any improvements that could be made. They may enlist students from other teams to review the solution and help identify changes.

STEP 8: Redesign – Team members consider modifications to their solution(s) based on the information gathered during the tests and presentation. Teams revisit the original need or problem to ensure their modifications still meet the necessary criteria and constraints, restarting the cycle of the Engineering Design Process.

THE ENGINEERING DESIGN PROCESS



This Engineering Design Process model was adapted from the Massachusetts Science and Technology/Engineering Curriculum Framework (published October 2006, http://www.doe.mass.edu/frameworks/scitech/1006.pdf).

STANDARDS ADDRESSED

Next Generation Science Standards	Common Core State Standards Mathematics
Practices 1. Asking questions, defining problems 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using math and computational thinking 6. Constructing explanations and designing solutions 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information *Cross-Cutting Concepts* 1. Patterns 2. Cause and effect 3. Scale 4. Systems and system models 5. Energy and matter 6. Structure and function *Core and Component Ideas* *Physical Science* PS2: Motion and Stability PS2.A: Forces and motion PS2.B: Types of interactions *Earth and Space Science* ESS1.B Earth and the Solar System *Engineering, Technology, and Applications of Science* ETS1.A: Defining and delimiting an engineering problem ETS1.B: Developing possible solutions ETS1.C: Optimizing the design solution ETS2.A: Interdependence of Science, Engineering, and Technology	*Standards for Mathematical Practice* MP1: Make sense of problems and persevere in solving them MP2: Reason abstractly and quantitatively MP3: Construct viable arguments and critique the reasoning of others MP4: Model with mathematics MP5: Use appropriate tools strategically MP6: Attend to precision *Grades 6-8* Expression and Equations – Reason about and solve one- variable equations. Represent and analyze quantitative relationships between dependent and independent variables Geometry – Solve real-world and mathematical problems involving area, and surface area Statistics and Probability – Develop understanding of statistical variability Summarize and describe distributions **ISTE NETS and Performance Indicators for Students, ISTE** *Critical Thinking, Problem Solving, and Decision Making* **Students:** ● Identify and define authentic problems and significant questions for investigation ● Plan and manage activities to develop a solution or complete a project ● Collect and analyze data to identify solutions and/or make informed decisions ● Use multiple processes and diverse perspectives to explore alternative solutions

BACKGROUND INFORMATION: FITNESS IN SPACE

The Human Body in Space: The Exercise Countermeasures Project

NASA plans to send astronauts beyond Earth orbit and into the solar system. These astronauts will need to perform a variety of physical tasks to accomplish their missions. Medical data from International Space Station (ISS) astronauts have revealed adverse health outcomes as a result of the weightless environment, including loss of bone density, decreased muscle strength, and endurance, reduced sensory-motor function (balance), and reductions in aerobic capacity. The astronauts may be physically unable to accomplish mission tasks if these health effects are not prevented. Exercise will play an essential role in lowering the risks from these effects when traveling elsewhere in the solar system, and ensuring optimal recovery on return to Earth.

Figure 3: Astronaut Sunita Williams exercises on the Combined Operational Load Bearing External Resistance Treadmill (COLBERT) on the ISS (NASA)

As part of NASA's Exercise Countermeasures Project (ECP), researchers are charged with developing exercise protocols and hardware to maintain astronaut health and fitness during long-duration space missions, and to preserve the capability to perform mission-critical tasks. NASA engineers and scientists must consider constraints on equipment size, exercise volume, and power limitations of the spacecraft and terrestrial habitats.

Types of Fitness Equipment in Space

Figure 4: Astronaut exercising on the ARED. (NASA)

<u>Resistive Exercise</u>

On Earth, resistive exercise, or strength training, is performed by lifting against a weight. During spaceflight, the Advanced Resistive Exercise Device (ARED) uses elastic bands to simulate weight bearing on the body. The ARED has the capability to simulate weights from 0 - 600 lbs. Resistive exercise prevents weakening of the major muscle groups, minimizes bone loss, and maintains strength and endurance.

<u>Treadmill Exercise</u>

Treadmill exercise includes walking, running, deep-knee bends, and some resistive exercises. It is used to maintain bone mass, cardiovascular fitness, muscle endurance, and sensory-motor function. The astronaut is held to the treadmill by a restraint system, including a harness worn around the shoulders and hips. The next generation treadmill (T2), provides more data than ever before on astronaut performance during exercise, including force-plate data which records the amount of pressure exerted by the astronaut on the belt of the treadmill.

Figure 5: Astronaut exercising on the cycle ergometer. (NASA)

Cycle Ergometry

Cycle ergometer exercise consists of pedaling a stationary cycle to provide general aerobic and cardiovascular conditioning, as well as improved muscular endurance. Cycling is an important aspect of physical conditioning for doing tasks such as space walks. Cycle exercise can be performed in either a manual mode, where cycling is controlled manually by the astronaut, or an electronic mode, where the work is varied by a controller for pedal speeds up to 120 rpm.

Leaving Earth Orbit

Long-duration exploration missions will extensive periods of confinement, isolation, surface spacewalks, and exposure to microgravity and partial-gravity environments. The next generation of exercise equipment will be key in the prevention of health-related issues. When designing exercise systems for exploration missions, NASA engineers and scientists must consider constraints on equipment size, weight, and power consumption due to limitation of spacecraft and surface habitats. They must also consider the best exercise routines, duration, and frequency to maintain astronaut health, while limiting interference with other mission tasks.

Figure 6: NASA researcher studying the performance of exercise equipment using a vertical treadmill. (NASA)

When spaceflight opportunities are not available for testing potential equipment and protocols, Earth-based analogs of weightlessness and partial-gravity are used. These include bed rest, zero-gravity aircraft, and vertical treadmill, all which reorient human subjects in such a way that Earth's gravity is not pulling through their feet as usual.

Learning from previous space missions, conducting new studies on current space missions, using human ground-analog and flight studies on Earth, and utilizing computer-based simulations of anticipated exploration will all help to develop more effective exercise hardware and protocols to keep astronauts healthy, safe, and fit for required mission tasks.

For more information, visit:

- Exercise Countermeasures Project website: http://spaceflightsystems.grc.nasa.gov/SOPO/ICHO/HRP/ExPC/
- ReelNASA playlist on Astronaut Mike Hopkins "Train like an Astronaut" series: https://www.youtube.com/playlist?list=PLTXQuaxXBKKzO9TicHf0ApIsiVTjndqf

SAMPLE TIMELINE

The EDC must be completed within the eight-week challenge period. The following timeline serves as a suggestion for the eight-week implementation. You may structure the sessions to fit your needs.

EDC Weeks	EDP	Actions
Pre-EDC	Pre-EDP	Attend Training and Order Materials
Week 1	Step 1 Step 2 Step 3	Identify the Need or Problem Research the Need or Problem Develop Possible Solution(s)
Week 2	Step 4 Step 5	Select the Best Solution Construct a Prototype
Week 3	Step 6 Step 7	Test and Evaluate Solution Communicate Solution
Week 4	Step 8 Step 1 Step 2	Redesign the Model Identify the Need or Problem Research the Need or Problem
Week 5	Step 3 Step 4	Develop Possible Solutions Select the Best Solution
Week 6	Step 5 Step 6	Construct a Prototype Test and Evaluate Solution
Week 7	Step 7 Step 8	Communicate Solutions (Compare Iterations) Recommend future Redesign
Week 8	Post-EDP	Create and Upload Student Videos

SAFETY

Safety is an important goal for all curricular areas of education. Safety issues are a special concern for STEM-based activities and courses. Many national and state academic standards address the need for schools and subject areas to promote student development of knowledge and abilities in a safe learning environment.

