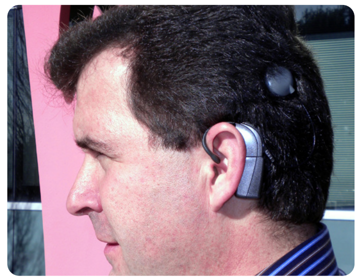
National Aeronautics and Space Administration

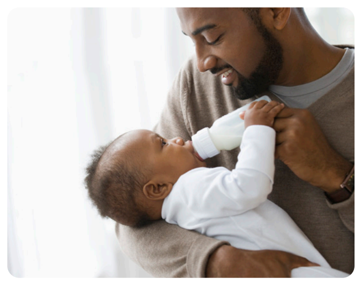
NASA Technology Spinoff Challenge

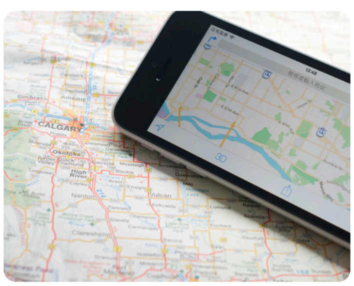
Educator Guide

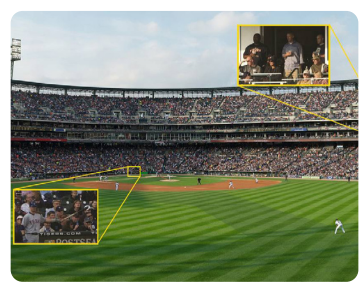










CROSS-DISCIPLINARY, ENGINEERING DESIGN

Next Gen STEM SPARX

For more about Next Gen STEM visit https://www.nasa.gov/learning-resources/for-educators/

Education Product	
Educators and Students	Grades 9-12

Contents

Preface

NASA SPARX (Sparking Participation And Real-world eXperiences in STEM) is an opportunity for pre-college youth and educators to engage with NASA's missions. SPARX uses evidence-based education practices to connect NASA with formal and informal educators and broaden student participation, especially in underrepresented communities. Using NASA-based themes and educational resources, participants will learn about NASA and STEM while creating projects to showcase their learning and engage with the Artemis Generation. SPARX activities are hands-on, standards-based, authentic learning experiences designed to provide opportunities for students to improve their STEM identity, connect with NASA work and missions, and receive recognition for the work they are doing.

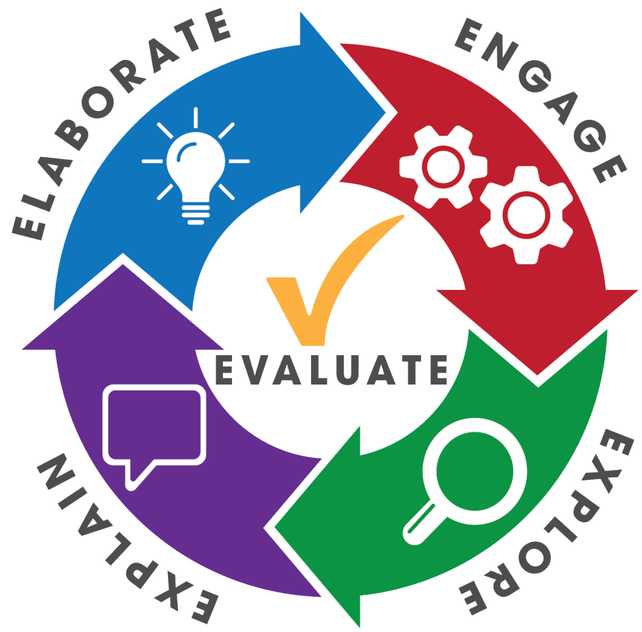
NASA's Office of STEM Engagement published the NASA SPARX Spinoff Challenge Educator Guide as part of a series of educator guides to help high school students reach their potential to join the next-generation STEM workforce. These activities can be used in both formal and informal education settings as well as by families for individual use. They are suitable for a variety of learners and adaptable for use with whatever resources you have available. Feel free to adjust the activities to better meet the needs of your participants. Each activity is aligned to national standards for science, technology, engineering, and mathematics (STEM), and the NASA messaging is current as of January 2023.

STEM EDUCATION STANDARDS

The STEM disciplines matrix below aligns each activity in this module to standards for teaching STEM according to primary focus areas within each discipline. The focus areas for science were adapted from the **Next Generation Science Standards (NGSS)**. The focus areas for technology were adapted from the **International Society for Technology in Education (ISTE)** Standards for Students. The focus areas for 21st century skills were adapted from the **Partnership for 21st (P21) Century Learning**. The focus areas for English and language arts were adapted from the **Common Core State Standards (CCSS)** for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects standards for grades 6-12.

Activity	Standard Areas													
	Science & Engineering			Technology					21st Century Skills			English/ Language Arts		
	Next Generation Science Standards			ISTE Standards for Students					P21 Framework			Common Core Standards		
	Engineering, Technology, and the Application of Science	Science & Engineering Practices	Crosscutting Concepts	Empowered Learner	Knowledge Constructor	Creative Communicator	Innovative Designer	Global Collaborator	Learning & Innovation	Life & Career Skills	Information, Media, and Technology Skills	Speaking & Listening	Literacy in Scientific & Technical Subjects	Reading Informational Text
Explore NASA Spinoffs				✓	✓	✓			✓	✓	✓	✓	✓	✓
Propose a Spinoff	✓	✓				✓			✓	✓		✓	✓	
Propose a Spinoff	✓	✓	✓			✓	✓	✓	✓	✓				

5E INSTRUCTIONAL MODEL



The 5E instructional model is a constructivist learning cycle that helps students build their own understanding from experiences and new ideas. This five-stage model was originally developed for the "**Biological Science and Curriculum Study (BSCS) Life and Living**" curriculum. Learn more about the 5E instructional model with **NASA's eClips**.

ENGAGE: Pique students' interest while pre-assessing prior knowledge. Students make connections between past and present learning experiences, which sets the groundwork for upcoming activities.

EXPLORE: Get students involved in the activity by providing them with a chance to build their own understanding. Students usually work in teams during this stage, which allows them to build a set of common experiences through sharing and communicating.

EXPLAIN: Provide students with an opportunity to communicate their understanding of what they have learned so far. Students at this stage can communicate what they have learned by introducing vocabulary in context and correct or redirect misconceptions.

ELABORATE: Allow students to use their new knowledge and explore its implications. Students expand the concepts they have learned, make connections, and apply their understanding in new ways.

EVALUATE: Determine how much learning and understanding has taken place. Students can demonstrate their learning through journals, drawings, models, and other performance tasks.

PROBLEM-BASED LEARNING PROCESS

In the problem-based learning process, the roles and responsibilities of educators and learners are different than in a traditional classroom setting. The educator acts as a facilitator by providing students with problems to work on, assisting them in identifying and accessing the materials or equipment to solve the problems, giving necessary feedback and support, and evaluating students' participation. Learn more about the **problem-based learning process**.

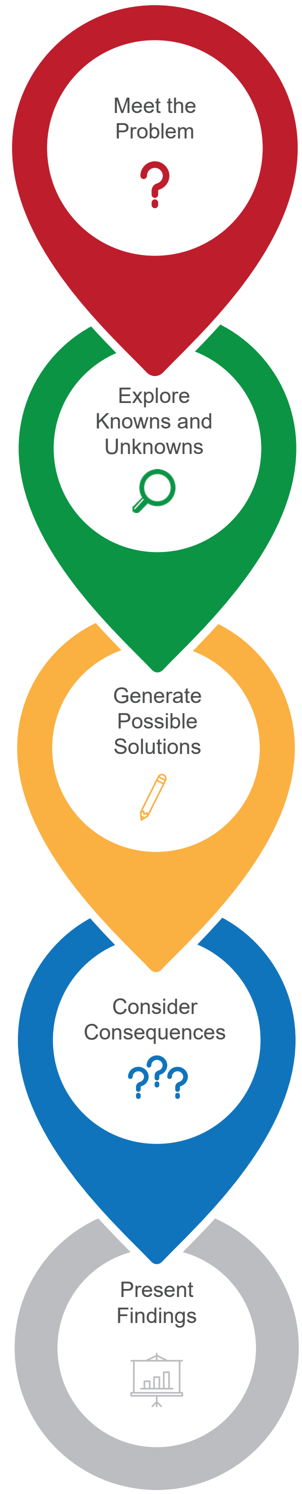
MEET THE PROBLEM: Identify the problem, introduce new vocabulary, and discuss previous experiences with the problem.

