# Teacher's Notes

## Broken Bones—Flinn STEM Design Challenge™

### Materials Included in Kit *(for 8 student groups)*

- Cardboard tube with foam insert, 9″, 8
- Foam sheets, peel and stick, 8
- Plastic yarn needles, 8
- Polyurethane foam pieces, 8″ × 10″, 8
- Rubber bands, 20
- Scalpels, disposable, 8
- Yarn, 364 yards

### Additional Materials Required *(for each lab group)*

**Optional extra tools for group use:**

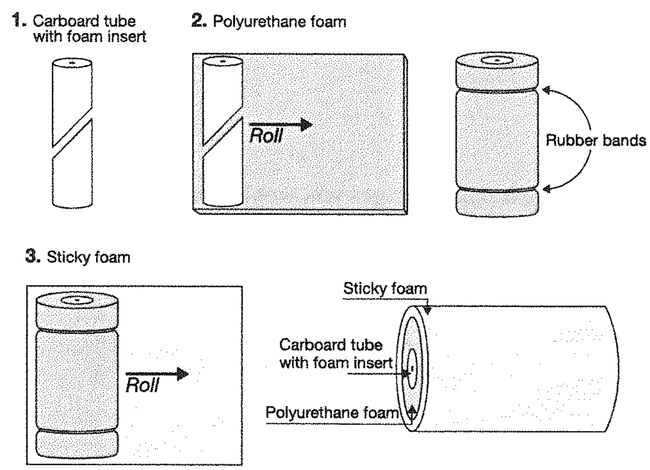
- Screw drivers
- Hammers
- Screws, 1″ or less
- Nails, 1″ or less

### Additional Material Required *(for* Pre-Lab Preparation*)*

Hand saw (optional)

### Pre-Lab Preparation

1. This kit includes four oblique fractues and four transverse fractures. To create other fractures see Teaching Tips.
2. Place a precut, cardboard tube with foam insert onto a 8″ × 10″ piece of polyurethane foam and roll. Place a rubber band at each end to hold the foam and cardboard tube in place.
3. Remove the backing from a sticky foam sheet. Roll the polyurethane foam and cardboard tube in the sticky foam sheet so the open ends are aligned (the portions that overlap should be considered the back of the leg—opposite where the students will make their incisions).




### *Safety Precautions*

*Ensure students have experience and/or direction on working with sharps. Discuss which tools are allowed to be used in the classroom. Have students wear protective eyewear and follow all laboratory guidelines during the activity. Remind students to wash their hands thoroughly with soap and water before leaving the laboratory.*

### Disposal

All materials are considered nonhazardous and can be disposed of in the regular trash. The scalpel is disposable and should be discarded in a sharps container.

## NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

**Disciplinary Core Ideas: Middle School**
MS-LS1 From Molecules to Organisms: Structures and Processes
LS1.A: Structure and Function
MS-ETS1 Engineering Design
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution

**Disciplinary Core Ideas: High School**
HS-LS1 From Molecules to Organisms: Structures and Processes
LS1.A: Structure and Function
LS1.B: Growth and Development of Organisms
HS-ETS1 Engineering Design
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution

**Science and Engineering Practices**
Asking questions and defining problems
Developing and using models
Planning and carrying out investigations
Constructing explanations and designing solutions
Obtaining, evaluation, and communicating information

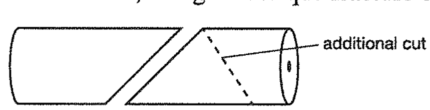
**Crosscutting Concepts**
Systems and system models

## Lab Hints

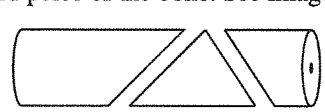
- Enough materials are provided in this kit for 8 groups of students. Each part of the lab can reasonably be completed in one 50-minute class period each (totaling 4 days).
- Students design their medical implantation device and will need to bring in their own materials to create and install the device. Discuss with students that the materials used to create their medical device do not need to be sophisticated. Materials can be creative and from around the house.
- Surgeons will usually avoid cutting through muscle tissue to repair fractures due to increased recovery time. However, the design of the femur for this lab uses foam; therefore, students will need to cut through muscle rather than separate or shift the tissue.
- X-ray fractures: #1 Transverse Fracture, #2 Oblique Fracture, #3 Spiral Fracture and #4 Comminuted Fracture.
- This kit includes four x-rays, groups can share the x-rays or photocopies can be made for each group.