It is the responsibility of the school's administration, teachers, and facilitators to provide a learning environment that is safe, up-to-date, and supportive of learning. Additionally, facilitators are responsible for their students' welfare in the classroom and laboratory.

Facilitators must be knowledgeable and diligent in providing a safe learning environment. Students should receive safety instructions relevant to the topics being taught. Assessments must accompany the lessons on safety, and records must be kept on student results. The facilitator must properly supervise students, while they are working. The facilitator must inspect and maintain equipment and tools to ensure they are in proper working condition. Parents should be informed that a safe environment exists during the program. The facilitator should keep all students safe and assure that a safe environment exists and that proper procedures are being followed in the classroom and laboratory.

1. Students should demonstrate respect and courtesy for the ideas expressed by others in the group.
2. Students should use tools and equipment in a safe manner and assume responsibility for their safety, as well as for the safety of others.
3. Students should make safety a priority during all activities.
4. Students should wear safety goggles when conducting the EDC.
5. Facilitators should approve all drawings before students start building their designs.
6. Facilitators should look for potentially hazardous combinations of materials and flimsy designs of structures.
7. Facilitators should be sure resources are clean and dry with no sharp edges.
8. Facilitators should be the only ones using hot-glue guns and sharp instruments.
9. Facilitators should not allow students to bring additional materials for their designs without prior approval.
10. Facilitators should make sure all materials are not damaged or in disrepair.

FACILITATOR PAGES

USING A KLEW CHART

FACILITATOR DIRECTIONS: This KLEW chart can be used as a starting point for science investigation. Before you start the challenge, students should complete the **KNOW** section of this chart. It will allow students to share their prior knowledge and experiences (whether accurate or inaccurate). The **LEARN** section is after students are given background information about living and working in space. This background information may come from videos, articles, and other supplemental information. The **EVIDENCE** section helps students to reinforce concepts that they learned using the background information and during the challenge by providing supporting information to validate what they stated in the LEARN column. In the **WONDER** section, students share any new questions they may still want to explore.

Please allow students to have flexibility in their answers. There are no right or wrong answers as long as the students answer the questions. Questions can be modified at the discretion of the Facilitator.

KNOW	LEARN	EVIDENCE	WONDER
What do I know about living and working in space?	**What did I learn about living and working in space based on my research?**	**What evidence do I have that supports what I learned about living and working in space?**	**What am I still wondering about living and working in space?**
NOTE: Have students complete this column before researching about living and working in space.	NOTE: Have students complete this column after researching about living and working in space.	NOTE: Have students complete this column using supporting information from articles, background information research, direct observation, and SME connections.	NOTE: Have students complete this column as they move through the process as a way of documenting ongoing questions.

THE ENGINEERING DESIGN CHALLENGE

You will be using the Engineering Design Process (EDP) to solve the challenge. The following pages will help you guide the students through the Challenge. You will break the students into teams of up to four students and follow each step of the EDP. Please note that both the Facilitator Pages and the Student Journal section are organized to align with the each step of the EDP.

THE CHALLENGE:

In the International Space Station (ISS) and future long-term crewed missions into our solar system, fitness and entertainment are critical to the physical and psychological health of astronauts.

Figure 7: Astronauts show off their skills aboard the International Space Station during the 2014 World Cup. (NASA)

As a team, you will work to design and build a game that astronauts can play in a microgravity environment:

1. The game must be played within a five to ten minute timeframe, and must have clear rules for identifying scoring and determining winners.
2. The focus of the game will be a projectile which is launched, not thrown, toward a goal.
3. The goal must fit within a one meter cube, and must be mountable at 0° (floor), 90° (wall), and 180° (ceiling). This will help to identify and understand the effect of gravity on the game.
4. Three identical copies (in terms of mass, size, or shape) of the designed projectile must be built, each weighing no more than 200 grams.
5. The projectile will be deployed by a launcher towards a goal at least two meters away.
6. The cost of all materials included in the final version of the game (three projectiles, launcher, and goal) is at most $10.00.

MATERIALS

The following is a suggested list of materials needed to complete this challenge. The quantity will depend on the number of students participating. Alternatives can be used if necessary.

- Digital scale or balance (1)
- Measuring tape (1)
- Rulers (1 per team)
- 1-inch strips of hook-and-loop tape
- General building supplies for teams to assemble their game. These could include:

aluminum foil
balloons
skewers or stirrers
binder clips
bubble wrap
buttons or beads
cardboard or cardstock
clothespins
cloth
coffee filters
cotton balls
empty paper towel/toilet paper tubes
glue sticks
mini foil pie plates
modeling clay
paper bags
paper clips
pennies
pipe cleaners
plastic cups
plastic eggs
plastic wrap
craft sticks or tongue depressors
rubber bands
scissors
staplers and staples
straws
string
masking, electrical, transparent and duct tapes

Pre-Activity Set-Up:

- Determine a unit cost for each of the materials available. These values can be raised or lowered to adjust the level of challenge difficulty. Teams should itemize their budget using the Budget Planning Worksheet on page 39.

STEP-BY-STEP FACILITATION INSTRUCTIONS

Introduce the Challenge

Provide students the information covered in the challenge description found on page 15. Use the Challenge Rubric on page 26 in the Student Journal section to show students how their work during this challenge will be evaluated.

The Engineering Design Process Steps with Guiding Questions

STEP 1: Identify the Need or Problem

- Help facilitate learning by asking Guided Questions:
  - How can our team design a _____ that will _____?
  - What needs to be solved/improved?
  - What are we trying to accomplish?
- Review the Engineering Design Process with the students.
- Show the NASA BEST video titled "Repeatability" found at https://www.youtube.com/watch?v=-2Az1KDn-YM.
- Ask team members why it is important to test their own designs.
- Team members should identify the specific criteria and constraints of the design challenge. The game must be played within a five to ten minute timeframe, and must have clear rules for identifying scoring and determining winners. The focus of the game will be a projectile which is launched, not thrown, toward a goal. The goal must be smaller than one cubic meter, and must be mountable at 0° (floor), 90° (wall), and 180° (ceiling), to reduce the game's dependence on gravity. Three identical copies (in terms of mass, size, or shape) of the designed projectile must be built, each weighing no more than 200 grams. The projectile will be deployed by a launcher towards a goal at least two meters away. The cost of all materials included in the final version of the game (three projectiles, launcher, and goal) is at most $10.00.
- Have team members fill out *Step 1: Identify the Need or Problem Worksheet* on page 29 in the Student Journal section.

STEP 2: Research the Need or Problem

- Help facilitate learning by asking Guided Questions:
  - Where can you find more information about the topic?
  - What questions could you ask an expert?
- Help team members answer any questions they have about the challenge. Use the Internet or school library to research answers. Sample resources have been provided in the NASA Resources section on page 41. Any questions that are left unanswered should be written down and saved to ask during the NASA Subject Matter Expert connections.

- Have the team members fill out Step 2: Research the Need or Problem Worksheet, page 30 in the Student Journal section.

STEP 3: Develop Possible Solutions

- Help facilitate learning by asking Guided Questions:
  - What are all the ways your team can imagine to solve this?
  - What do we need to do to add _____ to the design?
  - What might go wrong if we add _____ to the design?
- Each team member is to brainstorm and make sketches representing their ideas for a solution to the design challenge. The students will clearly label and identify each part of their drawing.
- Each team member should make sure that designs meet all constraints and criteria
- Have the team members complete Step 3: Develop Possible Solutions Worksheet page 31 in the Student Journal section.

STEP 4: Select the Best Possible Solution(s)

- Help facilitate learning by asking Guided Questions:
  - Would it be better to _____ or _____?
  - Can we combine more than one plan?
  - Would a _____ fulfill the constraints of the challenge?
  - Do we have the resources to build a _____?
- Each team member in the team is to discuss their ideas and drawings with the rest of the team.
- Each team member is to record the strengths and weaknesses of each of the designs.
- Have each team member fill out Step 4: Develop Possible Solutions Worksheet, page 32 in the Student Journal section.