EXPLORE THE KNOWNS AND UNKNOWNS: Use resources to explore the knowns and unknowns.

GENERATE POSSIBLE SOLUTIONS: Brainstorm possible solutions based on resources and prior experience with the problem.

CONSIDER CONSEQUENCES: Examine the pros and cons of each solution to determine a viable solution.

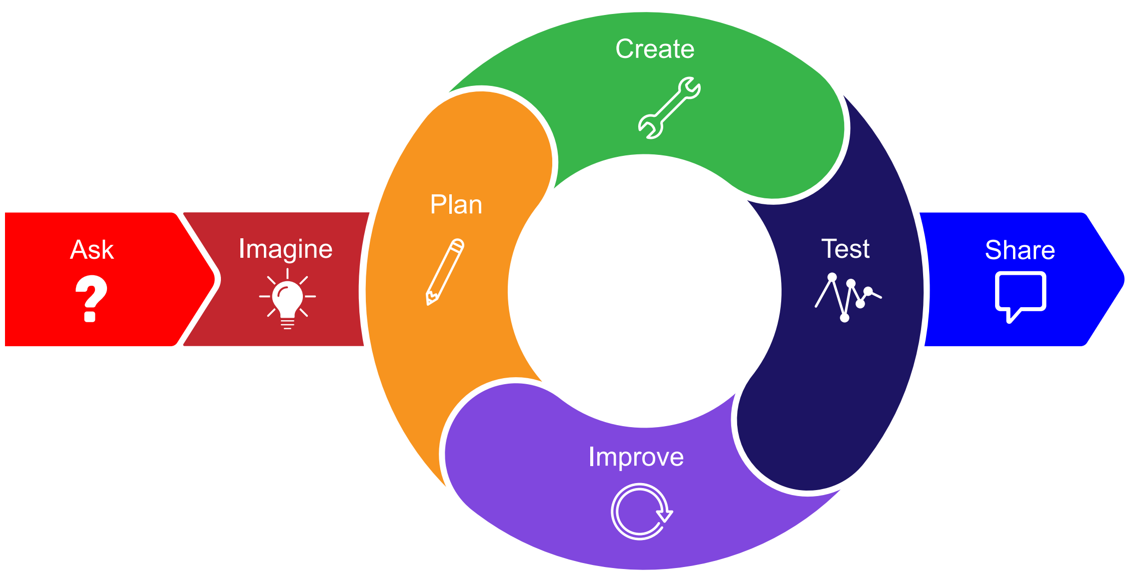
PRESENT FINDINGS: Communicate and discuss the process and solutions as a team.



ENGINEERING DESIGN PROCESS

The Engineering Design Process (EDP) is crucial to mission success at NASA. The EDP is an iterative process involving a series of steps that engineers use to guide them as they solve problems. Students can use the seven steps outlined below for many of the activities in this guide. **Learn more about the EDP** with astronauts Tom Marshburn and Matthias Maurer aboard the International Space Station.

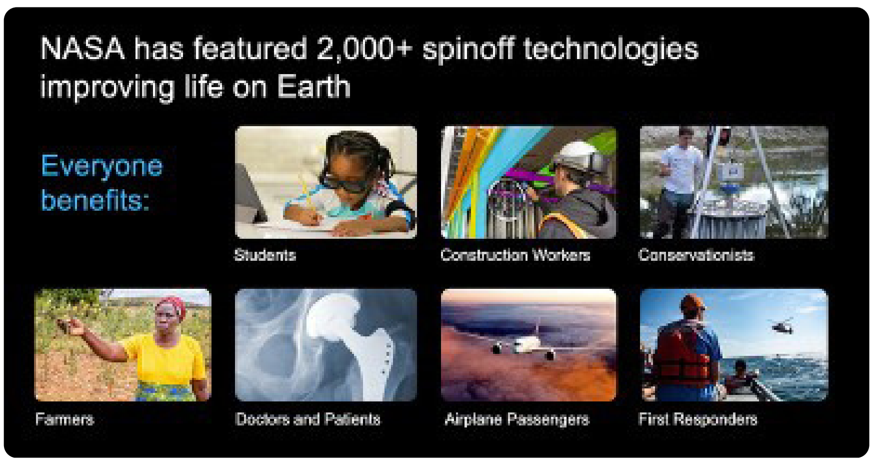
- **ASK:** Identify the problem, the requirements that must be met, and the constraints that must be considered.
- **IMAGINE:** Brainstorm solutions and research what others have done in the past.
- **PLAN:** Select and sketch a design.
- **CREATE:** Build a model or a prototype.
- **TEST:** Evaluate solutions by testing and collecting data.
- **IMPROVE:** Refine the design.
- **SHARE:** Communicate and discuss the process and solutions as a group.



Curriculum Connection

The NASA SPARX Spinoff Challenge could align with any NASA mission directorate and nearly any high school science curriculum. The challenge encourages innovation and application of science, technology, engineering, and mathematics (STEM), including the engineering design process. NASA spinoff technologies apply to all areas of life on Earth. It's up to each of us to find new and innovative ways to use these technologies to solve problems in our communities. Here are just a few examples of topics to explore:

- Anatomy and Physiology – **Temperature-controlling material** relieves symptoms of menopause
- Astronomy – Telescope mirror technology **improves eye surgery**
- Biology – Space radiation research **fights cancer** on Earth
- Chemistry – Safely **detoxifying soil and groundwater** with NASA technology
- Computer Science – **Learn to code** with NASA data
- Earth Science – Sensors on airplanes **measure snowpacks** in mountains to calculate the water they contain
- Environmental Science – NASA satellite data and climate modeling produce a **high-tech Farmer's Almanac** for everyone
- Marine Science – Acoustical pinger used to **safeguard porpoises** from net entanglement
- Oceanography – Satellite-respondent **buoys identify ocean debris**
- Physics – **High-performance lasers** advance autonomous vehicles, next-generation communications, and quantum computing
- Zoology – NASA technology aids **wildlife conservation**



Explore NASA's Space Technology Mission Directorate (STMD) at **https://www.nasa.gov/spacetech/**.

Teamwork

Everyone is a scientist and an engineer! It is important that everyone on the team be able to participate and contribute throughout these activities. If one student does all the building, the other students may be very bored during the building process. If one student is the leader, other students may not have a chance to share their ideas. Here are some possible roles that students can take:

Student Role	Description
Communications and Outreach	Takes notes on all team decisions and actions for use in a final presentation. If a camera is available, takes video and/or photos throughout the investigation or challenge for use in a final presentation.
Logistics	Makes sure that the team has all the resources they need, that resources are distributed fairly, and that the team knows when resources are running low.
Mission Assurance	Makes sure the team is following the plan. Keeps track of time and makes sure that everyone has a chance to have their voice heard.
Safety	Ensures all team members are wearing their safety goggles and following safety protocols.
Graphic Design	Creates drawings, diagrams, graphs, and other imagery to help the team plan and present ideas.
Human Capital	Ensures that all team members are contributing and have an opportunity to contribute.
Business Model	Answers fundamental questions about the problem you are going to solve, how you will solve it, and the growth opportunity within a given market. Identifies startup costs, expenses, and projections of revenue.

Introduction and Background

Technology drives exploration. On Earth and in space, NASA is developing, testing, and flying transformative capabilities and cutting-edge technologies for a new future of human and robotic exploration. NASA researchers take emerging technologies and mature them, delivering innovative solutions that can improve our capabilities to explore, save lives, and create economic growth.

NASA Spinoffs

NASA will continue to evolve technologies like advanced solar electric propulsion, large-scale solar sails, new green propellants, and composite cryogenic storage tanks for refueling depots in orbit. These **new space technologies** will spawn new knowledge and capabilities to sustain our future missions.

