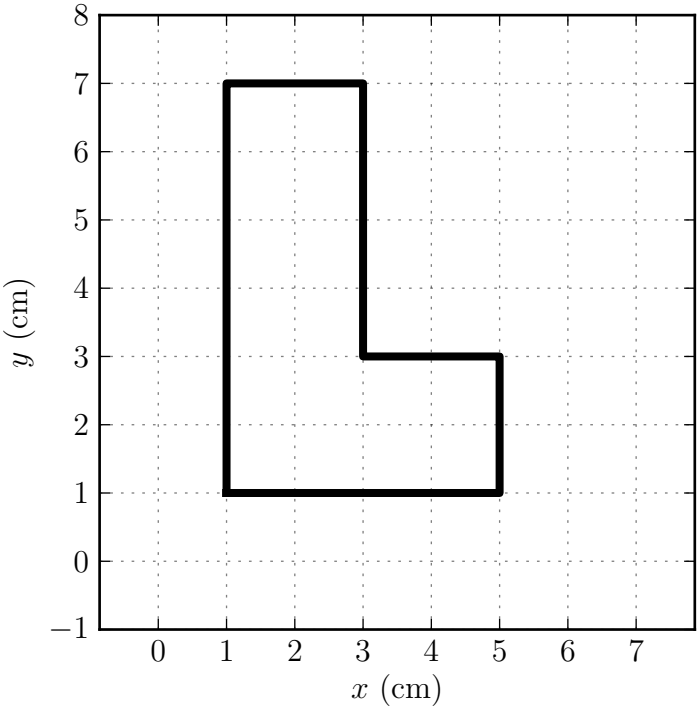
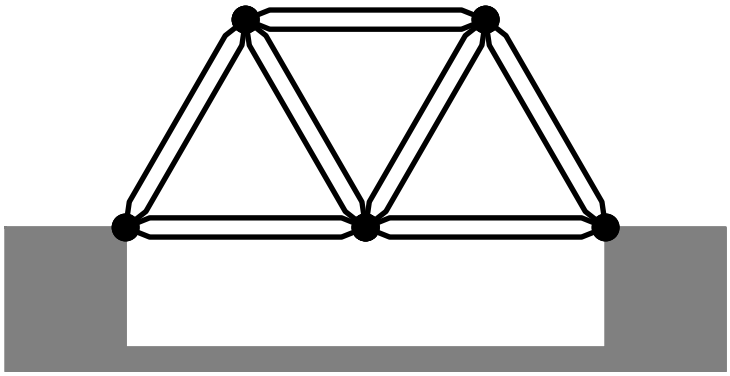
NYU General Physics 1—Problem set 8

Problem 1: The diagram shows a flat object cut out of a thick sheet of aluminum of constant thickness, so it has the same mass per unit area everywhere.



Find the position of the center of mass of this object, in the given coordinate system; that is, give the coordinates $(x_{\mathrm{cm}}, y_{\mathrm{cm}})$ of the center of mass. If you want practice, think up four qualitatively different ways of doing the center-of-mass calculation.

Problem 2: In the bridge pictured here, identify which beams are under *tension* stress, and which beams are under *compression* stress.



Problem 3: 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?