STEP 5: Construct a Prototype

- Help facilitate learning by asking Guided Questions:
  - What resources does your team need to gather?
  - What is the plan?
  - Who is doing what?
- Each team is to identify the design that appears to solve the problem.
- A final diagram of the design should be precisely drawn and labeled with a key. .
- Each team is to determine what materials they will need to build their design and assign responsibilities for each team member for prototype completion.
- The final drawings should be approved by the facilitator before building begins.
- Teams will receive the materials they will need to build their model and complete a budget sheet representing the cost of their model.
- Using the drawings, the teams are to construct their prototypes.
- Have each team member complete Step 5: Construct a Prototype Worksheet, page 33 in the Student Journal section.

STEP 6: Test and Evaluate the Solution(s)

- Help facilitate learning by asking Guided Questions:
  - How did the prototype perform when tested?
  - Was the design successful?
- Visit each team and test their designs to ensure they fit within the parameters of the challenge constraints. Help students in refining the game rules to be clear.
- Each team assigns a player to test their game three times (once at each of the three mounting positions for the goal – wall, floor, ceiling) using all three projectiles during each test. Student teams will record the duration of the game, as well as end score based on the team's defined scoring. From these tests, teams will determine consistency of the across all three mounting positions.
- During the ceiling tests, for safety, students should not position themselves directly underneath the goal to test their games.
- Have the students fill out pages 34-35 in the Student Journal section.

STEP 7: Communicate the Solution(s)

- Help facilitate learning by asking Guided Questions:
  - What did or did not work? Why?
  - What are the pros and cons of this solution?
- Team members are to document and report the results of their designs. They will identify what changes were made with each iteration of design and what the team believed caused the design to succeed or fail during the tests.
- Have the team members complete <u>row one</u> of the Step 7 Communicate the Solutions(s) Worksheet, page 36 in the Student Journal section.

STEP 8: Redesign

- Help facilitate learning by asking Guided Questions:
  - How did the prototype perform when tested?
  - What did and didn't work?
  - What could be improved in the next iteration of this design?
- Teams are to identify the cause(s) of any problems that were observed during testing. They will consider possible modifications to solve these problems.
- Have teams check that their redesigned model still meets all the criteria to solve the problem.
- Have the student fill out page 37 in the Student Journal section.

From here, the cycle repeats with redefined problems and redesigned solutions as often as time and resources allow. With each additional iteration, and depending on the amount of redesign students put into one iteration, some steps may only need a quick revisit to be sure students are on track, while some steps will need to be completely redone**. <u>In those cases, additional copies of cycle step pages should be made and added into the Student Journal section.</u>**

Submit Final Design

On the last design iteration, the documentation from Step 7 will be used to create a video of the design development and final design solution according to the Video Criteria and Video Rubric found on pages 27-28. Also at this time, use the Engineering Design Process worksheet on page 24 to test student knowledge of the entire design cycle.

STUDENT DEBRIEFING QUESTIONS

Engage the students in a discussion by reviewing all of the data and posing the following questions:

1. What was the greatest challenge or challenges for your team through this process?

2. What strategy or strategies did your team prove effective in overcoming your greatest challenge?

3. How did you use the Engineering Design Process to help you with your design?

4. What considerations did you have to include to make it fun for the astronauts?

5. If you were a referee for your game, would you find it easy to officiate and keep score? Why or why not?

6. How would your game perform aboard a spacecraft on a long-duration mission? What in your game, if anything, would perform differently in microgravity than on Earth?

CHALLENGE CHECKLIST

Prior to the Challenge

Things to download, print, review, and copy:

- ❑ 1. Download and review the Presentation Slides for Students.
- ❑ 2. Download, print, and review the Video Criteria and Rubric. Make a copy for each team of students.
- ❑ 3. Download, print, and review the Educator Guide, Spaced-Out Sports. Print the Student Journal pages for each team of students.
- ❑ 4. Download or bookmark the Introductory Video, Telling Our Story with Video, and any other videos needed for your presentation.
- ❑ 5. Download and review the Technical Requirements for the Video.
- ❑ 6. Download, review, and print the Media Release Form. Make one copy for each student.

Things to schedule, set up, or test:

- ❑ 1. Review the online Event Schedule and select at least one live event for students to interact with a NASA Subject Matter Expert.
- ❑ 2. Gather and organize materials from the Materials List for each activity.
- ❑ 3. Test your technology set-up to make sure students can see and hear videos, slides, etc.
- ❑ 4. Select a suitable and safe area to test and play student games.
- ❑ 5. Check your video or digital cameras to ensure they are fully charged and have enough memory or tape for recording challenge activities.

During the Challenge

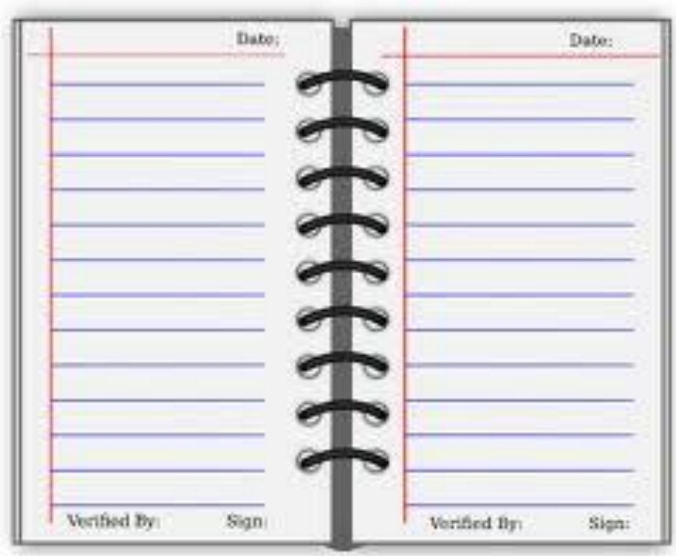
- ❑ 1. Distribute Media Release Form to each participating student and set a due date for return.
- ❑ 2. Ask each group of students to come up with a unique team name.
- ❑ 3. Use the Presentation Slides for Students to lead the students through the challenge.
- ❑ 4. Encourage each group to take pictures and video throughout the challenge to use in their final video.
- ❑ 5. Help students prepare questions and information to share with the NASA Subject Matter Expert for the live event for students.
- ❑ 6. Participate in one or more live events for students.

After the Challenge

- ❑ 1. Review Video Criteria and Rubric and Telling Our Story with Video with students.
- ❑ 2. Assist students as they plan and create their final video.
- ❑ 3. Upload student video submissions.
- ❑ 4. Allow enough time to send a separate email with entry information and media release forms for each video by April 16, 2015.
- ❑ 5. Participate in evaluation of the 21CCLC pilot program.

