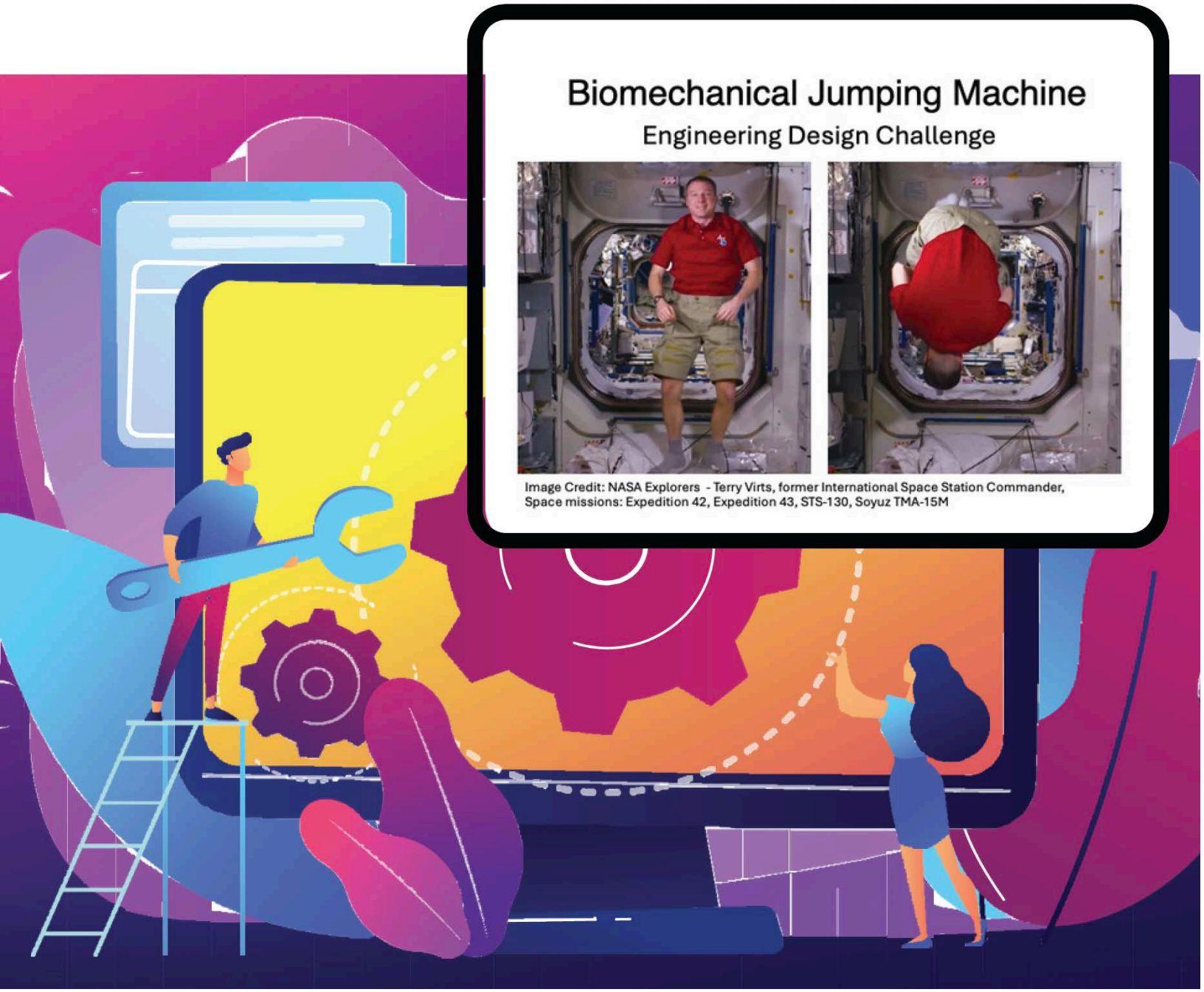
