Western Engineering Outreach

Artificial Bicep

Grade 3-5

Meet Today's ENG HERO!

Emily Lalone – Assistant Professor with Western Engineering

Emily Lalone is an Assistant Professor in the Department of Mechanical and Materials Engineering Department at Western University Dr. Lalone completed her BSc (Medical Science 2007) and her PhD (Biomedical Engineering 2012) at Western University. Dr. Lalone also co-directs the Musculoskeletal Biomechanics Laboratory at Western University. Her research interests are both interdisciplinary and translational and involves using research from Biomedical and Mechanical Engineering, Medical Imaging, Orthopedic Surgery and Rehabilitation. To learn more about Dr. Lalone, please visit:

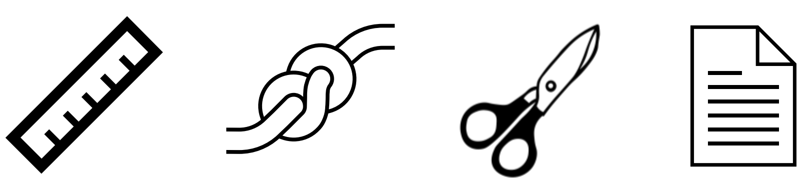
https://www.eng.uwo.ca/mechanical/faculty/lalone_e/index.html

Learning Goals:

- Grade 3 : 2.4 use technological problem-solving skills and knowledge acquired from previous investigations, to design and build devices that use forces to create controlled movement
- Grade 4: 2. investigate ways in which pulleys and gears modify the speed and direction of, and the force exerted on, moving objects
- Grade 5: 3.1 identify major systems in the human body (e.g., musculoskeletal system) and describe their roles and interrelationships

Materials:

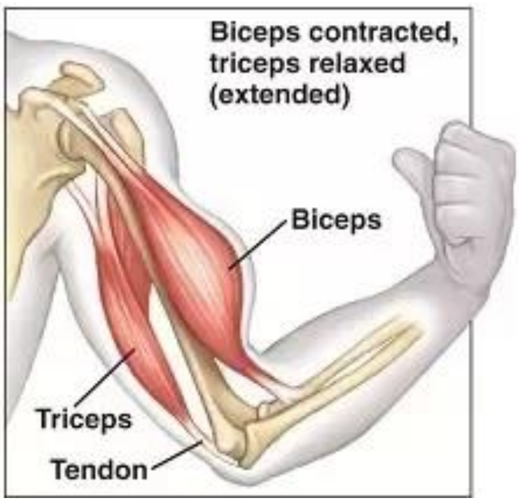
- Rubber bands of different lengths (or tubing)
- Thin rope
- String
- Scissors
- Paper
- Ruler
- Optional: Spring scale

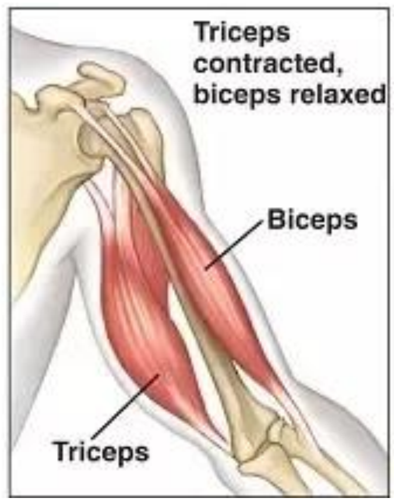


Engineering and Science Connections:

Background:

Who can guess how many muscles it takes to smile? (Answer: 17) How about to frown? (Answer: 43) Muscles often work together in teams to accomplish certain motions. Not all muscles work in such large groups though; most work in pairs. The reason muscles work together is because muscles only do work when they are contracting. For example, when you bend your arm at the elbow, your bicep is contracting, which means your bicep is pulling on the forearm, while your triceps are relaxing. When you straighten your arm, the opposite occurs. Your triceps are contracting (or pulling) while your bicep is relaxing. The teamwork between the biceps and triceps enables us to bend and unbend our arms. Without one of these muscles our arms would lose a lot of their functionality. How do you think engineering might be similar to muscles? Just like muscles, engineers work together in teams to achieve certain goals.





Has anyone ever had, or known someone who has had, a muscle cramp, or a similar problem in which you cannot use one or more of your muscles? When one or more of your muscles are injured, the teamwork between muscles is affected because the injured muscle can no longer do its part. Imagine if your bicep was hurt in your right arm, could you touch your right shoulder? No – well, not in the same way that you might usually touch your shoulder. You would need other muscles to get the job done, such as using your left arm to raise your right hand to your shoulder.

Most muscular system problems are repairable. The human body is an amazing healer in itself and this includes its ability to repair its muscular system. An important component of healing is rest. If a damaged muscle is continuously used, it does not heal quickly and it has a greater chance of being reinjured. In their busy lives, most people do not give themselves adequate time to rest properly; they continue moving as required by their everyday activities.

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Biomedical engineers can help. A biomedical engineer is a person who applies his/her knowledge of how things work towards helping the human body. These engineers can design devices to speed up the recovery of muscles so people can be back to their work sooner, or they design devices that allow a person to work without using their injured muscle so that the muscle can rest and recover naturally. Biomedical engineers play an important role in the health of people in a range of countries and situations all over the world.

Vocabulary / Definitions:

<u>Bicep:</u> The muscle located in front of the upper arm.
<u>Biomedical Engineer:</u> A person who blends traditional engineering techniques with the biological sciences and medicine to improve the quality of human health and life.
<u>Contracting:</u> (of a muscle) To become shorter or tighter in order to effect movement of the body.
<u>Engineer:</u> A person who applies his/her understanding of science and math to creating things that benefit humanity and our world.
<u>Muscular System:</u> The anatomical system of a species that enables its movement.
<u>Tricep:</u> The muscle located in the back of the upper arm.