Student Name: __________________ **Team Name**__________________

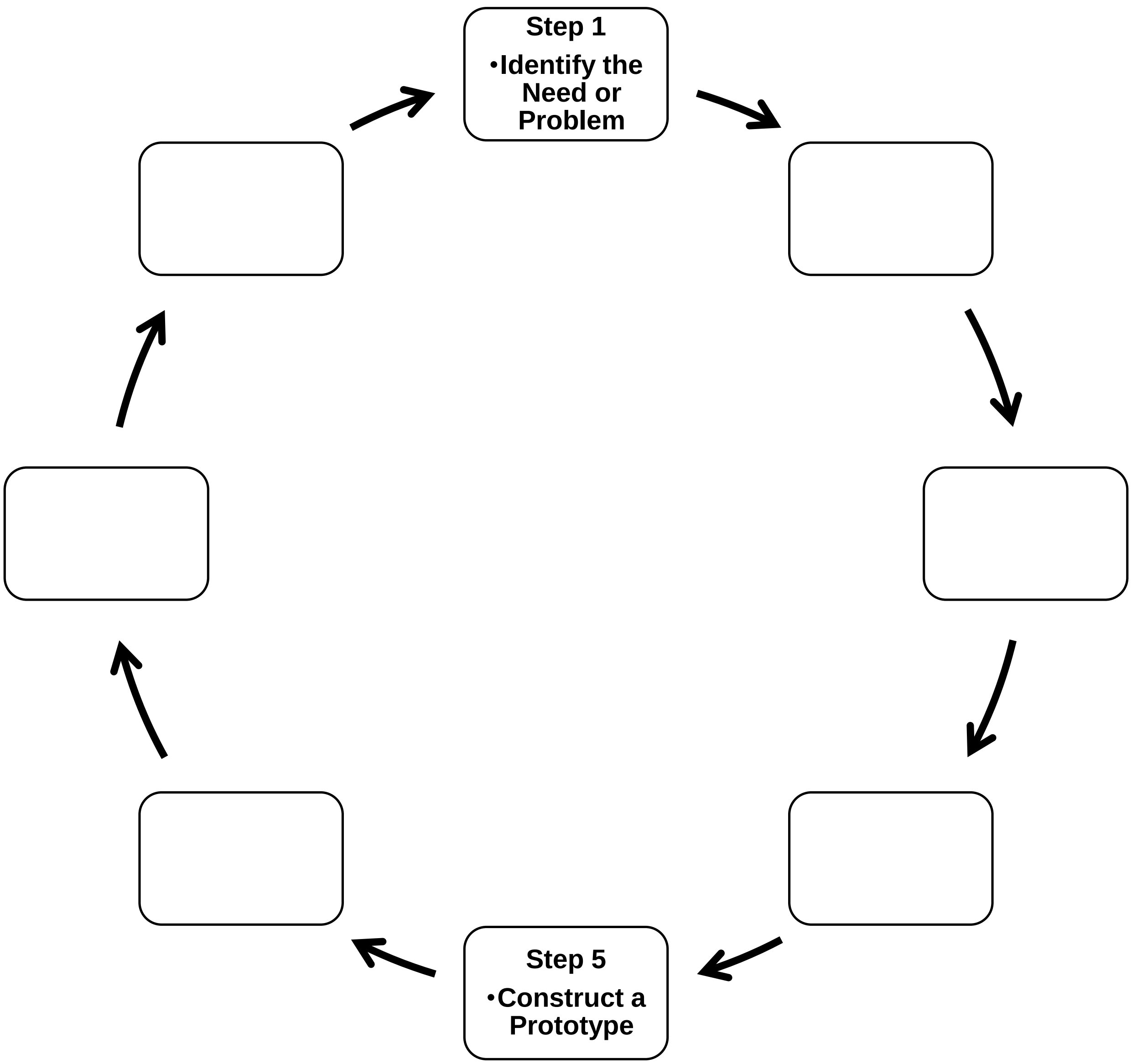
STUDENT TEAM CHALLENGE JOURNAL



ENGINEERING DESIGN PROCESS

Directions for the Students: Can you determine the sequence that engineers take to make a completed design? On your own, try to label the steps of the Engineering Design Process. Put the rest of the steps below in order based on the two that have already been filled in for you.

~~Identify the Need or Problem~~	Select the Best Possible Solution(s)
~~Construct a Prototype~~	Communicate the Solution(s)
Research the Need or Problem	Develop Possible Solution(s)
Test and Evaluate the Solution(s)	Redesign



KLEW CHART FOR STUDENTS

Student Name: ____________________ **Team Name**____________________

This Challenge is: _______________________________

KNOW	LEARN	EVIDENCE	WONDER
What do I know about living and working in space?	What did I learn about living and working in space based on my research?	What evidence do I have that supports what I learned about living and working in space?	What am I still wondering about living and working in space?

CHALLENGE RUBRIC

Use the Challenge Rubric below to assess each team's final design. It may be helpful to have each group explain how they use the Engineering Design Process, Steps 1-8, to create their designs.

Category	Below Target (1)	At Target (2)	Above Target (3)
1. Identifying the Need or Problem	Rephrases the problem with limited clarity and fails to identify criteria or constraints	Rephrases the problem clearly and identifies most criteria and constraints	Rephrases the problem precisely and identifies all criteria and constraints
2. Research the Need or Problem	Need or problem is not well researched and will not be helpful in development of solutions	Need or problem is adequately researched and may assist in development of solutions	Need or problem is thoroughly researched and can easily direct development of solutions
3. Develop Possible Solutions	Contributes implausible ideas or no ideas. Produces incomplete sketches. Does not present a concept	Contributes a plausible idea. Produces marginally accurate sketches of design concepts	Contributes multiple, plausible ideas. Produces accurate sketches of design concepts
4. Selecting the Best Possible Solution(s)	Inadequately analyzes strengths/weaknesses of possible solutions. Does not select a solution based on criteria and constraints of the need or problem	Satisfactorily analyzes strengths/weaknesses of possible solutions. Selects a solution based on some but not all criteria and constraints of the need or problem	Thoroughly analyzes strengths/weaknesses of possible solutions. Selects a promising solution based on thorough analysis of all criteria and constraints of the need or problem
5. Construct a Prototype	Prototype meets the task criteria to a limited extent	Prototype meets the task criteria	Prototype meets the task criteria in insightful ways
6. **Test and Evaluate the Solution(s)**	Data is inaccurately taken or does not reflect performance of the prototype	Data is taken accurately that reflects the performance of the prototype	Accurate data is taken that reflects the performance of the prototype and will clearly aid in redesign
7. **Communicate the Solution(s)**	Both the results of testing are not accurately reported and there is no sharing of areas of improvement	Either results of testing are not accurately reported or there is no sharing of areas of improvement	Results of testing are accurately reported and shares insightful areas for improvement
8. Redesign	Refinement based on testing and evaluation is not evident	Refinements made based on testing and evaluation results	Significant improvement in the design is made based on prototype testing and evaluation

Total Score: ______________________

Team Name: ______________________

VIDEO CRITERIA AND VIDEO RUBRIC

Video Criteria

Video submissions showcase your prototype and the process it took to go from initial design to final solution and should include the following information.

1. Teams MUST use the following script to introduce their video:
    a. "This is team (team name) and we did the 'Spaced Out Sports' challenge. The title of our video is ____________________."
    b. Do not identify the name of any student, teacher, school, group, or city/region in your video. Submissions that do not follow these directions will be disqualified.
1. Introduce special features and unique qualities of your design.
2. Discuss the results of tests from Step 6 and modifications made to improve the device from Step 8 for each design iteration.
3. Based on your results and modifications, explain your best design solution from Step 4. Be sure to give reasons for your choice.
4. Include photos or video of a summary of your work including drawings of your design, key measurements, and how the prototype was built and tested.
5. Identify any information provided by NASA Subject Matter Experts (SMEs) that helped you in your design or testing.
6. Explain which characteristics of your design provided the most reliable results and why?
7. Based on your results and the modifications you recorded in Step 7, include advice for the engineers working on this project in the future.
8. Total length of video should be three to five minutes.

The following Video Rubric will be used by evaluators to review and score each submitted video based on the above criteria and presentation style.

Video Rubric

Student Name: ___________________ **Team Name**___________________

This rubric can be used to review and assess the quality of each video. Each category will be scored 0-3 points. Totals for each column will be added for a final score.

