ME 115(b): Solution to Problem Set #4

Problem #1: Problem 2(a,c) in MLS text.

Part (a): The grasp is force closure.

Part (c): The grasp is force closure.

Problem #2: Problem 3(b) in MLS text.

The grasp is force closure.

Problem #3: Problem 4(b) in MLS text.

Depending upon your assumptions, there may be more than one answer to this problem. A reasonable answer follows. Choose a contact frame whose z-axis is normal to the planar contact surface, and whose x-axis is parallel to the longer edge. Clearly, normal forces and tangential frictional forces can be supported by this contact. It seems reasonable to assume that torque can be supported about the contact normal. The only point of debate centers on the possibility to support a torque about the x- and y-axes of the contact frame. We will assume that they can be supported, but opposing arguments can also be made. In this frame, the wrench basis is thus:

$$B = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

The friction cone is defined by

$$\begin{aligned} f_n &\geq 0 \\ \sqrt{f_x^2 + f_y^2} &\leq \mu f_n \\ |\tau_n| &\leq \gamma_n f_n \\ |\tau_x| &\leq \gamma_x f_n \\ |\tau_y| &\leq \gamma_y f_n \end{aligned}$$

where f_n is the normal force, f_x and f_y are the tangential frictional forces, τ_n is the torque about the contact normal, τ_x is the torque about the x-axis, and τ_y is the torque about the y-axis.

Problem #4: Problem 5(a) in MLS text.

An equilateral triangle cannot be grasped by two point contact with friction fingers, if $\mu = \tan 30^o$. If the two fingers contact adjacent sides of the triangle at locations equidistant from the common corner, they will each lie on the boundary of the other's friction cone, not in the interior. Moreover, if $\mu < \tan 30^o$, then they will not even lie on the boundary.