## Teaching Tips

- This STEM activity incorporates the engineering design process into a life or biomedical science activity. It can be used during an anatomy or human body unit or in a health class.
- This kit comes with 8, precut, femure models. There are four oblique fractures and four transverse fractures. If a comminuted fracture is desired, using an oblique fracture cut a third peice of the bone. See image below.




Precut, cardboard tube with foam insert—oblique fracture



Comminuted fracture

The foam insert will need to be glued to the small peice of cardboard tube to maintain its placement.

- The instructor must decide what types of equipment/tools students will be allowed to use. Power tools are not necessary. A 1-inch screw can be screwed into the cardboard tube with foam insert with a screwdriver.

# Teacher's Notes *continued*

- Be sure to discuss safety and use of scalpels, including disposal in a sharps container.
- Place a time constraint on the actual surgical procedure (Part IV) to relate to the use of anesthesia or patient tolerance.
- It is reasonable to allot extra time for the design and testing of the prototype (Part III).
- For Part III. Prototype, have students bring in paper towel rolls filled with paper towel, newspaper, etc. to test their prototypes prior to the final design and Part IV. Surgery and Implanation.
- Extensions to the activity can include adding additional characteristics to the thigh, complicating surgery. Ideas include veins and arteries, blood or connective tissue. Long thin balloons can be filled with fluid and placed inside the foam for blood vessels, ketchup can be used as blood, and rubber bands can be included as connective tissue (tendons and ligaments). Other possible extensions include students assembling the broken femurs and trading with another group or the inclusion of muscles (drawn onto the polyurethane foam) that groups would need to avoid during surgery to minimize tissue damage.

## Answers to Pre-Lab Questions

1. What is a biomedical-engineered device? Give two examples.

   *A biomedical engineered device does not include pharmaceutical (drug) or biological (vaccine) treatment methods, rather it combines engineering with medical science to advance healthcare treatment. Examples include a pacemaker, mircro-keratome and excimer lasers, and projection radiography (X-ray).*

2. Look at the X-ray in Figure 2 and determine which type of femoral shaft fracture is shown.

   *Oblique femoral shaft fracture.*

3. What type of medical devices designed by biomedical engineers would be utilized to diagnose and surgically repair a femoral shaft fracture?

   *Answers may vary but can include implants and medical imaging. Medical imaging would be a device designed by biomedical engineers that would be useful in diagnosing the type of fracture the patient endured. These devices give doctors the ability to "see" what is not visible directly. Most likely an X-ray would be utilized, however if the fracture was very thin, a CT scan may be used. Implants are devices placed inside the body to provide support to the organ/tissue. Many are made of metal or plastic.*

## Sample Data and Observations *(Student answers may vary)*

1. What is the problem being addressed in this activity?

   *The problem in this activity is designing a medical device that will repair a broken femur. Identification of the type of femoral shaft fracture is based on the X-ray and teacher-created femoral shaft fracture. The femoral shaft fracture is either oblique, transverse, spiral or comminuted.*

2. Record the research that was discovered as potential solutions to the problem.

   *Typical types of medical devices used to fix femoral shaft fractures include external fixation (pins and screws attached to bar or plate outside the leg), intramedullary nailing (titanium rod through marrow canal and screwed into hip and knee), or plates and screws (metal plates that are screwed into bone to hold bone fragments together). Most students will design an intramedullary nail (if the marrow canal is drilled out by the teacher) or plates and screws.*

3. Develop a step-by-step procedure of how the surgery will be performed. Include a description and sketch of the possible device(s) that will be used to correct the problem and how it will work.