Rubric Category	Best 3 points	Better 2 points	Good 1 point	Missing 0 points
Introduction Statement	Special features are stated clearly with additional words and/or images.	Special features are stated but no additional images are included.	Special feature statement is incomplete.	No statement is included.
Drawings	A detailed drawing of the final design, as well as detailed drawings of each iteration are included.	A detailed drawing of the final design is included, but no other iterations.	Rough drawings of the final designs or other iterations are included.	No drawings are included.
Engineering Design Process	All of the phases of the Engineering Design Process are mentioned.	More than four elements of the Engineering Design Process are mentioned.	At least one element of the Engineering Design Process is mentioned.	No mention of the engineering design process is included.
NASA Subject Matter Expert (SME) Comments	Interactions with NASA SMEs are discussed and show how the feedback was incorporated into design or testing.	Interactions with NASA SMEs are discussed and gives details about the feedback they provided.	Interactions with NASA SMEs are discussed in only general terms.	No mention of NASA SME interactions are included.
Video Criteria	All criteria are addressed thoroughly and thoughtfully.	Criteria are addressed.	Some criteria are addressed.	No criteria are addressed.
Photos or Video	Video of the build and test phases are included with additional still shots added.	The build and test phases are included in the photos/video.	Only the build *or* only the test phase is included in the photos/video.	No photos or video showing the build or test phases are included.
COLUMN SCORE				

Total Score: ______________________

STEP 1: IDENTIFY THE NEED OR PROBLEM

The Challenge:

In the International Space Station (ISS) and future long-term crewed missions into our solar system, fitness and entertainment are critical to the physical and psychological health of astronauts.

Figure 8: Astronauts show off their skills aboard the International Space Station during the 2014 World Cup. (NASA)

As a team, you will work to design and build a game that astronauts can play in a microgravity environment. The game must be played within a five to ten minute timeframe, and must have clear rules for identifying scoring and determining winners. The focus of the game will be a projectile which is launched, not thrown, towards a goal. The goal must fit within a one meter cube, and must be mountable at 0° (floor), 90° (wall), and 180° (ceiling). This will help to identify and understand the effect of gravity on the game. Three identical copies (in terms of mass, size, or shape) of the designed projectile must be built, each weighing no more than 200 grams. The projectile will be deployed by a launcher towards a goal at least 2 meters away. The cost of all materials included in the final version of the game (3 projectiles, launcher, and goal) is at most $10.00.

Based on this information and the challenge introductory video, answer the following questions.

1. Using your own words, restate the problem in the form of “How can I design a ___________ that will ___________?” Be sure to include all expected criteria and constraints.

2. What general scientific concepts do you and your team need to consider to begin solving this need or problem?

STEP 2: RESEARCH THE NEED OR PROBLEM

Conduct research to answer the following questions related to the challenge problem. Cite where you found your information on the line labeled "Source(s)."

1. Who is currently working on this or a similar problem today? What solutions have they created or are working on currently?

Source(s):

2. What questions would you ask an expert who is currently trying to solve problems like this one?

3. Who in our society will benefit from this problem being solved? How could this relate to everyday uses in society?

Source(s):

4. What are some innovative options for using the materials that are available to solve this challenge?

Source(s):

STEP 3: DEVELOP POSSIBLE SOLUTIONS

Sketch your “Spaced-Out Sport” in the space below. Label each part of your drawing. Consider the following questions when brainstorming your ideas.

What features and rules will your game design have?
Will your game work if your goal is mounted to the floor? The wall? The ceiling?
How will you construct your projectiles to be identical?
How will your launcher consistently deploy the projectile?

STEP 4: SELECT THE BEST POSSIBLE SOLUTION(S)

Work with your team to analyze each person's final drawing using the table below. Based on the team's discussions, determine which design will be used to solve the problem, and what features will be included to create team's prototype.

Design # Designer Name	Does this design meet all criteria and constraints of the problem?	What are the strong elements of this design?	What elements need to be improved?
1.			
2			
3			
4			

STEP 5: CONSTRUCT A PROTOTYPE

1. Make a final drawing of your prototype. Have it approved by your facilitator.

Approved by: ____________________________________

What are the resources that will need to be gathered?

____

____

____

____

Who in the group is doing what?

Team Member				
Responsibilities in the building process?				

STEP 6: TEST AND EVALUATE THE SOLUTION(S)

Report the following information:

Property	Constraint	Measured/Calculated
Mass of Each Projectile	Less than 300 g	Projectile 1: Projectile 2: Projectile 3:
Goal Dimensions	Fits within 1 m cube	Length: Width: Depth:
Cost	Less than $10.00	

Start by testing the launcher, the projectiles, and the target in three target mounting positions:

- **0° (floor)** – Mount the target on the floor, facing up.
- **90° (wall)** – Mount the target on the wall, facing out.
- **180° (ceiling)** – Mount the target on the ceiling, facing down.

Assign one team member to be the "player." This person will using the launcher to shoot each projectile three times, attempting to score based on the rules of your game. A second team member, designated as the "scorer" will record the score of each shot and calculate the mean average. A third team member can assist in retrieving projectiles and returning them to the player.

Complete the table below to record the performance of the assembled shield design. Rank the materials according to the scale shown below.

Mounting position	Projectile 1 score	Projectile 2 score	Projectile 3 score	Mean score
0° (floor)				
90° (wall)				
180° (ceiling)				

Based on your data, describe the construction of your launcher in terms of consistency.

____

____

Based on your data, describe the construction of your projectiles in terms of consistency.

____

____

Based on your data, describe the construction of your goal in terms of consistency.

____

____

If your team determines that there are issues with the equipment, skip the remaining testing for this iteration and move on to "Step 7: Communicate the Solution(s)." If your team feels that the game is ready, play a full game according to the rules your team created.

Evaluate your game by completing the table below.

Property to Test	Description of the Test	Rank (0 worst - 5 best)	Observations of Game
Entertainment	Would astronauts find this game fun?		
Exercise	Would astronauts consider this game exercise?		
Adaptation to Space Environment	Would this game work in space?		
Rules and Scoring	Is the game easy to play and fair?		

How long did the game last? _________ Did it meet the 5-10 minute criteria? _________

STEP 7: COMMUNICATE THE SOLUTION(S)

It is not enough to simply produce raw data. Scientists and engineers need to interpret the data so that they can convince others that their results are meaningful. This step will help you summarize how your design changed through multiple iterations of the engineering design process. Start by filling out the table about your initial prototype.

Iteration #	What are the key components to your initial prototype?	What do you think caused the design to succeed or fail during testing and why do you think that?
1		

All modifications to your design, both major overhauls and minor tweaks, should be recorded below to track the changes made. After every phase of tests, complete the chart below by describing changes and summarizing what results the testing showed.

Iteration #	What was added, removed, or changed in this iteration of your design?	What do you think caused the design to succeed or fail during testing and why do you think that?
2		
3		
4		
5		

STEP 8: REDESIGN

Did this iteration of your design meet all of the constraints of the original problem? ___________

What problem(s) did you discover while testing this iteration?

____

____

____

____

____

____

What will you do to try to improve your design based on this data?

____

____

____

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____

How do you predict that these changes will improve over the iteration you just tested?

____

____

____

____

____

____

STUDENT DEBRIEFING QUESTIONS

Engage the students in a discussion by reviewing all of the data and posing the following questions:

1. What was the greatest challenge or challenges for your team today?

2. What strategy or strategies did your team prove effective in overcoming your greatest challenge?

3. How did you use the Engineering Design Process to help you with your design?

4. What considerations did you have to include to make it fun for the astronauts?

5. If you were a referee for your game, would you find it easy to officiate and keep score? Why or why not?

6. How would your game perform aboard a spacecraft on a long-duration mission? What in your game, if anything, would perform differently in microgravity than on Earth?

