Overhauled Bicep Lab

Notes from Allic

1. Main suggestion: Cut content and make things inquiry-based
2. Just saying at the beginning something like "This lab will be different. We're expecting you to think about what steps to take, rather than just follow a recipe" has a big effect on the students' attitudes. [Jared is not surprised by this, though he hadn't thought of doing it.]

Warm-up

Meet the apparatus

In this experiment, you'll attempt to understand torques and rotational equilibrium using a model of the human arm.

Before we get into equations, take a moment to understand the equipment. Fill in the blanks on the diagram below, from among the following choices: upper arm (humerus), elbow, forearm, hand, and biceps muscle.

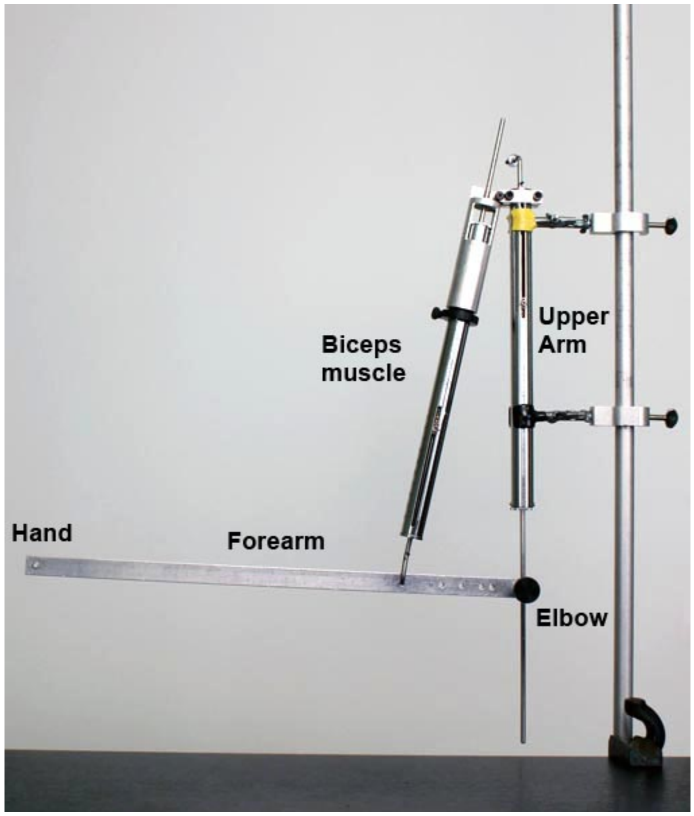
TODO – Block out the labels in the picture of the apparatus, and replace with blanks – similar to a diagram one might fill in for a biology course. Blanks include upper arm (humerus), elbow, forearm, hand, and biceps muscle.

Get your head in the game

Before making use of the apparatus, let's do a brief warm-up problem concerning *torque*.

TODO – Now include an unrelated warm-up problem dealing with static torque. Possibly take this from UMD open source tutorials, or from tutorial books.

Maybe include a section getting students acquainted with the torque equation we're attempting to verify (relating bicep force to the force on the hand).



Investigation

Rather than telling you exactly what to do, in this lab we're going to allow you much more freedom to investigate the physics behind this situation on your own.

Restart

Warm up – meta

- Assume students don't know anything about torque
- Give activity which guides them through torque
- Possibly just take from open source tutorial
- Ok, open source tutorial requires them to do experiment that we don't have resources

set up for (though we could relatively easily set them up)

Warm up

Warm up Problems:

1. Balancing weights on a ruler atop a fulcrum
   a. Two equidistant weights on opposite side of pivot
   b. Double one weight's distance; ask how much weight needs to be added and to which side
2. Replace one of the weights with an arbitrary force pointing downward
3. Replace arbitrary force with a cable at an angle (positioned like bicep)

Need to figure out how to introduce quantitative relations

- $\tau \sim rF$ (for orthogonal force)
- $\tau \sim rF \sin\theta$

Procedure

We wish to investigate some of the forces involved with weight lifting. Specifically, we'll examine the situation where you're holding a weight in your hand, with your forearm being horizontal. We'll measure the forces experienced by both the biceps muscle and the upper arm.

If you'd like, imagine yourself as a physical therapist or prostetic limb designer, who wishes to combine physics with some general experimental design skills to determine some of the forces involved in lifting objects.

** Common sense warning about using reasonable values, making sure to keep everything but the thing you're measuring constant, etc.**

** Discussion about which variables are relevant. Answer – forces, distances, angles. **

** Make sure to emphasize that we'll keep the forearm horizontal, to simplify things. **

Start by measuring the biceps force B and the upper arm force A for some fixed weight H being held in the hand.

Then devise and carry out a procedure for measuring the forces B and A for different weights H.

After taking several measurements (you can choose a number which seems reasonable), use your data to extrapolate a relationship between the biceps force B and the weight H in the hand. Write a quantitative formula for B as a function of H. *Hint: In case this terminology is a bit unfamiliar, it might help to know that, for example,* $y(t) = \left(10\,\mathrm{m}\right) + \left(4.9\,\mathrm{m/s^2}\right) \times t^2$ *is a formula for* y *as a function of* t *for a certain physical situation.* Make sure you specify the units of the quantities.

This data-only prediction will probably be cut for the sake of time

Choose a new value for H – one that you haven't measured yet, but that you are able to measure. Before you measure B, use your model to predict the biceps force B for this value of H.

** Ideally, first make a rough prediction of B based only on neighboring data points. **

Now use the apparatus to measure B for this value of H. How does it compare to the prediction from your model? (Calculate the percent deviation.)

Extrapolate further

The model you extrapolated from your data is a good description of the force B on this apparatus for this setup. But what if you change the apparatus somehow? For example, consider an apparatus which is the same as yours, except the forearm bar is longer. For the same value of the weight H in the hand, would the corresponding biceps force B change? In fact, it does – B is larger for a larger value of R (assuming all other parameters are left the same). ** Ideally ask them a question, to make sure they pay attention to this part. **

In reality, you probably want a model of the biceps force that is valid beyond your specific biceps setup.