Spinoff

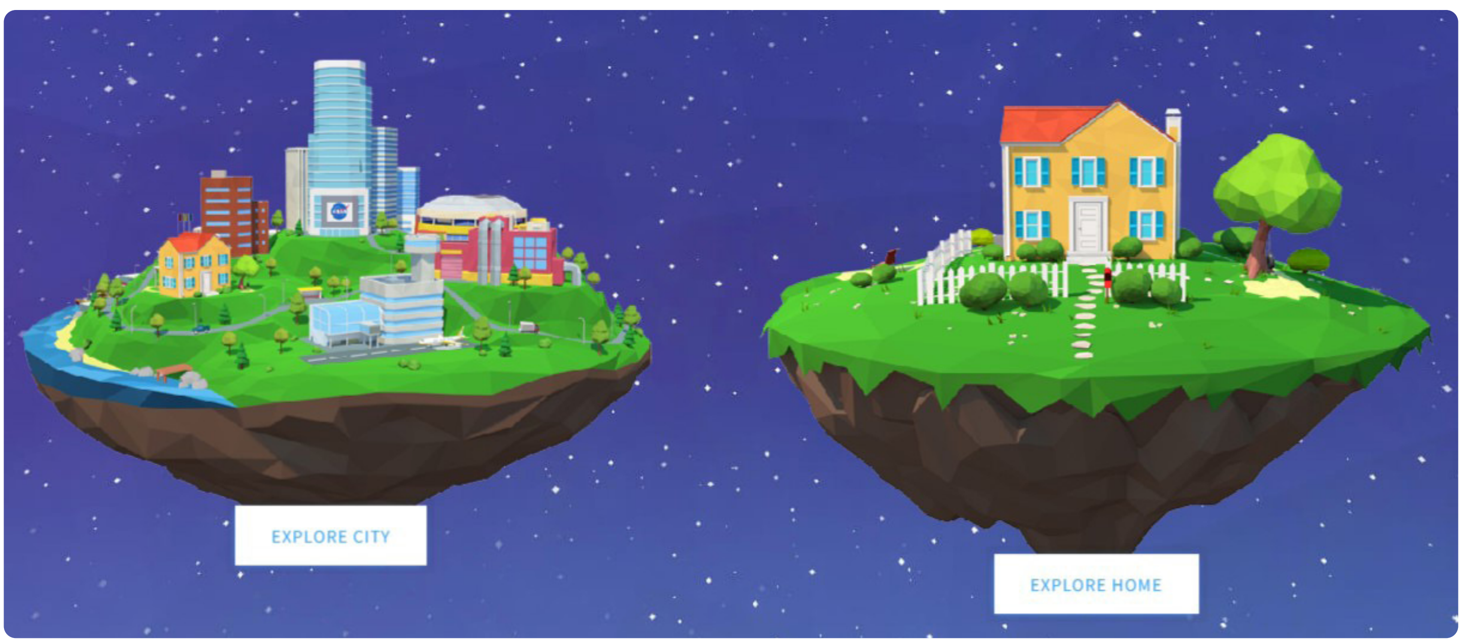
"**Spinoff**" highlights NASA technologies that benefit life on Earth in the form of commercial products and services used throughout daily life, from your cell phone camera to the memory foam in your mattress. NASA's Technology Transfer Program has profiled more than 2,000 spinoffs since 1976 – there's more space in your life than you think!

Spinoff Map

Spinoffs come from everywhere! Explore the **spinoffs map** and click on your state to find success stories where you live.

NASA Home and City

Have you ever wondered how space exploration affects your daily life? "Spinoffs" are commercial products and services derived from NASA technology or improved through NASA partnerships. These technologies – developed for the study of space and Earth – generate billions of dollars in both revenue and cost savings, create tens of thousands of jobs, and improve quality of living across the United States and worldwide. Our **NASA Home & City** interactive web app allows you to explore spinoff technologies you can find in your everyday life, demonstrating the wider benefits of America's investments in its space program.



Other NASA Spinoff Challenges

- **Minority University Research and Education Project (MUREP) Innovation and Tech Transfer Idea Competition** (MITTIC)
  - The MUREP Innovation and Tech Transfer Idea Competition (MITTIC) is a spinoff challenge to develop new ideas for commercialization open to multi-disciplinary student teams attending **Minority Serving Institutions (MSIs)**.
- **Technology Transfer University**
  - Technology Transfer University (T2U) brings real-world, NASA-proven technologies into the classroom. NASA's T2U program connects universities with NASA-developed technology to allow students to work with federal government research and technology.
- **Technology Transfer Expansion**
  - The Tech Transfer Expansion (T2X) Program includes a focus on entrepreneurial innovation and creating partnerships to help accelerate commercialization. T2X envisions prosperous NASA-infused tech startup ecosystems across the U.S.

STEM Careers and NASA Internships

NASA's unique mission provides benefits in big and small ways. Dollars spent for space exploration create jobs, jump-start businesses, and grow the economy. Our innovations improve daily life, advance medical research, support disaster response, and more. We're constantly evolving and finding new ways to add value.

At NASA, our people are as diverse as our mission. We have assembled a team of world-class experts from many different fields and backgrounds who share a passion for exploration. The resulting diversity of thought and collaborative environment foster innovation and groundbreaking ideas. Learn more about how you can be a part of this dynamic team!

STEM Careers

What kinds of careers would you expect at NASA? NASA is more than astronauts. The NASA workforce includes scientists, engineers, IT specialists, human resources specialists, accountants, writers, technicians, lawyers, artists, and more. Explore the career resources below to learn about various traditional and non-traditional careers at NASA.

- **Astrobiology Career Path Suggestions**
- **Astronaut Biographies**
- **Astronaut Requirements**
- **NASA People**
- **NASA STEM Stars**
- Surprisingly STEM: **Marine Biologists @ NASA Kennedy**
- Surprisingly STEM: **Soft Robotics Engineers @ NASA Langley**
- **USAJOBS Website**
- **Women @ NASA**

NASA Internships

Did you know that students can launch their careers with a NASA internship? NASA Office of STEM Engagement (OSTEM) paid internships allow high school and college-level students to contribute to agency projects under the guidance of a NASA mentor. The Pathways program offers current college-level students and recent graduates paid internships that are direct pipelines to full-time employment at NASA upon graduation. NASA Fellowships allow graduate-level students to pursue research projects in response to the agency's current research priorities. Learn more about these opportunities using the links below.

- **NASA Intern Stories**
- **NASA Internship Opportunities**

Activity One: Explore NASA Spinoffs

EDUCATOR NOTES

Learning Objectives

Students will

- Explore and research an existing NASA spinoff.
- Create a presentation summarizing a NASA spinoff.
- Explain how NASA technology benefits life on Earth.
- Share a presentation with others and answer questions as needed.

Investigation Overview

In this activity, students will select a NASA spinoff and then research applications of this technology at NASA and around the world. Students will showcase what they have learned with others (e.g., another class, community STEM night, senior center) by creating a presentation (e.g., blog, podcast, poster, song, video).

Suggested Pacing 1-2 hours

Education Standards

21st Century Skills (P21 Framework)	
Learning & Innovation • Creativity and Innovation • Critical Thinking and Problem Solving • Communication • Collaboration ***Life & Career Skills*** • Initiative and Self-Direction	• Social and Cross-Cultural Skills • Leadership and Responsibility ***Information, Media, and Technology Skills*** • Information Literacy • Media Literacy • Information, Communications, and Technology Literacy
Technology (ISTE)	
Standards for Students Empowered Learner: • 1.1.c: Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways. • **Knowledge Constructor:** • 1.3.a: Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits. • 1.3.b: Students evaluate the accuracy, perspective, credibility, and relevance of information, media, data or other resources.	***Standards for Students (continued)*** 1.3c: Students curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions. ***Creative Communicator*** • 1.6.a: Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication. • 1.6.c: Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models, or simulations. • 1.6.d: Students publish or present content that customizes the message and medium for their intended audiences.
English / Language Arts (CCSS)	
Speaking & Listening • CCSS.ELA-LITERACY.SL.9-10.1.D: Respond thoughtfully to diverse perspectives, summarize points of agreement and disagreement, and, when warranted, qualify or justify their own views and understanding and make new connections in light of the evidence and reasoning presented. • CCSS.ELA-LITERACY.SL.11-12.1.D:Respond thoughtfully to diverse perspectives, synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task. • CCSS.ELA-LITERACY.SL.9-10.4: Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task. • CCSS.ELA-LITERACY.SL.11-12.4: Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.	***Literacy in Scientific & Technical Subjects*** • CCSS.ELA-LITERACY.RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. . • CCSS.ELA-LITERACY.RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. • CCSS.ELA-LITERACY.RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. • CCSS.ELA-LITERACY.RST.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. • Reading for Informational Text • CCSS.ELA-LITERACY.RI.9-10: Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. • CCSS.ELA-LITERACY.RI.11-12: Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

Investigation Preparation

- Read the Introduction and Background and the Educator Notes of this activity to learn about the challenge.
- NASA Engages is composed of NASA Experts who share NASA missions and content at educational, professional, civic, and other public venues. Audiences include preschool to college, libraries and museums, scouts, professional and technical organizations, community groups and other non-profit organizations. Experts are made up of professionals from education, engineering, science, and other fields. This new platform* allows individuals associated with an institution or organization to submit requests for NASA Experts to engage in events. *The platform is online here: **https://stemgateway.nasa.gov/nasaengages/s/**.
  For questions, email **HQ-NASAEngages@mail.nasa.gov**
- Activity Two and Activity Three build upon this activity. Students must follow the proposed plan to achieve a holistic understanding of NASA spinoffs, their applications, and their benefits to society.