BUDGET PLANNING WORKSHEET

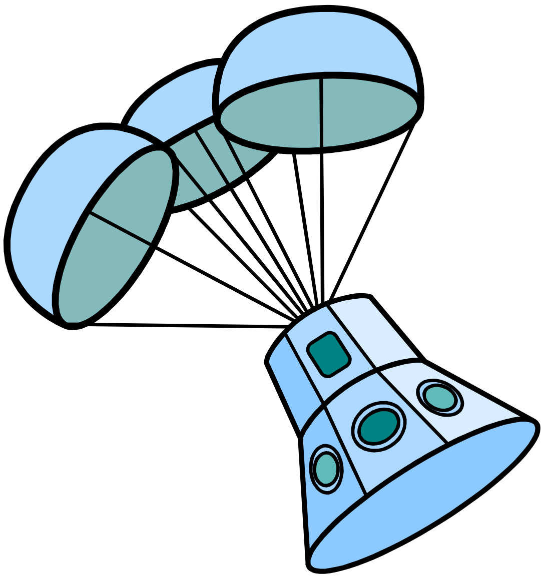
Team Name: ___________________

Directions: As a team, complete the cost sheet below. Be sure to include all of the materials that are needed, quantity, unit cost (determined by your facilitator), and the final total to complete your design. Try to use the least amount of materials to keep the cost of your design low.

Line Item Number	Material	Unit Cost	Quantity	Item Total
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

TOTAL COST ____________

SUPPORT MATERIALS



NASA RESOURCES

Videos

Spaced-Out Sports career videos (playlist)
http://education.ssc.nasa.gov/sos_videos.asp

ReelNASA - Train like an Astronaut series (playlist)
https://www.youtube.com/playlist?list=PLTXQuaxXBKKzO9TicHf0ApIsiVTjndqf_

Websites

NASA's Exercise Physiology and Countermeasures (ExPC) Project
http://spaceflightsystems.grc.nasa.gov/SOPO/ICHO/HRP/ExPC/

Train like an Astronaut with Mike Hopkins
http://www.nasa.gov/content/train-like-an-astronaut-with-mike-hopkins/#.VJGe9yvF81I

"Spaced Out Sports" poster and bookmark
http://education.ssc.nasa.gov/pdf/Spaced_Out_Sports/Spaced_Out_Sports_Poster.pdf
http://education.ssc.nasa.gov/images/spacedoutsports/SOSbookmarkfront.jpg
http://education.ssc.nasa.gov/images/spacedoutsports/SOSbookmarkback.jpg

NASA's Do-It-Yourself (DIY) Podcast - Sports Demo
http://www.nasa.gov/audience/foreducators/diypodcast/sd-video-index-diy.html

For more information and to access the Help Desk, visit the 21CCLC NASA STEM Challenge website at http://y4y.ed.gov/stemchallenge/nasa.

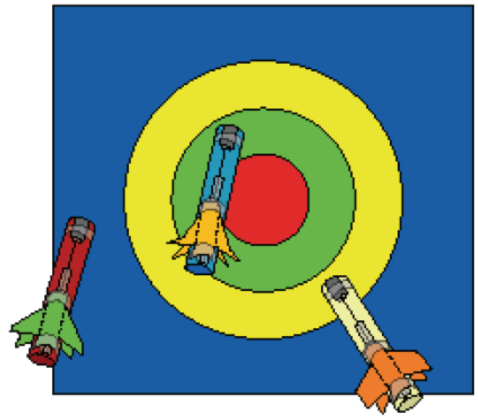
EXTENSION ACTIVITY

Javelin Rockets

Objectives:

Students will:

- construct and fly paper rockets with hook-and-loop-covered nose cones
- investigate launch angle versus distance with their rockets
- compete in a rocket javelin sports event



Javelin Rocket game illustration.

Preparation:

Obtain and cut 38.1 cm (15-inch) lengths of 1.27 cm (1/2)" PVC pipes, one for each student. A PVC cutter from hardware stores is recommended, but a fine-tooth saw and sandpaper will work, as well. Also, prepare a felt target.

Materials:

- 38.1 cm (15-inch) lengths of 1.27 cm (1/2-inch) PVC pipe (One per student)
- One rocket pattern on copy machine paper, per student
- Scissors
- Cellophane tape
- Rulers
- Felt target (see instructions below)
- Two- to three-inch hook-and-loop strips (adhesive-backed strips or strips for sewing can be used)
- Marker pens or crayons for decorating rockets (optional)
- Meter stick or tape measure for measuring flight distances
- 30.5 cm (12 inches) of string or thread
- Small metal washer or nut

Management Tips:

Students will use the PVC pipe as construction forms for building their rockets. They will also use the pipe for launching their rockets by blowing through the end. Because of the low cost of PVC pipe, it is recommended that one pipe segment should be made for each student with their names written on them. Otherwise, pipes will have to be disinfected with a good cleansing and sanitizing agent between uses.

Some students may have trouble generating enough wind power to launch their rockets. Have them practice blowing through the pipes. Tell them to inflate their cheeks with lips closed to build up pressure inside their mouths, and then sharply puff through the tube.

Have students practice launching their rockets at different angles in an open space, such as a gym, cafeteria, or outside. Let them discover the relationship between angle and distance. After students have explored launching their rockets informally, have students diagram what happens at different trajectories. Discuss their conclusions and other factors that might affect the flight of their javelins and then start the rocket javelin competition.

Making the Target

Obtain a large piece of felt from a fabric store. Felt is available in 183 cm (72-inch) bolts. Buy some smaller pieces of different colors for making the rings. Use fabric glue or stitching to hold the rings and bull's-eye in place. Mount the target loosely against a wall. Allowing the target to hang free provides some cushioning for the rockets and better gripping of the hook-and-loop tips.

Procedure: Building javelin rockets

1. Set up a supply area for paper and tools.

2. Review the procedure for making javelin rockets. The diagram to the right shows the construction steps.

3. Have students cut their sheets of paper in half across the middle to make two sheets 21.5 cm (8.5 inches) by 14 cm (5.5 inches) in size. One sheet will be used to roll the rocket body, and the other will be used for making rocket fins.

4. Encourage students to design their own fins. Shapes for fin ideas are shown. The rectangular shape between the different fin shapes has been scaled and does not match the paper tube.

5. Conduct a preflight checkout. Make sure that the front end of the rocket is closed and that the hook-and-loop material is mounted securely with cellophane tape across the nose cone. If you are using adhesive-backed strips, it may not be necessary to use tape as well, but tape will help the hook-and-loops strips to stay in place.

