Engineering for Sport

Overview

A video introduction describes how engineers team up with a rock climber to redesign a prosthetic leg for use in climbing. Students tackle the same challenge for a different sport or activity.

Guiding Question

How can we use technology to re-create the functions of the human body for specific tasks?

Objective

Students will be able to observe the functions of the human body and design a technology that can replace those functions.

Background

Biological limbs have capabilities that are difficult for prosthetics to replicate, especially for users who participate in sports. Joints such as the ankle, hip, and shoulder have many degrees of freedom. Electrical signals from neurons control the body's movements and return sensory information, giving athletes the fine motor control they need for top performance.

Engineers use high-tech materials, computer-aided design, and sensors to design prostheses that can perform repeated, complex, forceful, and precise movements. Prostheses can include sensors that artificially extend the nerves in the amputated limb, allowing an athlete to control the prosthesis's movements. Some, such as the limb shown in the Engineering for Sport video, behave in the same way as natural limbs with moving joints. Others, such as running "blades," use completely artificial designs crafted from specialized materials rather than moving parts. As technology becomes more advanced, prostheses often look less lifelike but move more naturally.

Time: 15–20 minutes

Grade Level: 6–8

Vocabulary

- **Constraints**
- **Criteria**
- **Degree of freedom**
- **Prosthesis**
- **Prosthetics**

Standards

NGSS MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

NGSS MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

CCSS.ELA-Literacy.W.6.2.d

Preparation

For this activity, the educator will need the following:

- Video: *Engineering for Sport* (2:36)
- A way to show the video to students
- 1 copy of Blade Runners (English | Spanish)

For this activity, each group of 2–3 students will need the following:

- 1 copy of Make It Move (English | Spanish | Answer Key)
- pencils
- erasers
- artist's body model with flexible joints (optional)

EiE® Connections

Learn more about the Engineering Design Process in the EiE Video Library.

Continue your classroom activities with these units:

Engineering Everywhere®

- Engineering Prosthetic Tails
- Engineering Safety Helmets

Museum of Science Connections

The Engineering Design Workshop, Powered by MathWorks includes real stories of people using the engineering skills of creativity, breaking down problems, and iteration. Access these videos online through the *Engineering Stories virtual exhibit*.

Listen to the Pulsar podcast episode "Can We Restore Mobility to Spinal Injury Patients?" to learn about another approach to restoring mobility.

Family Connections

Continue the engineering at home with these activities:

- Trophy Triathlon
- Pass the Peppers

Credits

The Engineering for Sport video was developed with the generous support of MathWorks, Sophia and Bernard M. Gordon, Margaret and Jim Wade, and Jack Turner and Tee Taggart.

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Activity Instructions

These steps offer support for implementing the *Engineering for Sport* video introduction and follow-up activity with students

1. Before showing the video introduction, discuss these questions:

> **Q: What does a prosthesis or a prosthetic device do?**
>
> *A: Possible responses include helping people who are missing a body part walk, run, or pick up objects.*

> **Q: What kinds of movements does the body make during sports?**
>
> *A: Accept all responses. Possible responses include quick movements, stretching and bending, colliding with other people or objects, or using equipment.*

If a student in your classroom has a prosthesis or knows someone who does, welcome their valuable perspective in this conversation. However, do not single them out by asking them directly to share.

2. Play the video Engineering for Sport (2:36). This video shows how engineers work with an elite rock climber to make a prosthesis, or artificial replacement body part, specifically for rock climbing.

3. After showing the video, discuss these questions:

> **Q: Why are prostheses a useful technology?**
>
> *A: Accept all responses. Possible responses include that they help people do the sports they enjoy or they help people stay active.*

> **Q: How is the rock-climbing prosthesis different from other prosthetic legs?**
>
> *A: Possible responses include that the climber can move it by thinking and that the ankle can move in more ways than other prostheses.*

Q: Criteria are what a successful design needs to do or have, and constraints are limits on a design. What are the criteria and constraints for the engineers making a prosthesis for rock climbing?

A: Possible responses include that the ankle needs to move and the leg must be light and strong at the same time.

Q: What other features could you add to a prosthetic leg to make it even better for rock climbing?

A: Accept all responses. Possible responses include grippy material, suction, or a smaller "foot" that could fit into crevices.

4. Display the *Blade Runners* (English | Spanish) visual resource. Point out how the engineers of this running prosthesis did not try to make it look lifelike by including a complicated moving joint. Instead, they used a single piece of a material that could bend and flex. Discuss these questions:

Q: How is the blade different from the prosthesis you saw in the video?

A: Possible responses include that it doesn't have moving parts and it isn't shaped like a leg or foot.

Q: Would the blade work well for rock climbing?

A: Possible responses include that it would not because the ankle cannot rotate.

5. Have students form small groups. Distribute the *Make It Move* (English | Spanish) handout to students and introduce the follow-up activity. Tell students that they will take on the role of the engineers in the video, but they will design their prosthetic legs for a different sport or activity.

To shorten the activity or provide extra support, offer a limited selection of sports or activities that move the leg in specific ways, such as ice skating, long jump, and soccer. Have students record their selected sport or activity on the handout.

6. Explain that students need to understand the degrees of freedom, or different directions the leg joints move or rotate during the sport or activity. Normally, engineers work closely with prosthesis users to create a design. For this brief activity, students will rely on what they know about participants in their sport or activity. Group members can take turns drawing, describing, or demonstrating gestures, poses, or actions that a person might do during the sport or activity. If available, they can use an artist's model to take a closer look at these poses.

7. Have students work together to draw a simple diagram in the first box showing how the biological leg moves during their chosen sport or activity. Emphasize that this drawing is meant to communicate information, so it does not need to be a work of art. Encourage them to add arrows to describe the degrees of freedom, as shown beginning at 1:11 in the video. Have them include dotted lines showing how signals travel from the brain to the leg along nerves.

8. In the second box, have students sketch or describe a concept for a prosthetic leg that can reproduce the same degrees of freedom. Encourage students to include an explanation of how the athlete controls the leg. Remind students of the criteria and constraints for a prosthesis used in sports or activities.

9. After completing the activity, discuss these questions:

> **Q: What makes a leg hard to re-create using artificial materials?**
>
> *A: Accept all responses. Possible responses include the body's range of motion and its ability to control movements using nerve signals.*

> **Q: What are the design criteria and constraints of an artificial leg for use in the sport or activity you chose?**
>
> *A: Accept all responses. Possible responses include light weight, high strength, and precise control.*

> **Q: How would you improve your design if you had the opportunity?**
>
> *A: Accept all responses.*

> **Q: How can we use technology to re-create the functions of the human body for specific tasks?**
>
> *A: Possible responses include using sensors to transfer nerve signals or using materials that mimic the body's motions.*

Glossary

Constraints
limits on a design

Criteria
what a successful design needs to do or have

Degree of freedom
an angle or direction in which an object can move or rotate

Prosthesis
an artificial device that takes the place of a missing body part

Prosthetics
the design of artificial replacement body parts