Materials

- Computer with internet access.
- Word processing, spreadsheet, and/or presentation applications.

Safety

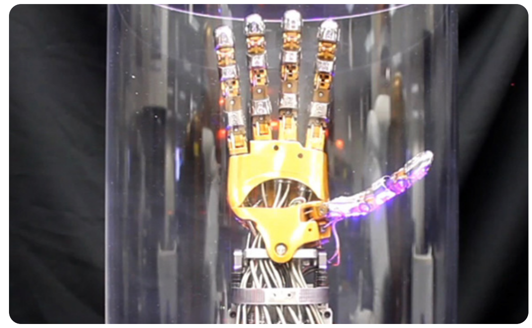
- There are no safety concerns with this activity. Follow all safety protocols of your school or organization and always practice good situational awareness.

Introduce the Investigation

- NASA has made great accomplishments in space, but our research also benefits life on Earth. These innovations, which crossover into everyday life, are called NASA spinoffs, and many have improved products people use daily. Spinoffs initially began as reports presented to Congress during budget hearings. After noticing a large amount of public interest, the first official four-color NASA Spinoff print edition was published in 1976. Every year a new NASA Spinoff publication is released, featuring new ways that NASA research has greatly benefited humankind. In this activity, students will learn how NASA technologies have evolved over time for use by many people worldwide.
- Students will research how the original technology was used by NASA and understand the value of its use as a commercial product. In addition, students will choose a NASA spinoff technology of interest to them or developed in their state and prepare a presentation to share what they have learned with others.

Share With Students

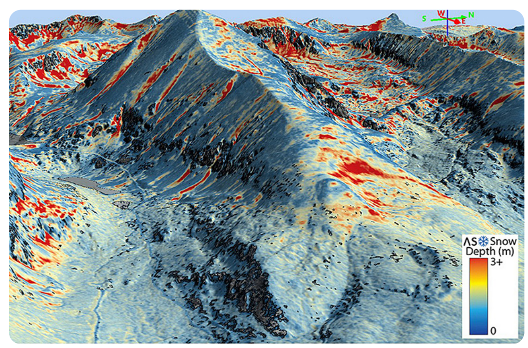
Brain Booster



Robonaut 2 robotic hand. Credits: NASA

The world's first industrial-strength robotic glove only exists because NASA and General Motors (GM) realized that space exploration and automobile manufacturing had a lot of common goals.
Learn more: **Robotic Glove Spinoff**

On Location



NASA collected hyperspectral and lidar data from several mountain chains, using the technology to accurately measure snow depth and snow quality to calculate the amount of water contained in the snowpack. Credits: NASA

Measuring snow depth and quality in the highest elevations of a mountain chain requires special sensors. Using NASA-developed technologies, it is now possible to calculate the amount of water contained in a snowpack.
Learn more: **Getting Water Out of Snow**

Facilitate the Investigation

ENGAGE

- Share with students the following: "NASA is everywhere – space technology turns up in nearly all corners of modern life. The world has come to rely on GPS signal correction software created by NASA, which enables precision agriculture, airplane navigation, smartphones, Earth science, and more. A lightweight, high-pressure tank NASA invented to hold rocket fuel now stores life-saving oxygen to keep pilots, firefighters, and intensive care patients breathing – not to mention gases that power city buses and even paintball guns. Fitness enthusiasts may be surprised to learn about NASA's contribution to the Bowflex Revolution resistance-exercise home gym. Students should begin by listing their interests, perhaps with the class in a brainstorming session or survey. Students are more likely to have buy-in if they are inspired by their interests.
- Begin the lesson by asking students the following questions:
  - How does exploration on and off the Earth benefit our lives?
  - What is the value of creating multi-purpose technologies?
  - Can you think of a device or technology that you use daily? How has this technology improved your life?
- After discussing these questions with students, watch this short video, "**How NASA Technology Improves Life on Earth**."

EXPLORE:

NASA technologies – developed for the study of space and Earth – have generated billions of dollars in both revenue and cost savings, created tens of thousands of jobs, and improved quality of living across the United States and worldwide. Our NASA Home & City interactive web app allows you to explore some spinoff technologies you can find in your everyday life, demonstrating the wider benefits of America's investments in its space program.

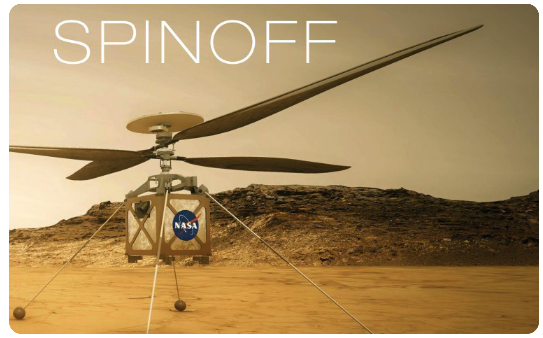
- Students will explore the NASA Home & City website and identify three NASA technologies found in a home and three NASA technologies found in a city.
- Students will then explore the NASA Spinoff publication from the year they were born and describe the benefits of one technology highlighted in that year.
- Spinoffs come from everywhere! Ask students to navigate to the NASA spinoff map and choose one NASA spinoff technology developed near your community. Research how this technology benefits the public and identify how it was used at NASA.

EXPLAIN

- Students will select one NASA spinoff technology from the NASA Home & City website, NASA Spinoff publication, or the NASA spinoff map to report on what they have learned.
- Think-Pair-Share: In pairs, students share their selected spinoffs.

Share With Students

FUN FACT!



Cover image for the NASA 2021 Spinoff publication. Credits: NASA

Memory foam, enriched baby formula, wireless headsets, and digital camera sensors are just a few examples of NASA spinoffs.

Learn more: **NASA Spinoff Archive**

CAREER CORNER


Barbara L. Brown, director of Exploration Research and Technology at NASA's Kennedy Space Center. Credits: NASA

Barbara L. Brown serves as the director of Exploration Research and Technology Programs at NASA's John F. Kennedy Space Center in Florida. She leads processing, assembly, integration, and test payloads and flight science experiments bound for the International Space Station. She serves as Kennedy's lead for the formulation of concepts to support uncrewed operations on the Moon and Mars.

Learn more: **Barbara L. Brown**

Students ask and answer open-ended questions such as

- "Why do you think…?"
- "What evidence do you have …?"
- "How would you adapt your technology to….?"

ELABORATE

- Ask the students to prepare a presentation (e.g., poster, video, blog, podcast, commercial) to share their chosen spinoff with others. Encourage them to be creative.
- Review the Criteria and Constraints chart for presentation parameters.

Criteria	Constraints
Must be creative (e.g., poster presentation, artwork, podcast, song, commercial).	May not be longer than 3-5 minutes.
Share how NASA used the technology.	Must cite verified resources.
Explain how the technology is used in everyday life.	
Include an image of the NASA spinoff.	Must use a verified NASA image.

EVALUATE

- Students will share their presentation of their chosen NASA spinoff. Students should be prepared to ask and answer questions to/from their audience about how NASA has used the technology and how it benefits the public.