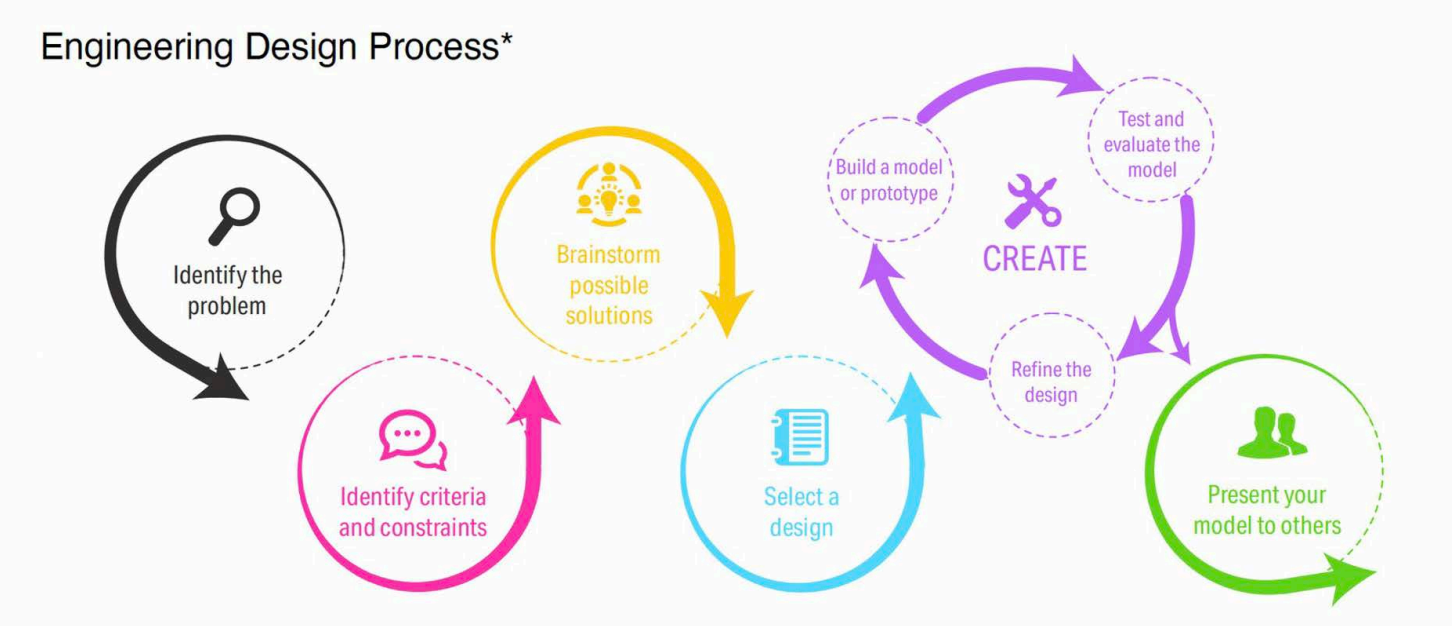
Secondary Engineering Design Packet



