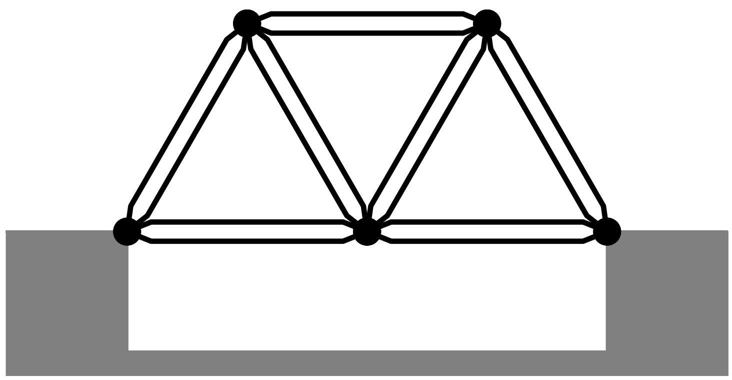
NYU General Physics 1—Problem set 8

Problem 1: In the bridge pictured here, identify which beams are under *tension* stress, and which beams are under *compression* stress.



Problem 2: A typical adult man is holding his left arm at a right angle, so the upper arm is pointing straight down, and the forearm is pointing horizontally forwards. His hand is oriented palm-up. He is holding a 20 kg grocery bag by its handle in his left hand. Look up the point of attachment of the relevant tendon and make sensible estimates (or look them up) for all lengths and masses. In what follows, treat the "hand plus forearm" to be one monolithic object; that is, we primarily want to understand the forces at or near the elbow.

(a) Draw a free-body diagram for the hand-plus-forearm system, identifying all significant forces acting on it (including from the bag handle, and don't forget the elbow joint—the contact force from the upper arm bones).

(b) Compute the magnitudes and directions of all forces, and the magnitudes and directions of all torques, taking the elbow to be the axis of rotation (that is, the origin or reference point). For simplicity, take the tendon direction and joint contact force both to be precisely vertical. This is not a bad approximation.

(c) Look up the definition of "mechanical advantage" and compute the mechanical advantage the grocery bag has over the tendon. Why would evolution (such a brilliant designer) decide to put tendons under this kind of stress?

Problem 3: A very thin ladder of length L and mass M leans against a vertical wall, on a horizontal floor, making an angle of θ with respect to the wall. Imagine that there is a large coefficient of friction μ at the floor so that the ladder is in static equilibrium, but assume that the wall is frictionless.

(a) Draw a free-body diagram for the ladder, showing all forces acting.

(b) Using the bottom of the ladder as the axis of rotation or origin, compute all the forces and torques on the ladder such that it is in equilibrium.

(c) Why did I make the wall frictionless?

(d) Re-solve the problem using the *top* of the ladder as the axis of rotation or origin. What is different in the end?

(e) At what angles θ would the ladder start to slip? If $\mu = 0.8$ (not unreasonable for rubber ladder feet on a wood floor), what is the maximum angle at which you could lean the ladder?