Extensions

- Students search for NASA spinoffs in their home, school, or community and sketch or take photos of those items. Students should not use images from the internet.
- Include a spotlight on one career related to the selected technology (e.g., chemist, mechanical engineer).

Resources

- **NASA Spinoff Timeline**
- **NASA Home and City: Trace Space Back to You**
- **NASA Technology Transfer Program**

Activity Two: Propose a NASA Spinoff

EDUCATOR NOTES

Learning Objectives

Students will

- Brainstorm possible spinoff technologies from NASA's patent portfolio, then select one feasible idea through discussion.
- Create a proposal for a hypothetical NASA grant.
- Present their proposal to a panel of reviewers.

Challenge Overview

To simulate the NASA Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR) grant processes, students will develop and pitch a proposal "tank style" to a "NASA review panel" regarding a hypothetical spinoff of their own devising.

Suggested Pacing

2-4 hours working time plus 5-10 minutes proposal time per group

National STEM Standards

Science and Engineering (NGSS)	
Will vary based on the spinoff technology selected, but will likely include: ***Science Content Standards*** • HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. • HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	***Science and Engineering Practices*** • Practice 1 - Asking questions (for science) and defining problems (for engineering) • Practice 3 - Planning and carrying out investigations • Practice 6 - Constructing explanations (for science) and designing solutions (for engineering) • Practice 7 - Engaging in argument from evidence • Practice 8 - Obtaining, evaluating, and communicating information
21st Century Skills (P21 Framework)	
Learning & Innovation • Creativity and Innovation • Critical Thinking and Problem Solving • Communication • Collaboration	***Life & Career Skills*** • Initiative and Self-Direction • Social and Cross-Cultural Skills • Leadership and Responsibility
English / Language Arts (CCSS)	
Speaking & Listening • CCSS.ELA-LITERACY.SL.9-10.1.C: Propel conversations by posing and responding to questions that relate the current discussion to broader themes or larger ideas; actively incorporate others into the discussion; and clarify, verify, or challenge ideas and conclusions. • CCSS.ELA-LITERACY.SL.9-10.1.D: Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented. • CCSS.ELA-LITERACY.SL.9-10.4: Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task. • CCSS.ELA-LITERACY.SL.9-10.5: Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.	***Literacy in Scientific & Technical Subjects*** • CCSS.ELA-LITERACY.RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. • CCSS.ELA-LITERACY.RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. • CCSS.ELA-LITERACY.RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

Challenge Preparation

- It is highly recommended to do Activity One from this guide before this activity to ensure that students have a solid understanding of the concept of spinoff technologies.
- Decide what form(s) of written proposal you consider acceptable. Common choices include a slide deck, a 1-2 page written explanation, a brochure, a poster, a digital slide deck, or other common visual aids.
- Find 2-3 people who can act as the "NASA reviewers" for the final presentation. Ideally, these would be people

from local aerospace, manufacturing, or other STEM-focused industries. The **NASA spinoff map** may help you find such companies in your area. Other educators, librarians, and even parents/guardians can be good choices too.

- Consider using a formal presentation space such as a stage or conference room to add realism to the presentations.
- Optionally, print the presentation rubric so that students will have a strong idea of what success in this activity looks like.

Materials

- No special materials are required for this activity beyond what might be needed for the written proposal.

Safety

- There are no safety concerns with this activity. Follow all safety protocols of your school or organization and always practice good situational awareness.

Introduce the Challenge

- Show the class the video "**How to License a NASA technology**."
- Group students into teams of three to five. Explain that each team will portray a fictional company that wants to create a new spinoff. Just like NASA requires real companies to submit an application and then talk to a licensing manager at NASA, student companies will have to put together a short proposal and then present it to a "NASA review panel."
- Optionally, allow students a few minutes to come up with a company name as a team-building exercise.

Facilitate the Challenge

MEET THE PROBLEM

The requirements for this challenge are as follows:

- All teams must develop a written proposal for a spinoff based on NASA technology. This spinoff must be substantially different than an existing commercial off-the-shelf technology.
- After developing their proposal, all teams must deliver a presentation regarding that proposal.
- All team members must contribute to both the proposal and the presentation.

EXPLORE KNOWNS AND UNKNOWNS

- Each student should find at least one technology that they think might be a good candidate for a spinoff from **NASA's patent portfolio**
- Then, each student should determine the STEM behind that technology. For example, is the most important aspect of the technology lasers, gravity, composite materials, or something else? Each student should take a few minutes to investigate that topic to make sure resources exist to help the team.

Share With Students

Brain Booster

Bowery Farming builds vertical farms that eliminate the problems that limit outdoor farming such as drought, winter temperatures, and bug infestations. Credits: Bowery Farming Inc.

Scaling up NASA's data-driven vertical growth model to support commercial, Bowery Farming builds vertical farms inside formerly abandoned city buildings, to provide fresh produce to local retailers and restaurants.
Learn more: **Indoor Farming**

On Location

Maurice Kanzala collects a water sample from a shallow dug well in rural Uganda.

In rural Uganda, the water app instructs users on how to perform, among other simple tests, a coliform bacteria test inspired by NASA's research, which allows field workers to record and share water quality or other data on how the water source is functioning over time.
Learn more: **Water Sharing Software**

GENERATE POSSIBLE SOLUTIONS

- As a team, each student shares their candidate technology and the STEM behind it. The remainder of the team should work to identify at least one advantage and one disadvantage of selecting each candidate technology.
- After all the students have shared their candidate technologies, the team should come to a consensus on which one will be the basis for the team's proposed spinoff
- As a team, all students should investigate the selected NASA technology and the STEM behind it.
- After taking some time to understand the basics, each team member should propose a possible spinoff. As before, all team members should propose an idea for a spinoff; then, the team should select the best idea only after everyone has shared an idea.

CONSIDER CONSEQUENCES

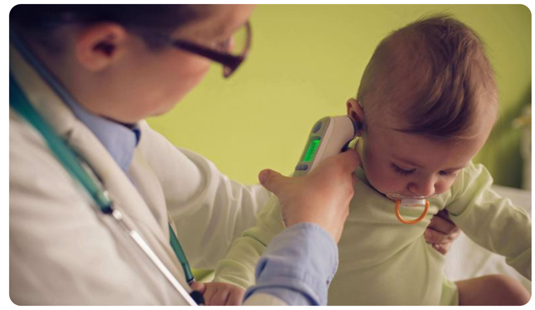
- Once the team has agreed on a spinoff, the students should develop their written proposal. The proposal should contain, at a minimum
  - some explanation of the STEM behind the proposed spinoff
  - at least three reasons NASA should fund the proposed spinoff
  - a hypothetical plan, such as a timeline, materials, or research needed, for developing the spinoff
- Everyone on the team must contribute to the proposal in some way.

PRESENT FINDINGS

- Each team will have a few minutes (recommended 3-5, maximum 10) to present their proposal to the panel
- After the presentation, the panel will ask the team one or two clarification questions, which the team must answer to the best of their ability.
- If possible, allow teams to share their presentations with a wider audience. For example, a school-based team could present in front of students from a young grade or as part of a science fair. An after-school program could invite families to come to watch the presentations. **Lead Teachers and students should follow their school or organization's guidelines for these types of events. Any community engagement should follow local social distancing guidelines or be virtual.**
- If your school or organization's guidelines allow, consider posting pictures of your presentations with the hashtag #NextGenSTEM.

Share With Students

FUN FACT!



Doctor taking the temperature of a baby using an ear thermometer.

Astronomy technology, once used to measure the temperature of distant stars and planets, now measures the temperature of humans with high-speed medical thermometers.

Learn more: **Infrared Ear Thermometers**

CAREER CORNER

Megan Victor, New Technology Representative at NASA's Kennedy Space Center. Credits: Megan Victor

Megan Victor works in the Office of Technology Transfer at the Kennedy Space Center (KSC). Her earliest role was as the database administrator for the NASA Technology Transfer System, which is used to document innovations. Today she is KSC's new technology representative.

Resource

- If students need an example of what a presentation might look like, Onedrus is one of many companies that have used NASA technology. The excerpt of the video "**Startup NASA Feature Series: Onedrus**" from 16:47 to 24:22 may give students an idea of how real companies propose to NASA. The entire channel has many such examples.

