Name:___________________
Due Date:___________________

Humans and Tools

Part I: The Human Body

Write-up
1. Simple force diagrams of each part
2. Length measurements
3. Calculations of both forces requested
4. Answers to summary questions

CAUTION: In this lab you can take measurements off of a live body or off of a skeleton. Please be very careful if you use the skeleton! It is not very stable (can you tell why?) and can fall over and break very easily. Treat it GENTLY!

Part A: Keep Your Head Up!

In the diagram below the head is shown as an example of a first class lever. The resistance, R, is the weight of the head. The fulcrum, F, is the part of the skull that rests on the vertebrae. The neck muscles provide the effort, E. (A first class lever is like a see-saw.) Assume that the cute little boy in Jerry McGuire is correct and the human head weighs 8 lb. Assume also that the diagram is somewhat correct and that the center of gravity is about at your cheek bone.

Make approximate horizontal measurements off of your lab partner's head of the distances between the fulcrum and the center of gravity of the head (his/her cheekbone) and between the fulcrum and where the neck muscles attach. You can also make these measurements off of a skull if you like. It's easier to see on a skull where the head balances and where the neck muscles attach.

Use these values and what you know about balanced torques to calculate how much force the neck muscles are constantly pulling to hold up your head **and** how much force the spinal column is pushing up against the weight of the head and neck muscles?

Part B: Try to Stand On Your Toes!

In the diagram below the foot is shown as an example of a second class lever. The resistance, R, is a force directed downward by the tibia (leg bone) into the foot. The fulcrum, F, is the place where the ball of your foot connects with the ground. The calf muscle provides the effort, E. (A second class lever is like a wheelbarrow.) The value of the force at the fulcrum is actually half your weight but directed upward. It is directed upward because you are pushing down on the floor and the floor is pushing upward on your foot with an equal and opposite force (Newton's 3rd Law!)

Make measurements on your foot or the skeleton's foot from the ball of your foot to your ankle (Fulcrum to Resistance) and from the ball of your foot to the end of your heel (Fulcrum to Effort). Use these values and the value of half your weight to calculate the resistance (how much compression is between your leg bone and foot bone) and the effort (how much your calf muscle has to pull upward to help you stand on your toes).

Part C: Lifting & Throwing!

In the diagram below the forearm is shown as an example of a third class lever. Third class levers help give velocity – like a catapult or a baseball pitcher. The resistance, R is a weight like a ball directed downward. Assume that this weight is 2 lbs (about 1 kg). At the fulcrum, F, is a force directed downward by the humerus (upper arm bone) into the ulna (forearm bone). The bicep muscle provides the upward effort, E.

Take measurements on your lab partner's arm. Measure the horizontal distance between the palm of their hand to their elbow (Fulcrum to Resistance) and from where their bicep attaches to their elbow (Effort to Fulcrum). This last measurement is a bit tricky you need to hold your arm at a 90 degree angle and then poke around with your other hand to find where the bicep attaches to your forearm. Or if you use the skeleton you can see a rough spot on the forearm where the bicep articulated with the forearm. Use these values to calculate the resistance (how much compression is between your humerus (upper arm) and elbow (ulna) and the effort (how much your bicep muscle has to pull upward to help you hold up the weight).

Summary Questions

1. Using your results from the “head” & “neck muscle” analysis, estimate and recalculate the forces involved when someone tackles someone by pulling down on their facemask in football. Why do you think that this is a pretty bad idea?
2. Many body builders are relatively small people. Their limbs are shorter but their muscles attach at about the same distances as larger people. Why would this help them to be better bodybuilders? Calculate an example to support your answer.
3. Similarly to #2 it’s been found that many world class athletes’ muscles attach further away from their joints. Why would this assist someone in being a better runner, thrower etc? Calculate an example to support your answer.

Part II: Tools

A. From three of the groups of tools below choose 1 tool. From a fourth group choose 2 tools (5 tools total):
   i. Screwdrivers (square-head, phillips, flat-head)
   ii. The claw of the claw hammer, crow bar
   iii. Needle nose pliers, regular pliers, channel lock pliers
   iv. Plumbing wrench, crescent wrench, box-end wrench, open-end wrench, socket wrench

B. Describe how these tools are meant to be used. What about the tool provides the leverage to increase your input for force into a large output force? *Pliers have two functions be sure to talk about and analyze both of them.

C. Make scaled drawings of each of the 5 tools.

D. Draw a force diagram on the tool showing where the applied force is and how that gets amplified in the use of the tool.

E. Calculate the mechanical advantage of each tool from your measurements:

$$\left[{}^{\text{Force Out}}/_{\text{Force In}}\right] = \left[{}^{\text{Lever Arm In}}/_{\text{Lever Arm Out}}\right]$$

F. For the 2 tools that are from the same category discuss the advantages and disadvantages of using one tool over another.