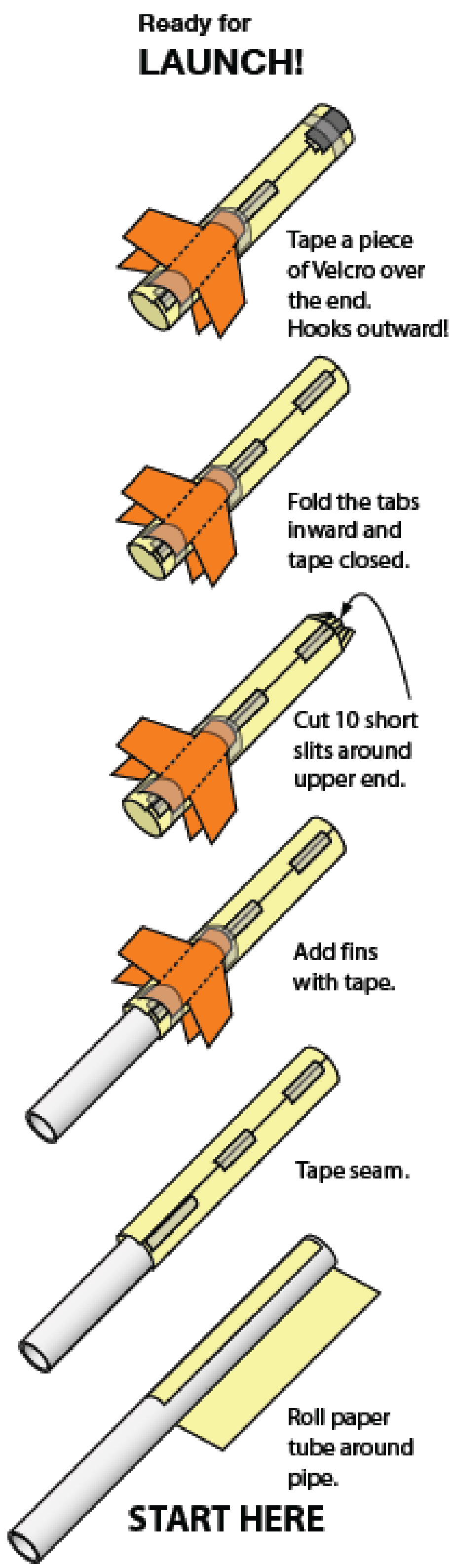
6. Select an open area to test the rocket javelins. Caution students about aiming their rockets. They must not shoot their rockets at each other. Set up a firing line behind which all students must stand. Remind students to take notes on their data sheets. After all rockets have been fired, students may retrieve them. Remind students to try different launch angles and compare the angles to the distances the rockets fly.

7. Allow students to modify the fins on their rockets. They may wish to reduce their size or change their shape.

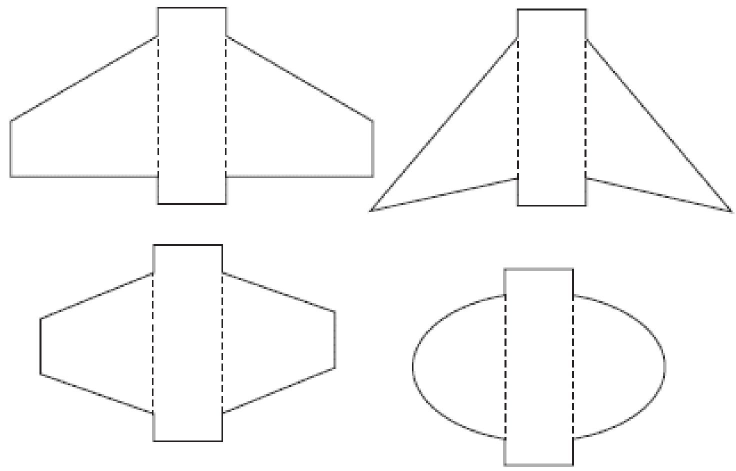
8. When all students are proficient with their rockets, then it is time to hold the javelin rocket event. Have students create the basic rules (e.g., how far away the target is, a point scoring system, how many tries per person, etc.).

9. Hold the javelin rocket event and have the winners share their secrets - design of their rocket, aiming strategy, etc.

Ideas for rocket fin shapes.



Ideas for Rocket Fin Shapes
Samples not drawn to scale.



Assessment:
Collect student data sheets.

Discussion Questions:

Is there a relationship between the launch angle and the distance the rockets flew? Explain
Assuming students used the same force to launch their rockets each time, the answer is yes. Through trial and error, rockets launched at a 45-degree angle will fly the farthest. Rockets launched at a lower angle will be drawn to the floor by gravity before they have gone very far. Rockets launched at a higher angle will use up some of their momentum opposing gravity and will land closer to the launch site.

Will rockets travel farther across the surface of the moon or Mars if the same launch force is used? Explain.
Yes. There are three reasons for this. First, the rockets will fall more slowly on the moon or Mars because their gravity is not as strong as Earth's. Second, both bodies are much smaller than Earth. Although each is round, the curvature of Earth is flatter than that of the moon or Mars. A well-launched rocket javelin on the moon or Mars will fly over the horizon and have farther to go before hitting the surface. Third, the moon doesn't have an atmosphere and the atmosphere of Mars is about 1/100 the density of Earth's atmosphere, at sea level. With little or no atmosphere, atmospheric drag is eliminated and greater distances are possible.

If rocket javelins were flown inside the International Space Station, how would they be aimed to hit the target? Explain.
The ISS and astronauts inside it are traveling together on a curved path that enables them to orbit the Earth. Because of this, a rocket javelin launched down the length of the ISS modules would appear to travel in a straight line. This requires a mental adjustment. On Earth, rocket javelins have to be aimed above the target because gravity causes the rocket to fall towards the ground. With just the right direction and speed, the rocket arcs to the target. In orbit, the illusion of traveling in a straight line means that you have to aim directly at the target.

Javelin Rocket Student Name: ________________

1. Design and build your javelin rocket.
2. Follow the steps provided by your teacher to make the rocket body.

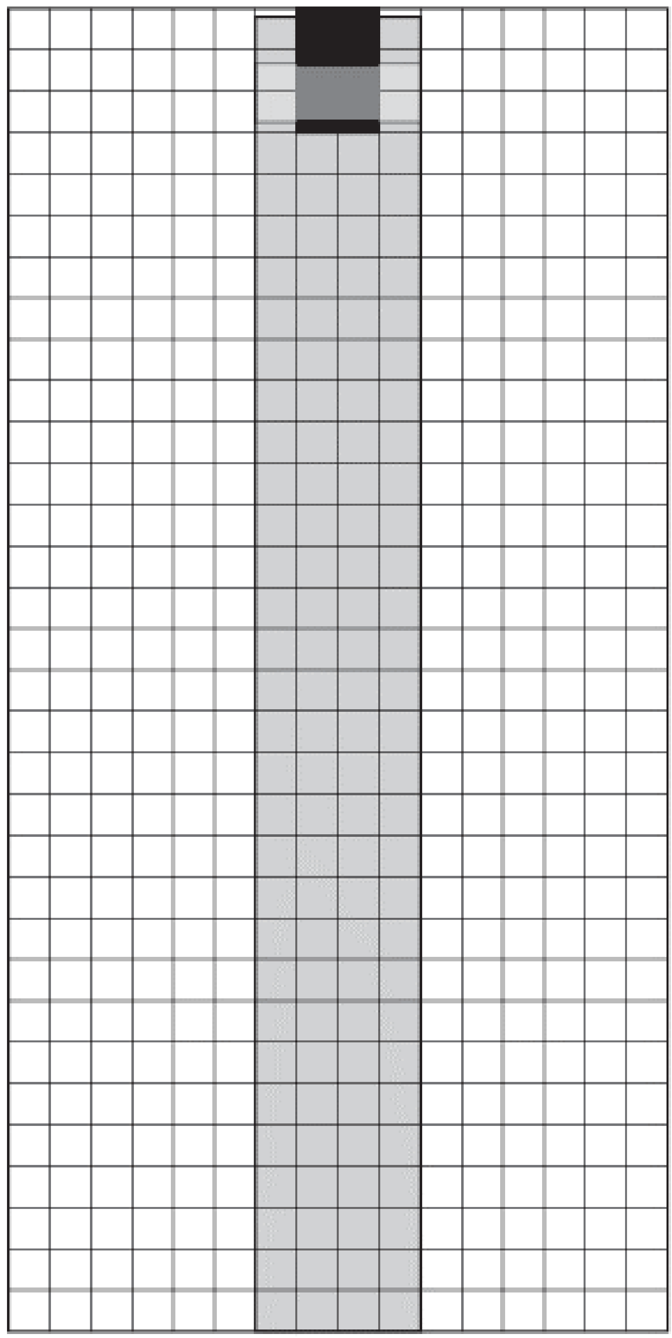
   This is the long tube. One end of the tube will be closed off with tape, and a hook-and-loop strip will be taped over that end.
3. Decide what kinds of rocket fins you want your javelin rock to have.