Extension

- The Minority University Research and Education Project (MUREP) Innovation and Tech Transfer Idea Competition (MITTIC) is a more formal version of this activity for college students at Minority Serving Institutions (MSIs). If your students excel at this activity, the next step might be to have them elevate their pitches to the standards set by MITTIC. More information, including sample pitches, can be found at the **MITTIC website**.

Activity Three: SPARX Spinoff Design Challenge

EDUCATOR NOTES

Learning Objectives

Students will

- Build a model or prototype of their NASA spinoff.
- Use the engineering design process to test and refine their solution.
- Create a presentation demonstrating their solution.

Challenge Overview

Student teams will use NASA technology in an innovative way to solve a problem in their community. Teams must bring their concepts into reality by developing a model or working prototype of their proposed spinoff, testing, and then refining their solution using the engineering design process.

Suggested Pacing

6-12 hours

Science and Engineering (NGSS)	
Will vary based on the spinoff technology selected, but will likely include: ***Disciplinary Core Ideas*** • HS-ETS1-1 Engineering Design: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. • HS-ETS1-2 Engineering Design: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. • HS-ETS1-3 Engineering Design: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. ***Crosscutting Concepts*** • Cause and Effect: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.	• Structure and Function: The way an object is shaped or structured determines many of its properties and functions. ***Science and Engineering Practices*** • Asking Questions and Defining Problems: A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested. • Developing and Using Models: A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations. • Constructing Explanations and Designing Solutions: The products of science are explanations, and the products of engineering are solutions. • Obtaining, Evaluating, and Communicating Information: Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity.
21st Century Skills (P21 Framework)	
Standards for Students • Knowledge Constructor 3d: Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions. • Innovative Designer 4a: Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems. • Innovative Designer 4c: Students develop, test and refine prototypes as part of a cyclical design process.	***Standards for Students (continued)*** • Creative Communicator 6c: Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations. • Global Collaborator 7c: Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal. • Global Collaborator 7d: Students explore local and global issues and use collaborative technologies to work with others to investigate solutions.
English / Language Arts (CCSS)	
Learning & Innovation • Creativity and Innovation • Critical Thinking and Problem Solving • Communication • Collaboration	***Life & Career Skills*** • Flexibility and Adaptability • Initiative and Self-Direction • Social and Cross-Cultural Skills • Productivity and Accountability

Challenge Preparation

The educator should

- Read the Introduction and Background and the Educator Notes of this activity to learn about the challenge.
- Plan an Optional Scaffolding Activity if students need additional experience with the engineering design process.

The students should

- Be familiar with NASA spinoffs and the Technology Transfer Program. See Activity One: Explore NASA Spinoffs.
- Select a technology from NASA's patent portfolio and propose a hypothetical spinoff of their own devising. See Activity Two: Propose a NASA Spinoff.

Materials

- Computer with internet access
- Other materials needed will depend on the selected spinoff technology

Safety

There are no safety concerns with this activity. However, educators should identify any safety concerns related to the specific spinoff technology and associated materials selected by each team. Follow all safety protocols of your school or organization and always practice good situational awareness.

Introduce the Challenge

- Engage students with the "**Did You Know That's a NASA Technology?**" video.
- Introduce students to the engineering design process using the "**STEMonstrations: Engineering Design Process**" video.
- Use one of NASA's Optional Scaffolding Activities if students need additional experience with the engineering design process before completing this challenge.
- Discuss the Challenge Overview, Learning Objectives, the following criteria and constraints, and any additional constraints unique to your situation/setting.

Facilitate the Challenge

Criteria	Constraints
Create at least two iterations of your design.	Complete all steps of the engineering design process at least once by the assigned deadline.
Document all steps of the engineering design process, including how the design was tested, analysis of those tests, and resulting improvements to the final design.	Keep within budget, material, and safety constraints as defined by your teacher.
Teams will share their solution with NASA in a video presentation.	Presentations should be at most 5 minutes in length.

? ASK

Prompt students with the following discussion/research questions:

- What problem will be solved with the newly designed spinoff technology?
- Which technology/spinoff are you redesigning for your new spinoff?
- How does the original technology or spinoff work?
- What criteria and constraints should be considered as you design your new spinoff?
- What criteria will be the most difficult to meet? Why?

Share With Students

Brain Booster

Cristiana Oprea wearing Walero motorsport racewear while driving for the European Rally Championship. Credit: Walero

Phase-change materials originally developed for spacesuits are now being used in specialized undergarments to help keep race car drivers cool in the cockpit. Learn more: **Spacesuits to Racing Suits**

On Location

Smartphone navigation apps have a short "time to first fix," rarely having to search long for a satellite signal, thanks to data from JPL's Global Differential GPS.

Global Positioning System (GPS) is an Air Force program, but NASA algorithms are largely to thank for the system being useful for secure, precision applications. Raw GPS data can be off by 30 feet or more, so NASA's Jet Propulsion Laboratory developed software to correct for these errors, enabling real-time precision GPS. Learn more: **Adding Accuracy to GPS**

Discuss why it is important to clearly identify the problem. Stating the problem along with the criteria and constraints helps to evaluate the effectiveness of solutions.

IMAGINE

- Teams should research and document what others have done to solve the problem already, then generate new ideas for solutions. Through this market research, teams must identify how their solution would add value
- To help facilitate teamwork, suggest that all team members sketch and share ideas before the team chooses one design to construct. They might select the best design or merge concepts together into a brand-new design. They should justify their choice.

PLAN

- Plans for building a prototype could include a design sketch, a list of needed materials, a budget, a timeline for development and testing, and a list of team members' roles.

CREATE

- If building a working prototype is time- or cost-prohibitive, students may create a 3D model or schematic using graph paper, computer-aided design, or another appropriate design tool.
- Consider finding local community mentors (e.g., STEM or aerospace companies, college/university students) to help students create prototypes. Partner with an industrial technology or computer science class to help with models or simulations.

TEST

- Teams should carefully document the testing process, including testing protocols, observations, and data collected.
- Teams must describe the strengths and weaknesses of the model.

IMPROVE

- Teams should justify any changes made to the design using evidence from testing and document how those changes improved the new design.
- If time allows, teams can cycle through the steps of testing and improvement to further refine their design. Remind teams to reflect on whether their design satisfies all criteria and constraints while solving the identified problem.

SHARE

- Students will share with NASA their solutions (i.e., model or prototype) and what they have learned throughout this process. The presentation should be a video demonstration of their 3D model or simulation. The video should be at most 5 minutes.

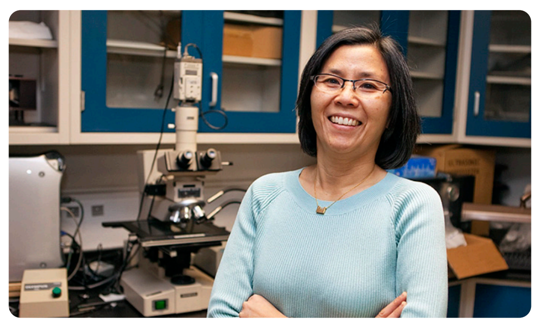
Share With Students

FUN FACT!

President Barack Obama poses for a selfie with science popularizers Bill Nye, left, and Neil deGrasse Tyson, right. Image courtesy of the White House.

When NASA needed miniature cameras for interplanetary missions, they created the complementary metal oxide semiconductor (CMOS) active pixel sensor. CMOS is the eye of the camera and is found in DSLR cameras, cell phone cameras, and even medical imaging and dental x-ray devices.
Learn more: **CMOS Sensors**

CAREER CORNER



Emilie "Mia" J. Siochi, leads structural nanomaterials development effort at Langley Research Center. Credits: NASA

Meet Emilie "Mia" J. Siochi from NASA's Inventors Hall of Fame. Siochi holds more than two dozen patents and is a proponent of use-inspired research including the areas of structural nanomaterials, bioinspired materials, and self-healing materials.
Learn more: **Mia Siochi**

Extensions

- Include a career spotlight in the presentation to highlight careers related to the spinoff.

