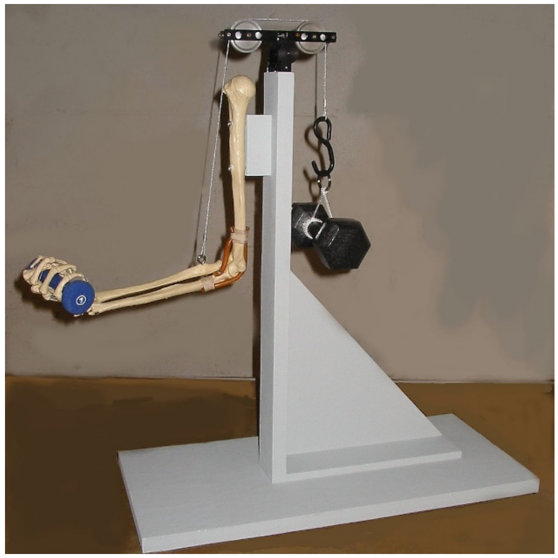
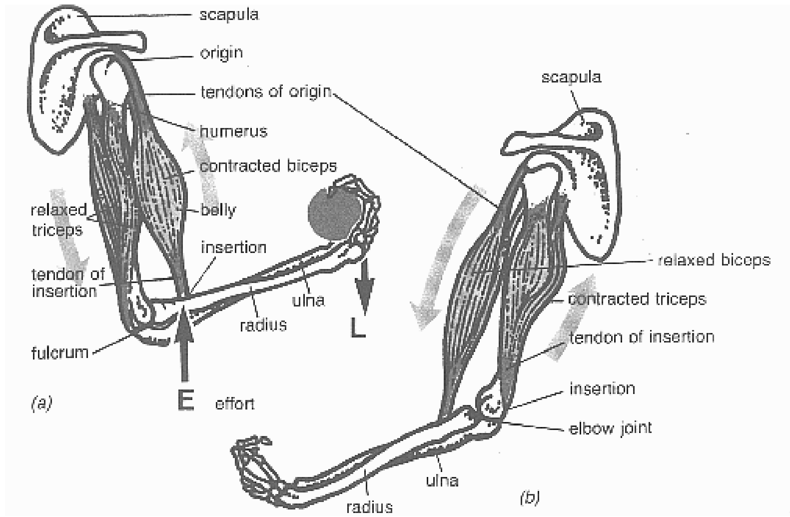
Arm Curls



Purpose: Demonstrates leverage, the articulation of our elbow joint, and the actual force the bicep must produce to lift a weight. (*i.e.* the discipline of biometrics is introduced.) This somewhat grisly demo may appeal to the premed students, who constantly complain that physics has nothing to do with medicine. Here, the human arm is more or less accurately assembled, with the ligaments that hold the elbow joint together simulated with surgical tubing. The bicep is replaced with a steel wire, whose tension can be adjusted by hanging weights on its free end.

How strong do you really have to be? This demo shows that for every pound you want to curl, the bicep must provide about 8 pounds of tension. How does the particular rigging of your arm determine your lifting ability? [It is said that the attachment point for weight lifters is often found proportionally further out along the radius.] Do bigger people have it easier?



Note: The bicep muscle becomes a tendon (the *biceps brachii* tendon) which attaches at a thickened area on the radius (medical jargon: *Insertion*). The top (*Head*) of the bicep really attaches to the shoulder area in two places (thus the name *bicep!!*).The astute student may notice that the hand is a little funny. It's true: for ease of construction the left hand was used, with the fingers and thumbs turned upside down.

Physics Note: With the notation of the simplified figure below, a little simple mechanics and a lot of trigonometry gives you that the ratio of tension (T) to weight (W) lifted is given by

$T/W = [R/b]\,[1 + r^2 + 2r\cos(\mathrm{W}-180^{\circ})]^{1/2}$

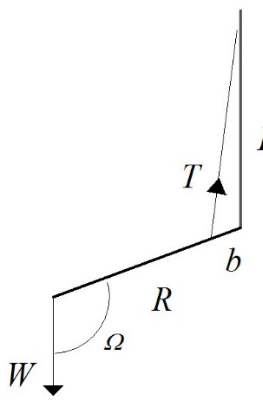
where

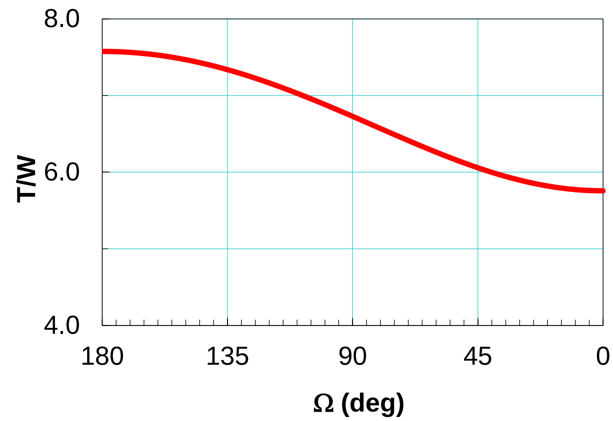
R = length of the *radius* and wrist,

b = distance to bicep insertion,

H = length the of *humerus* and

$r = b/H.$





So, the model says that it's hardest to get started with the curl, and should take 7 ½ pounds to lift 1 pound weight. The demo shows a different behavior: The attached weight starts the curl into motion, but comes to an equilibrium somewhere near $W = 90^o$. The model doesn't take into account the elbow ligaments/tubing (which provide a restoring force) or the weight of the bones. The formula above also answers the question of scaling. Since *T/W* depends only on the ratios of bone lengths to insertion distance, a large person has no advantage over a similarly proportioned small person.

Extra Equipment: None.

Location: Shelf A5.