   Draw a picture of what you want them to look like.
4. Make your fins and tape them to the lower end of the rocket.

   If you want to change the shape of the fins, use the scissors to trim them.

Your rocket is ready to fly!

Front end of Javelin Rocket with Velcro held with tape.



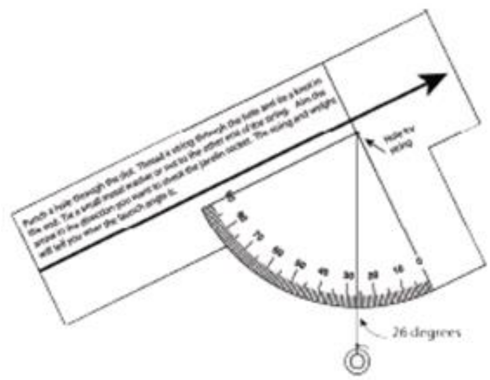
Fins go on this end of the rocket.

Javelin Rocket Student Name: ________________

Practice Record

Test Flights – Launch Angle and Distance

Launch your rocket several times. Use the same amount of force each time. Estimate your launch angle using the quadrant sighting device.



Write the angle below and measure how far your rocket traveled. Measure to the point where the rocket hit the floor and not to where the rocket slides or bounces.

Which launch angle worked best?

Launch Angle	Flight Distance

Using the space below, describe how your rocket flew (it flew straight, it curved, it spun, etc.) Did you do anything to make it fly better?

____

____

____

____

Javelin Rocket Competition Record

Try to hit the target with your javelin rocket. Use your practice flights to determine which launch angle will send your rocket to the bulls-eye.

Use the space below to describe your results (on target, dead center, missed, close, etc.).

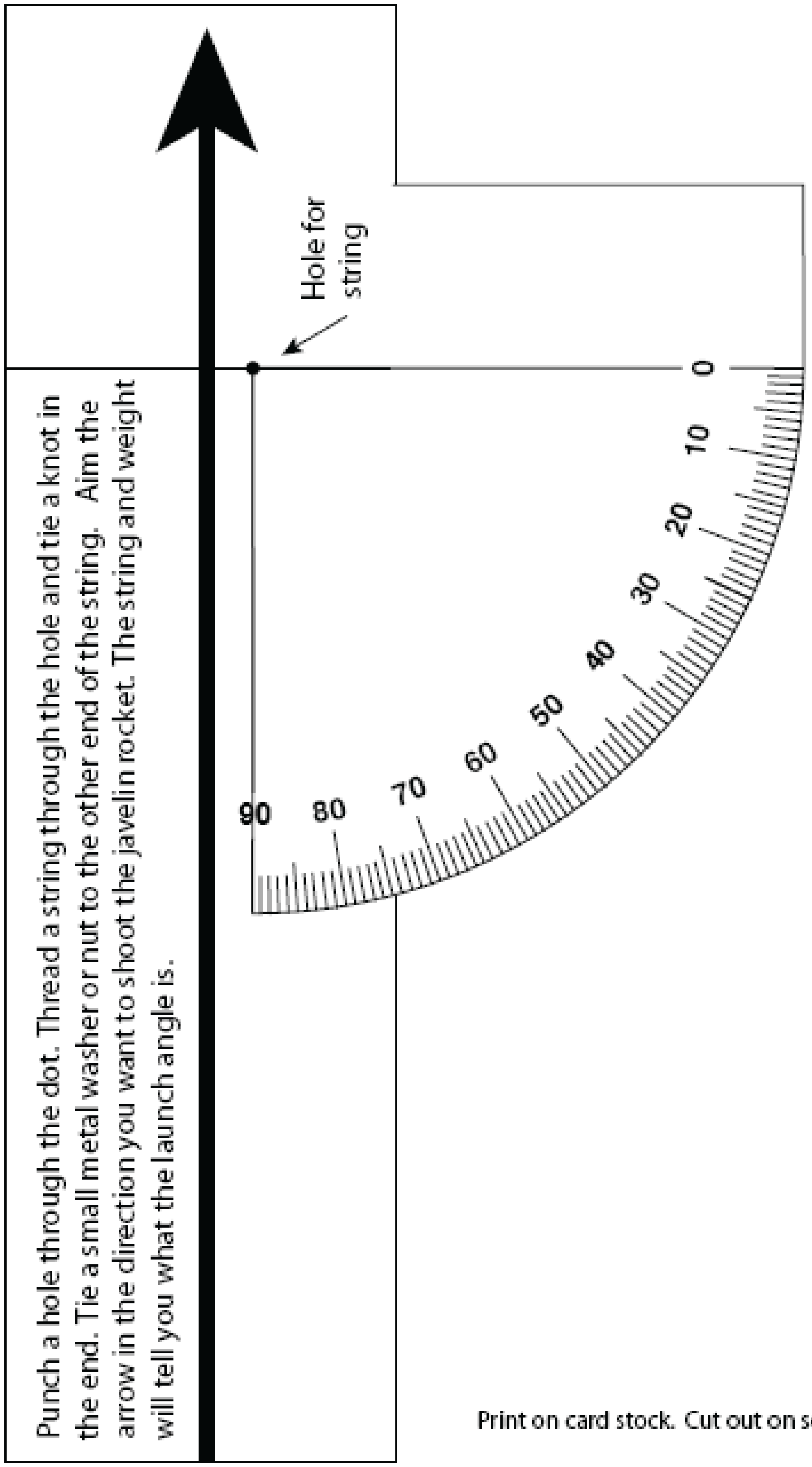
____

____

____

____

Javelin Rocket   Student Name: ________________



Print on card stock. Cut out on solid lines.

GLOSSARY OF TERMS

Acceleration – the rate by which an object changes its velocity with time (See Velocity)

Balanced Force – a force acting on an object that exactly balances another force acting on that same object from the opposite direction. (e.g., gravity pulling on you while your muscles and bones act in the opposite direction enabling you to stand)

Center of Mass – the average position of all of the mass of an object (also called the balance point)

Constraints – the limits placed on the design due to available resources and environment

Criteria – standards by which something may be judged or decided

Drag – forces, such as air friction, acting in the opposite direction from the force propelling the object. (e.g., gravity causes a person to fall, but a parachute provides drag that slows the fall to a safe velocity)

Force – a push or a pull

Friction – forces that resist the motion of an object through the air or across a surface

Gravity – the attraction between objects due to their mass

Inertia – the property of an object that causes it to resist a change in motion

Iteration – one cycle of a repetitive process

Mass – the amount of matter contained in an object

Microgravity – an environment created by freefall in which gravity's effects are greatly reduced

Moment of Inertia – the principle of inertia applied to rotating objects (See inertia)

Momentum – the mass of an object times its velocity (inertia in motion)

Newton's Laws of Motion – Three laws that describe the motion of objects

1. Objects continue in a state of rest or motion in a straight line unless acted upon by an unbalanced force.
2. The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to the mass of the object.
3. Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.

Neutral Buoyancy – a condition of an object in a fluid, such as water, where all the forces on that object are balanced, and the object neither rises nor sinks (e.g., an astronaut in a water tank practicing spacewalks)

Prediction – the act of attempting to tell beforehand what will happen

Template – a pattern used to guide in making something accurately

Unbalanced Force – a force acting on an object that causes it to move (a force not balanced by an opposing equal force)

Velocity – the speed and direction of a moving

"The most important thing we can do
is inspire young minds and to advance the kind of science, math and technology education that will help youngsters take us to the next phase of space travel."

Senator John H. Glenn, Jr.,
NASA Astronaut and United States Senator

National Aeronautics and Space Administration

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