Optional Scaffolding Activities

- **Additive Manufacturing: You Can't Take It All With You**
- **Eggstronaut Parachute Design Challenge**
- **Heavy Lifting Crane Building Challenge**
- **MEDLI2: Heat Shield Design Challenge**
- **MISSE-X: Material Science Experiment**
- **On Target Physics Challenge**
- **Spacecraft Structures: A Lesson in Engineering**
- **Water Filtration Challenge**

Appendix A. – Rubric for 5E Instructional Model

5E Step	Novice (0)	Apprentice (1)	Journeyperson (2)	Expert (3)	Level of student knowledge (Score)
ENGAGE	Student does not identify any prior knowledge or connections to previous learning experiences	Student identifies irrelevant or inaccurate prior knowledge or connections to previous learning experiences	Student identifies one example of relevant and accurate prior knowledge or connection to previous learning experience	Student identifies two or more examples of relevant and accurate prior knowledge or connections to previous learning experiences	
EXPLORE	Student does not participate in brainstorming discussion	Student participates in brainstorming discussion (asks questions, for example) but does not contribute possible hypotheses, solutions, or tests	Student contributes at least one possible hypothesis, solution, or test to brainstorming	Student contributes at least one possible hypothesis, solution, or test to brainstorming and an alternative or improvement to another student's idea	
EXPLAIN	Student does not provide explanation of observations	Student provides an explanation of observations that is inaccurate, incomplete, or lacks evidence	Student provides an accurate, complete explanation of observations based on evidence	Student provides an accurate, complete explanation of observations based on evidence and supplements their reasoning with either evidence or evidence-based explanations from others	
ELABORATE	Student does not draw reasonable conclusions based on evidence	Student draws reasonable conclusions but does not use scientific terminology or evidence	Student draws reasonable conclusions using scientific terminology and evidence	Student draws reasonable conclusions using scientific terminology as well as evidence and can make reasonable predictions based on those conclusions	
EVALUATE	Student does not demonstrate understanding of concept or can only repeat provided definitions	Student demonstrates an understanding of concept by providing definitions or explanations in their own words, drawings, models, etc.	Student demonstrates an understanding of concept by applying it to new questions or by analyzing new evidence	Student demonstrates an understanding of concept by explaining how evidence caused their knowledge to progress over time or by proposing new ways to use their new knowledge (such as follow-up experiments)	
				Total	

Appendix B. – Rubric for Proposal Presentation

Factor	Novice (0)	Apprentice (1)	Journeyperson (2)	Expert (3)	Level of student knowledge (Score)
Understanding NASA Technology	Presentation does not reference either the NASA technology or the underlying STEM content.	Presentation explains at least one of the NASA technology or the underlying STEM content but not both	Presentation explains both the NASA technology and the underlying STEM content	As per Journeyperson, plus explains how the two relate to each other.	
Justifying the need for a spinoff	Presentation does not include any viable arguments for why NASA should fund the spinoff	Presentation includes one or two viable arguments for why NASA should fund the spinoff	Presentation includes at least three viable arguments for why NASA should fund the spinoff	As per Journeyperson, plus provides data or other evidence supporting the arguments.	
Planning	Presentation does not include any hypothetical planning for developing the spinoff	Presentation contains a single piece of evidence of hypothetical planning such as a timeline, materials needed, or research ideas.	Presentation contains multiple pieces of evidence of hypothetical planning such as a timeline, materials needed, or research ideas.	As per Journeyperson, plus identifies community resources besides NASA funding that could support the development process.	
Teamwork	Not all team members contribute to the presentation.	All team members contribute to the presentation, but their individual contributions to the proposal process are not identified	All team members contribute to the presentation, and their individual contributions to the proposal process are identified	As per Journeyperson, plus the distribution of work is fair and equitable.	
Q&A	Team does not respond to question(s) from the panel	Team responds to question(s) from the panel but does not explain the answer.	Team responds to question(s) from the panel and explains the answer.	As per Journeyperson, plus the answer utilizes appropriate STEM terminology	
				Total	

Appendix C. – Rubric for Problem-Based Learning (PBL)

PBL Step	Novice (0)	Apprentice (1)	Journeyperson (2)	Expert (3)	Level of student knowledge (Score)
MEET THE PROBLEM	Student does not identify the problem	Student incorrectly identifies the problem	Student identifies part of the problem	Student fully and correctly identifies the problem	
EXPLORE KNOWS & UNKNOWNS	Student does not identify knowns and unknowns	Student incompletely identifies knowns and unknowns	Student identifies knowns and unknowns using experience but uses no resources	Student completely identifies knowns and unknowns using experience and resources	
GENERATE POSSIBLE SOLUTIONS	Student does not brainstorm	Student generates one possible solution	Student provides two possible solutions	Student provides three or more possible solutions	
CONSIDER CONSEQUENCES	Student does not identify any consequences	Student determines inaccurate or irrelevant consequences	Student identifies consequences accurately	Student identifies consequences accurately and provides a rationale	
PRESENT FINDINGS	Student does not communicate results	Student shares random results	Student shares organized results, but results are incomplete	Student shares detailed, organized results with class	
				Total	

Appendix D. – Rubric for Engineering Design Process (EDP)

EDP Step	Novice (0)	Apprentice (1)	Journeyperson (2)	Expert (3)	Level of student knowledge (Score)
Identify the problem (ASK)	Student does not identify the problem	Student incorrectly identifies the problem	Student identifies part of the problem	Student fully and correctly identifies the problem	
Brainstorm a solution (IMAGINE)	Student does not brainstorm	Student generates one possible solution	Student provides two possible solutions	Student provides three or more possible solutions	
Develop a solution (PLAN)	Student does not select or present a solution, or the solution is off task	Student presents a solution that is incomplete or lacking details	Student selects a solution but does not consider all criteria and constraints	Student selects a solution that considers all criteria and constraints	
Create a prototype (CREATE)	Student does not directly contribute to the creation of a prototype	Student creates a prototype that does not meet problem criteria and constraints	Student's prototype meets most problem criteria and constraints	Student creates a prototype that meets all problem criteria and constraints	
Test a prototype (TEST)	Student does not contribute to the testing of the prototype	Student conducts tests that are irrelevant to the problem or do not accurately assess strengths and weaknesses of the prototype	Student conducts carefully performed tests that consider one to two strengths and weaknesses of the prototype	Student conducts relevant and carefully performed tests that consider three or more strengths and weaknesses of the prototype	
Redesign based on data and testing (IMPROVE)	Student does not contribute to the redesign	Student does not improve the design or address concerns	Student addresses one concern to improve the design	Student addresses two or more test-based concerns to improve the design	
Communicate results from testing (SHARE)	Student does not communicate results	Student shares random results	Student shares organized results, but results are incomplete	Student shares detailed, organized results with the group	
				Total	

Appendix E. – Glossary of Key Terms

Computer-aided design (CAD) - Computer-aided design (CAD) is the use of computer-based software to aid in the design process.

Engineering Design Process - An iterative process that engineers use to guide them in the problem-solving process.

Model - A copy of something, often smaller than the original object.

Patent - An intellectual property right granted to an inventor, issued by the United States Patent and Trademark Office (USPTO), "to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States."

Proposal - A plan, formally written, put forward for consideration or discussion by others.

Prototype - The first example of a machine or industrial product from which all later forms are developed.

Schematic - A diagram, plan, or drawing that represents the elements of a system.

Simulation - Representation of the behavior or characteristics of one system through the use of another system, especially a computer program designed for the purpose.

Spinoff - NASA spinoffs are technologies, products, and processes developed with NASA technology, funding, and/or expertise.

Sustainability - Taking action to enable a future where the environment and living conditions are protected and enhanced.

Technology - The application of scientific knowledge for practical purposes, especially in industry including machinery and equipment.

Technology Readiness Level Definition - **Technology Readiness Levels (TRL)** are a type of measurement system used to assess the maturity level of a particular technology.

Technology Transfer - Technologies developed for missions in exploration and discovery are made broadly available to the public, maximizing the benefit to the Nation.