Student Packet (Grades 6-12)

https://nasaeclips.arc.nasa.gov/



IDENTIFY THE PROBLEM

- Identify the goal, problem, or challenge.
- Ask all questions you have about the problem.

IDENTIFY CRITERIA AND CONSTRAINTS

- Identify the conditions that must be met to solve the problem.
- Identify anything that might limit a solution such as cost, availability of materials, and safey.

BRAINSTORM POSSIBLE SOLUTIONS

- Research what others have done to solve the problem.
- Generate new ideas for solutions.

SELECT A DESIGN

- Choose two or three brainstormed ideas and sketch each design.
- Select one design to construct and list reasons to justify your choice.

CREATE

Build a Model or Prototype

- Create a plan to build a model or prototype.
- List materials needed to construct the model or prototype.
- Build the model or prototype.

Test and Evaluate the Model or Prototype

- Test the model or prototype to see if it works.
- List the strengths of the design.
- List the weaknesses of the design.

Refine the Design

- Make improvements to the design.
- Justify the changes.

PRESENT YOUR MODEL TO OTHERS

- Explain your ideas to others.

* An accompanying teacher implementation guide is available on the NASA eClips website.

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Engineers use the engineering design process (EDP) to solve problems. Their knowledge of science, mathematics, and other subjects helps them design possible solutions. Work as an engineer to navigate through the iterative steps in the EDP to solve this challenge.

Problem Scenario

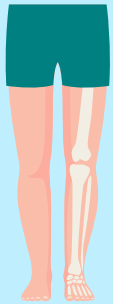
Being physically fit is important for everyone, but it is especially important for astronauts living and traveling in space. Being in space for extended periods of time put extra stress on their bodies. To counteract the stresses of living in space, astronauts must exercise a lot.

Biomechanics is the science of how our body moves. This includes how muscles, bones, tendons, and ligaments work together so we can perform different tasks. Some examples are using our hands and arms to lift a fork to eat. We swing our feet to kick a ball. We bend our knees to sit, stand, walk, and jump.

Assume the role of a biomedical engineer to design and build a Biomechanical Jumping Machine to show the importance of muscles in movement. Your machine must jump vertically at least 3 feet or 91.44 centimeters or more.

Resources and Activities to Build Knowledge

Jumping Demo



1. Stand up tall with your legs straight and jump as high as possible without bending your knees.

How does it feel?

2. Bend your knees and jump.

Was the straight leg or bended knee jump higher?

Rubber Band Testing

1. Collect rubber bands of different sizes and thickness.

2. Put on safety goggles.

3. Stand behind the line.

4. Shoot the rubber bands at the target on the wall.

In what ways did the types of rubber bands respond differently?

Articles

Astronaut Exercise
Melissa L. Gaskill, MAY 20, 2024
https://www.nasa.gov/missions/station/iss-research/astronaut-exercise/

Anthropometry, Injury Biomechanics, & Ergonomics - Improving Living and Working Conditions in Space
Robert E. Lewis, March 16, 2023
https://www.nasa.gov/directorates/esdmd/hhp/anthropometry-and-biomechanics/

Counteracting Bone and Muscle Loss in Microgravity
Space Station Research Integration Office, December 1, 2023
https://www.nasa.gov/missions/station/iss-research/counteracting-bone-and-muscle-loss-in-microgravity/

Videos

What is Biomechanics? by Utah Valley University
https://youtu.be/FsOR2zALauo?si=sr-4XAYr2lLz-1nz

Biomechanics of Sports: Running, Jumping, and Hitting by Technovation
https://youtu.be/u6Ogy4JtRcY?si=2Jq579KZa96xfW_1

NASA eClips Our World: Exercise in Space
https://nasaeclips.arc.nasa.gov/video/ourworld/our-world-exercise-in-space
Find out why exercise is so important to the astronauts who travel into space.

NASA eClips Our World: Exercise Equipment
https://nasaeclips.arc.nasa.gov/video/ourworld/our-world-exercise-equipment
Learn about the exercise equipment used by the astronauts in space to keep astronauts fit and healthy.

Identify the Goal, Problem, or Challenge

State the problem.

Ask all questions you might have about this problem.

What have others done to solve this problem?

Research what others have done to solve this problem.

Person/Group	Their Solution	How did it work?

Identify and describe expected outcomes.

Identify Criteria and Constraints

Identify any requirements. Identify anything that might limit a solution, such as cost, availability of materials, and safety. What additional challenges affect possible solutions?

Criteria & Constraints: For this challenge, you will follow the same steps as NASA scientists and engineers to design and build a biomechanic jumping machine.

