

The Human Arm Model Lab

Introduction:

In this experiment you will examine two main muscles in the arm, the biceps and triceps, by simulating the muscles and motion of an actual human arm. The arm model is capable of measuring changes in position at the shoulder and elbow using built-in potentiometers. Cords are used to represent the biceps and triceps muscles. You can pull the cords to make the arm move and use force sensors to measure the forces exerted by the muscles.

Equipment:

Supplies needed in addition to arm model components:

- ◆ Table clamp
- ◆ 60 cm rod
- ◆ Right angle clamp
- ◆ Short rod
- ◆ 2 force sensors w/ 1 screw from the motion sensors

Please see figures 1, 4-8 included with the arm model for information on how to attach the cords to stimulate the muscles. The triceps is straightforward, but there are three biceps insertion points (inner, standard and outer) that may be used.

Set up

Angle Sensor

1. Connect the cable from the elbow to Channel 1 of the angle sensor
2. Connect the cable from the shoulder to Channel 2 of the angle sensor
3. Connect the angle sensor to your PASPORT interface (note: the PASPORT input will be automatically recognized by your computer – it is simpler to use as you do not need the interface box as an intermediary)
4. Make sure your PASPORT interface is connected to your computer, and start DataStudio

Force Sensor

1. Connect a force sensor to the same PASPORT interface as the angle sensor
2. Use one of the included cord locks to make a loop in the biceps or triceps cord and attach it to the force sensor's hook (as shown in Fig 6 and 7 included with the arm model)
3. Depending on which experiment you are performing, you will need to clamp the force sensor somewhere nearby (as shown in Figures 9-13 included with the arm model). The type of mounting varies depending on the experiment and will be explained for each experiment.

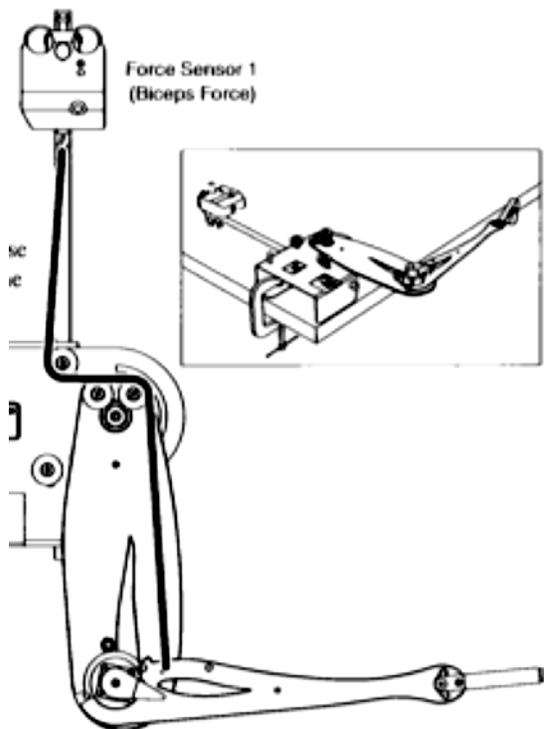
Experiment: Biceps Force versus Perpendicular Load

Hold your arm in front of you with your elbow bent at 90° . Now have your lab partner pull your hand to try to straighten your elbow. Resist the load force so that your elbow remains at 90° .

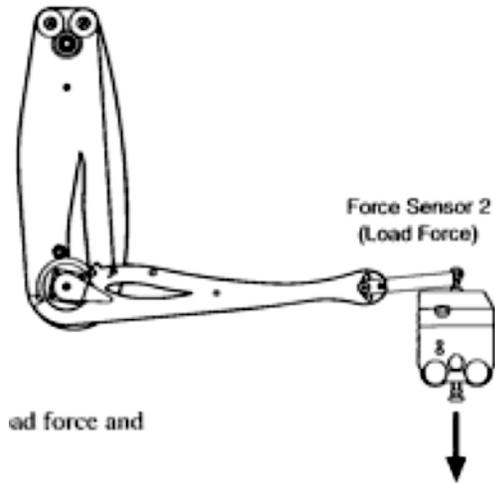
Answer the following:

1. Which muscle (the biceps or triceps) did you use to resist this load? How do you know?
2. Was the muscle force greater than, less than, or equal to the load force applied to your hand?
3. If your partner pulls your hand with a force of 1 N, guess how much muscle force is needed to keep your elbow at 90° .

- ◆ Clamp the arm model horizontally on the table.
- ◆ Clamp the rod to the base of the model as shown in the diagram and attach a force sensor to the rod.
- ◆ Lock the shoulder at 0° .
- ◆ Attach a cord as illustrated. Adjust the length of the cord so that the elbow is held at about 90° .
- ◆ Connect the two force sensors to your interface. The second force sensor will be held in your hand and apply the load force to the model's hand.
- ◆ Set the sampling rate of both force sensors to 20 Hz.
- ◆ Prepare a graph to plot biceps force versus load force.



Start data collection. Hook the second force sensor onto the model's hand and pull in the direction indicated in the illustration below. Slowly increase the force while watching the graph. When the load force reaches about 2 N, stop data collection.



4. Using words and numbers, explain the relationship between load force and biceps force.
5. Were your predictions accurate? Explain.
6. Draw a free-body diagram showing all forces (in the plane of rotation) acting on the forearm.
7. What is the net force on the forearm?
8. What is the net torque?

Repeat the experiment with the elbow at a different angle, but keep the load force perpendicular to the forearm.

9. How does the ratio of biceps force to load force change for elbow angles greater and less than 90° .

Repeat the experiment with the cord attached at the other two biceps insertion points.

10. Discuss how changing the insertion point affects the results.