Activity:

Let's get started!

Your challenge is to create a product for a bicep strain that provides assistance to the muscles so that it does less work to bend the arm. The designs should enable the wearers to continue their working days while helping their biceps rest so that they heal quickly and correctly.

Example shoulder and hand harnesses:

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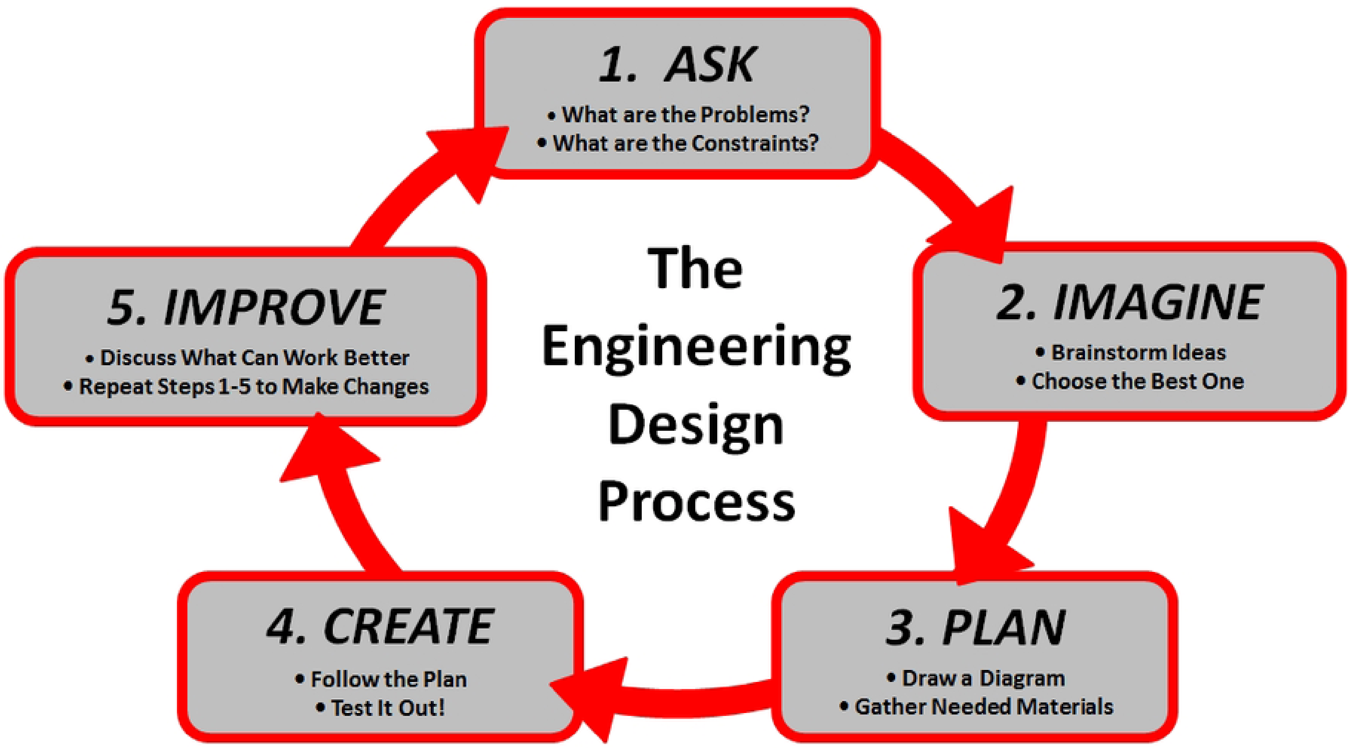
Test your device on two criteria:

- force applied -how much pulling force a device has when the arm is unbent
- distance applied. -how far a device helps the arm bend.

A larger force and longer distance is desired, obviously within reason; we do not want the rubber bands to break or be so tight that students cannot unbend their arms.

Engineering Design Process:



Helpful Hints:

- A shoulder harness might have two loops of rope connected, like a figure eight, so that one goes around the arm and the other goes around the chest
- A hand harness might also be created from rope made into a figure eight with one loop going around the middle finger and the other going around the wrist.
- Use the rubber bands to connect the shoulder harness to the wrist harness so that they pull on the arm when it is straight.

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Example final biomedical design product.

- Take about five minutes to "ask" questions by researching more about the arm and existing harnesses and then "imagine" how you could solve the design challenge.
- Next "plan" your designs on a piece of paper. Pick the one that looks like it would work the best with the materials you have.
- After picking a design, take about 20 minutes to "create" your design.
- When you are done, test your device.
    - To test the applied force of a device, wear it, but keep the hand harness off. Then pull the hand harness down so that the rubber bands are as long as they would be with their arm was extended. Then attach the spring scale to where the rubber bands meet the hand harness and measure the force being applied by the rubber bands. A stronger force means the less the bicep has to work to bend the arm.
    - To test the distance, the machine applies a force to the arm, have students wear their device and pull the hand harness down, similar to the last test. Then, place a ruler where the rubber bands attach to the hand harness. Slowly raise the hand harness until the rubber bands are no longer stretched. Measure the distance the rubber bands were stretched. The greater the distance, the longer the machine helps raise the arm. Have students record their team measurements on the board.

What Did You Learn?

- Today we learned about the human muscular system and about different muscles and their interactions
- We also learned about the engineering design process and about designing a system to help support muscles in recovery

Future Learning

- What are some other systems or harnesses you could make to support other body parts?
- Investigate these further by learning about what types of muscle support harnesses already exist and how they are similar.

Share your creations!

We would love to see what you made. Email as at discover@uwo.ca or tag us on social media.

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Thanks for discovering with us!