- The biomechanic jumping machine must jump 120 centimeters ($3\frac{15}{16}$ feet) or more in the air vertically.
- You must use the potential and kinetic energy stored in elastic/rubber bands as a force.
- The jumping machine must carry a weight of 8 grams or more.

More Resources to Build Knowledge

STEMonstrations: Newton's Third Law of Motion
https://youtu.be/dCF--YOjiOw?si=iK6SwFPAiHikYFXv

STEMonstrations: Kinetic and Potential Energy
\https://youtu.be/OpxGp2P48kI?si=oimOMrgef0R-lhNt

STEMonstrations: Exercise (Bone Density and Muscle Stress in Microgravity)
https://youtu.be/lssYrWDvv6w?si=QoylcdxT4NvrlWaU

Musculoskeletal by NASA Glenn Research Center
Article with videos and graphics
https://www1.grc.nasa.gov/space/human-research-program/computational-modeling/musculoskeletal/

Brainstorm Possible Solutions

Generate new ideas for solutions. Consider what others have done to solve this problem and include prior research.

Select a Design

Make a detailed sketch of the design you want to try from your brainstormed list. Label each sketch, dimensions and the materials included in the drawing.

Make a list of materials you will need. Describe why you have chosen these materials.

Material/Object	Quantity	Reason for Selection

Create
Build a Model or Prototype

Follow your plan and drawing to build the model or prototype.

- How did your drawing help you build your model or prototype?
- How would your drawings and notes help others?

If there are any differences between your drawing and your model or prototype, explain why you made these changes.

Test and Evaluate the Model or Prototype

Test your model. Describe the process you use to test your design.

Record your results.

Refine the Design

Make changes to improve your model or prototype. Go back and mark any changes you made on your original drawing.

Evaluate the results of the tests for strengths/weaknesses and successes/failures.

- Does your design solve the problem?
- Is it headed in the right direction?

How did the constraints affect the design? Discuss what changes or compromises had to be made.

Peer Review

Share your design with others working on the same challenge to get feedback.

Present Your Model or Prototype to Others

Explain your ideas to others. You might:

- Make a poster or infographic.
- Give a speech.
- Make a short video.
- Make a multimedia presentation.
- Write a letter to NASA convincing them to build your model or prototype.

  Be sure to include sketches, pictures, data, or graphs in your presentation.

What did you learn or discover? How does your design solve the problem?

How did you work as a team? What was each person's valuable contribution?

What might be your next problem to solve?

Engineering Design Challenge Checklist for Secondary

Engineering Design Process

My work shows evidence of all parts of the engineering design process.

- ☐ I identified and explained the problem in detail including all criteria and constraints.
- ☐ I researched how others have solved the problem.
- ☐ I listed possible solutions and selected one.
- ☐ I developed a plan for construction that includes a diagram of the solution that explains the parts and their purpose, and a list of Mark if trueneeded materials and tools.
- ☐ I followed the plan to create the model or prototype and noted any issues, the cause of the issue, and how to resolve the issue.
- ☐ I tested my solution and recorded the results accurately in organized data tables. I identified the strengths and weaknesses in the design of my model or prototype.
- ☐ I made and documented modifications to improve the design based on test results.
- ☐ I presented my model or prototype to others and explained how I used the design process to solve the problem. I shared what I discovered and learned.

Collaboration / Teamwork

I shared responsibilities for completing the work. I showed an appreciation for the contributions of each team member.

- ☐ I voluntarily engaged in all steps of the project and completed the tasks required by my team role.
- ☐ I listened to the ideas and feedback of team members.
- ☐ I offered solutions and compromises to solve conflicts that came up.

Content Knowledge and Skills

I thoughtfully discussed and applied specific content knowledge related to the design challenge.

- ☐ I showed how bones and muscles work together.
- ☐ I explained the importance of exercise for healthy bones and muscles.
- ☐ I measured to the nearest 16th of an inch and to the nearest millimeter.
- ☐ I used the rubberbands and cups to show and identify kinetic and potential energy.