   *Student answers will vary. Students must include the type of femoral shaft fracture, a sketch of the implant device they intend to use (plate, screws, intramedullary nail), the equipment required to install the implant device (screwdriver, metal rod, screws) and the dimensions of the implant device. Discussion of the surgical process should include making the incision through the skin and muscle, holding the tissue off the bone while affixing the implant device, how the implant device will be attached, whether it will be on one side or both, and the process of stitching the skin and muscle back together.*

*Example:*

*— Oblique femoral fracture*

*— Implant device: plates with screws*

*— Equipment needed:*

*Phillips screwdriver*

*1″ screws, 4*

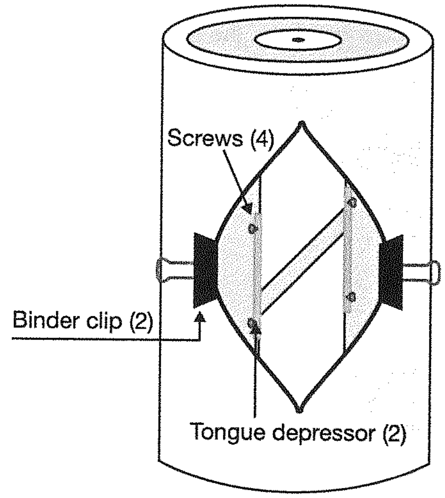
*Large binder clips, 2*

*Tongue depressors (5 cm long × 2 cm wide), 2*

*Permanent marker*

*Yarn*

*Needle*




*Procedure:*

1. *Determine the location of the break by feeling along the skin.*
2. *Mark the skin where the incision will be made.*
3. *Make incision through the skin.*
4. *Make incision through the muscle.*
5. *Secure the skin and muscle away from the bone using the binder clips.*
6. *Stabilize the bone and affix the plate by screwing one tongue depressor to the left side of the bone using two screws, one above the fracture and one below the fracture.*
7. *Screw the second plate (tongue depressor) to the right side of the bone using two screws, one above the fracture and one below the fracture.*
8. *Remove binder clips and pull muscle over bone.*
9. *Pull skin over muscle.*
10. *Suture the skin and muscle using yarn and needle.*

4. After discussing and refining the individual designs, collaborate with your group to design the final implant device and develop detailed procedural steps for performing the surgery.

   *Student answers will vary. This will be similar to Question 3, but will also include the names of group members and their responsibilities and roles during the lab activity.*

5. Construct a prototype—a preliminary model—of the implantation device that will repair the femoral shaft fracture. Record the strengths and weaknesses of the prototype and any changes that were made for the final design.

   *Student answers will vary. Strengths may include the ease of affixing the implant device to the "bone" and how secure the bone is held together. Weaknesses may include cracking or breaking of device while affixing the device to the bone, length of the device, ability to screw into the "bone" and how secure the bone is held together post-operation.*

6. Perform the surgery, which includes incision, implantation of the device, and suturing the tissue, to repair the broken bone. Record each step with great detail. Upon completion of the surgery, evaluate the effectiveness by examining the femur by checking for strength and stability, feeling the skin for abnormalities, and the cleanliness of the sutures (scar).

   *Student answers will vary but must include precise details. Step-by-step notes should be taken during the surgery by the recorder and copied by the remaining group members. Evaluation of the procedure should be discussed here. It should include the secure placement of the bone, the length of time to complete the surgery, the look of the stitches, and overall group work.*

## Teacher's Notes *continued*

7. In paragraph form, write a post-operation summary about the surgical procedure to the patient and their family explaining what was performed and the success of the surgery.

   *Student answers will vary. The summary should include all the steps from the Engineering Design Process graphic organizer that is on the first page of the* Broken Bones Worksheet.

8. Discuss what changes you would make to your biomedical device and surgical procedures for the future.

   *Student answers will vary based on effectiveness of their device.*

## Reference


Sakakeeny, J. Repairing Femoral Fractures. *Integrating Engineering and Science in Your Classroom*; Brunsell, E.; NSTAPress: Arlington, VA, 2012.


## The *Broken Bones—Flinn STEM Design Challenge™* is available from Flinn Scientific, Inc.

| Catalog No. | Description |
|---|---|
| FB2131 | Broken Bones—Flinn STEM Design Challenge™ |

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