Appendix F. – Glossary of Links

STEM Education Standards

Next Generation Science Standards - **https://www.nextgenscience.org/**
International Society for Technology in Education (ITSE) Standards for Students - **https://www.iste.org/standards/iste-standards-for-students**
Partnership for 21st (P21) Century Learning - **https://www.battelleforkids.org/networks/p21/frameworks-resources**
Common Core State Standards (CCSS) for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects - **https://learning.ccsso.org/wp-content/uploads/2022/11/ADA-Compliant-ELA-Standards.pdf**

5E Instructional Model

Biological Sciences Curriculum Study (BSCS) Life and Living curriculum - **https://bscs.org**
5E instructional model with NASA eClips™ - **https://nasaeclips.arc.nasa.gov/teachertoolbox/the5e**

Problem-Based Learning Process

Problem-Based Learning and Adult English Language Learners - **https://www.cal.org/adultesl/pdfs/problem-based-learning-and-adult-english-language-learners.pdf**

Engineering Design Process

STEMonstrations: Engineering Design Process - **https://www.nasa.gov/stem-content/stemonstrations-engineering-design-process/**

Curriculum Connection

Feeling Hot, Staying Cool - **https://bscs.org**
Telescope Mirror Tech Improves Eye Surgery - **https://spinoff.nasa.gov/Telescope-Mirror-Tech-Improves-Eye-Surgery**
Space Radiation Research Fights Cancer on Earth - **https://spinoff.nasa.gov/Space-Radiation-Research-Fights-Cancer-on-Earth**
Safely Detoxifying Soil and Groundwater with NASA Technology - **https://spinoff.nasa.gov/detoxifying-soil-and-groundwater**
Learning to Code with NASA Data - **https://spinoff.nasa.gov/Learning-to-Code-with-NASA-Data**
Getting Water out of Snow with NASA Technology - **https://spinoff.nasa.gov/Getting-Water-Out-of-Snow-with-NASA-Technology**
A High-Tech Farmer's Almanac for Everyone - **https://spinoff.nasa.gov/A-High-Tech-Farmer's-Almanac-for-Everyone**
Safeguarding Porpoises - **https://spinoff.nasa.gov/spinoff1997/er1.html**
Satellite-Respondent Buoys Identify Ocean Debris - **https://spinoff.nasa.gov/Spinoff2009/er_5.html**
High-Performance Lasers Make Waves in Self-Driving Cars, Quantum Devices - **https://spinoff.nasa.gov/Lasers-Make-Waves**
NASA Technology Aids Wildlife Conservation - **https://youtube.com/watch?v=-95NJdX5PPE**
Space Technology Mission Directorate - **https://www.nasa.gov/spacetech/**

Introduction and Background

Explore Space Tech - **http://www.nasa.gov/technology**
NASA Spinoff - **https://spinoff.nasa.gov/spinoff**
Spinoff Map - **https://spinoff.nasa.gov/map**
NASA Home and City - **https://homeandcity.nasa.gov/**
Minority University Research and Education Project (MUREP) Innovation and Tech Transfer Idea Competition (MITTIC) - **https://microgravityuniversity.jsc.nasa.gov/nasamittic**
The Minority Serving Institution (MSI) Exchange - **https://msiexchange.nasa.gov/**
Technology Transfer University (T2U) - **https://technology.nasa.gov/t2u**
Technology Transfer Expansion (T2X) - **https://technology.nasa.gov/t2x**
Astrobiology Career Path Suggestions - **https://astrobiology.nasa.gov/career-path-suggestions/**
Astronaut Biographies - **https://www.nasa.gov/astronauts**
Astronaut Requirements - **https://www.nasa.gov/audience/forstudents/postsecondary/features/F_Astronaut_Requirements.html**
NASA People - **https://www.nasa.gov/people-of-nasa/**
NASA STEM Stars - **https://www.nasa.gov/stem-content/nasa-stem-stars-webchat-series/**
Surprisingly STEM: Marine Biologists @ NASA Kennedy - **https://www.youtube.com/watch?v=tCvv5E4foKE**
Surprisingly STEM: Soft Robotics Engineers @ NASA Langley - **https://www.youtube.com/watch?v=VuxnPLU_KEs**

USAJOBS Website - **https://www.usajobs.gov/Search/Results?k=NASA**
Women at NASA - **https://women.nasa.gov/**
NASA Intern Stories - **https://www.nasa.gov/stem/interns/index.html**
NASA Internship Opportunities - **https://intern.nasa.gov/**

Activity One: Explore NASA Spinoffs

Online Request Form - **https://speakers.grc.nasa.gov/request/request.cfm**
Brain Booster (World's first industrial-strength robotic glove) - **https://spinoff.nasa.gov/robotic-glove-finds-commercial-handhold**
On Location (Measuring Snow Depth) - **https://spinoff.nasa.gov/Getting-Water-Out-of-Snow-with-NASA-Technology**
Spinoff 2019: How NASA Technology Improves Life on Earth - **https://www.youtube.com/watch?v=3rH3KAcYgBs**
NASA Home and City - **https://homeandcity.nasa.gov/**
NASA Spinoff publication - **https://spinoff.nasa.gov/spinoff/archives**
NASA Spinoff Map - **https://spinoff.nasa.gov/map**
Career Corner (NASA STEM Stars: Chief Technologist - Kennedy Space Center) - **https://www.youtube.com/watch?v=gn5U0TMPwFw**
NASA Spinoff Timeline - **https://spinoff.nasa.gov/Spinoff2008/pdf/timeline_08.pdf**
NASA Home and City: Trace Space Back to You - **https://homeandcity.nasa.gov/**
NASA Technology Transfer Program - **https://technology.nasa.gov/?t=partneringtool**

Activity Two: Propose a NASA Spinoff

NASA Spinoff Map - **https://spinoff.nasa.gov/map**
How to License a NASA Technology - **https://www.youtube.com/watch?v=wq98nb4VI5k**
NASA's Patent Portfolio - **https://technology.nasa.gov/patents**
Brain Booster (Bowery Farming) - **https://spinoff.nasa.gov/indoor-farming**
On Location (mWater app) - **https://spinoff.nasa.gov/Spinoff2015/ps_3.html**
Startup NASA Feature Series: Onedrus - **https://www.youtube.com/watch?v=0sZtMNtppyo&t=1007s**
Sample Pitches at The Minority University Research and Education Project (MUREP) Innovation and Tech Transfer Idea Competition (MITTIC) - **https://microgravityuniversity.jsc.nasa.gov/nasamittic**
Fun Fact (Infrared Ear Thermometers) - **https://homeandcity.nasa.gov/nasa/bathroom/233/infrared-ear-thermometers**

Activity Three: SPARX Spinoff Design Challenge

Did You Know That's a NASA Technology? - **https://www.youtube.com/watch?v=zz2AFNIE-WY**
STEMonstrations: Engineering Design Process - **https://www.nasa.gov/stem-content/stemonstrations-engineering-design-process/**
Brain Booster (Phase-Change Materials) - **https://spinoff.nasa.gov/phase-change-racewear**
On Location (GPS NASA Algorithms) - **https://spinoff.nasa.gov/Spinoff2019/ps_1.html**
Fun Fact (CMOS Sensors Enable Phone Cameras, HD Video) - **https://spinoff.nasa.gov/Spinoff2017/cg_1.html**
Career Corner (Meet Emilie "Mia" J. Siochi from NASA's Inventors Hall of Fame) - **https://technology.nasa.gov/ihof/inventors.php#Emilie%20%22mia%22-Siochi**
Additive Manufacturing: You Can't Take It All With You - **https://www.nasa.gov/sites/default/files/atoms/files/you_cant_take_it_all_with_you_grades_6-12_educators_tagged.pdf**
Eggstronaut Parachute Design Challenge - **https://www.nasa.gov/wp-content/uploads/2019/07/eggstronaut-parachute-challenge-educator-guide.pdf**
Heavy Lifting Crane Building Challenge - **https://www.nasa.gov/stem-ed-resources/otm-heavy.html**
MEDLI2: Heat Shield Design Challenge - **https://www.nasa.gov/sites/default/files/best_medli_workbook.pdf**
MISSE-X: Material Science Experiment - **https://www.nasa.gov/sites/default/files/best_misse-x_workbook.pdf**
On Target Physics Challenge - **https://www.nasa.gov/sites/default/files/atoms/files/edu_on-target.pdf**
Shoebox Glider Challenge - **https://www.youtube.com/watch?v=ium3IS41Xqc**
Spacecraft Structures: A Lesson in Engineering - **https://www.nasa.gov/stem-ed-resources/edc-spacecraft-structures.html**
Water Filtration Challenge - **https://www.jpl.nasa.gov/edu/teach/activity/water-filtration-challenge/**

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https://stemgateway.nasa.gov/connects/s

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