Prosthetic Leg Lesson Plan
Biomedical Engineering

Objective

- Connect science and math to fun, hands-on projects like constructing a prosthetic leg.
- Develop problem-solving skills.

Standards and Objectives

- 7th Grade Standard 3, Objective 2
- Biology Standard 3, Objective 1

Learning Outcomes

Students will learn:

- About prosthetic limb design and biomedical engineering
- Abstract thinking and creative design skills
- Rudimentary building skills

Essential Questions

- Who makes prosthetic devices?
- How does anatomy relate to engineering?
- How do engineers help change lives?

Time Required (Itemized)

- Topic introduction – 30 minutes
- Students' design brainstorm – 30 minutes
- Proposal Sheet – 30 minutes
- Leg Construction – 150 – 200 minutes (option: students can construct their leg at home or in the classroom).
- Presentations – 50+ minutes (depends on number of groups and number of students)

Assessments

- Design guide (attached)
- Prosthetic Leg Proposal Sheet (attached)
- Completed leg
- Students should give 5-10 minute presentations about their leg. This is the chance for students to explain their designs and reasoning behind their design. This is also a great tool to make students thoroughly think about their prosthetic design, so they don't just tape PVC pipe and called in a "prosthetic leg".

Materials

- Drill

- Hot glue gun
- Scissors
- Bolts
- Screws
- Hot glue
- PVC
- 2x4 wood
- Plungers
- Foam
- Painter sponge
- T-shirts
- Towels
- Sheets
- Rope
- Bungee cords
- Velcro
- Rubber bands

***The material list can be unlimited. Offer materials as you see fit. For this activity, students can also be responsible for bringing their own materials.

Lesson Description

Biomedical engineers create prosthetic limbs for a variety of disabilities and injuries. Prosthetic limbs are created for a whole range of people from small children to strong, muscular athletes. Engineers must take into consideration the client, and craft a prosthetic device that will benefit that person regardless or size, activity level, gender, or age. This prosthetic device activity will focus on creating a lower leg prosthetic. Major design concerns for a lower leg prosthetic leg design include: leg structure, cushioning system, attachments, stabilizing system, and connections throughout the prosthetic device.

Leg Structure:

The lower leg structure should be an average height (14 – 18 inches). If the student decides to make the leg longer or shorter, then make sure they specify for whom the leg is being constructed. A basketball player will need a longer prosthetic. A young child will need a smaller design. Students can also make their leg adjustable just like the lower section of crutches. Give students a continuum of design ideas for the basic leg structure. Some materials to suggest for the leg structure: PVC pipe, plunger, foam, wood 2x4, metal straps, etc. The list of possible materials is endless. This is a good start.

Cushioning:

The client will rest his or her upper thigh on the top of the lower leg prosthetic. The upper thigh will slightly rub or bump the top of the prosthetic leg every time the client walks. Regular rubbing or bumping can be very painful. The client's comfort must be

considered during the design. Material suggestions: the top of a plunger, large painter sponge, old t-shirts, sheets, towels, foam, etc.

Attachments:
How the prosthetic will attach to the client's thigh is critical. If the leg will not stay attached to the client's thigh, then how will the client be able to use his or her prosthetic effectively? This is the trickiest part for students to design. Students can create a variety of attachements using bungee cords, Velcro, rubber bands, rope, straps, and material. Some students may choose to attach the prosthetic to the leg around the thigh. Others may choose a design in which they attach the prosthetic to a belt.

Stabilizing:
The leg needs to be stabilized on the bottom with a shoe or some type of wide structure with traction. Typically, the leg structure resembles some type of post. The bottom is narrow and hard. It is difficult to balance on a hard, narrow structure, and the bottom can slip on hard floors.

Connections:
The students will need to connect all the pieces of their designs together. Bolts, screws, hot glue, and duct tape are typically used.

Questions to ask students:

- How will the client's height and weight affect your design? Will you need to make it shorter, taller, thicker, or narrower?
- How much weight should your leg hold?
- What will happen if your leg is not stable?
- What will happen if your leg attachment does not securely hold the prosthetic to the client's thigh?
- What about aesthetics? Do you think your leg should be able to fit under pants? Should you be able to change the shoe, so the client can always match his or her shoes?
- What about cost? How much money do you want to spend on materials? Can you build a quality prosthetic with a limited budget?

Procedure:

- Introduce the topic to the students. You can use the Prosthetic Leg presentation, or create your own introduction.
- Make sure you walk the students through each section they will need to design: leg structure, cushioning, attachments, stabilizing, connections, etc.
- Talk about different materials they can use
- Have your students fill out a Design Guide (attached) as the class talks about the design requirements and materials. The design guide will give them some direction as they brainstorm their own designs.
- Give them an opportunity to brainstorm their own design. Encourage them to sketch their design and start to determine materials.

- After the class has had enough time to create an initial design, then introduce to the class the Prosthetic Leg Proposal Sheet.
- The proposal sheet will help the students clarify their design and examine some advantages and weaknesses of their design. The proposal sheet also includes a cost analysis sheet.
- Get out materials, and have students start building their legs.

Notes from the College of Engineering:

- You can decide to have the students work independently or in groups. Either way will work.
- You will have a couple options about obtaining materials. First, you can insist the students supply all their own materials. Second, you can supply all the materials and make the students work with a limited amount of supplies and/or budget. Third, you can do a combination. For example, provide the pvc, screws, bolts, and duct tape and then require the students to bring the rest.
- When this activity was done with 7th & 8th graders, the College supplied each team with $6 worth of supplies. The students were required to bring the rest from home.
- I used the proposal sheet to assign students into groups. I attempted to match similar designs and material requests for each team. This way the students were able to work independently initially and think about how they would create a prosthetic lower leg, but they also got to work with a group.