MECH 577 Optimum Design

Project # 1: Single-Variable Optimization
The Minimax Design of a Truss

Assigned: September 2, 2010 Due: September 28, 2010

A team of aircraft engineers is designing a landing gear mechanism that is modelled as an *equilateral* triangular truss, displayed in Fig. 1 in its deployed configuration. The structure is composed of two links of length ℓ, of the same structural steel, of Young modulus E and cross-section areas A_1 and A_2. The landing gear is retracted from its deployed configuration by means of a hydraulic piston that applies a pull P at node O_3, at an angle $\theta = 105^\circ$ with the vertical. For a fixed amount of material, i.e., for $A_1 + A_2 = A$, where A is a constant, find the *optimum values* of A_1 and A_2 that will lead to a *minimum value* of the *maximum stress* in the structure. Here, if σ_i denotes the stress in the ith link, the problem can be formulated as

$$\min_{A_1, A_2} \max\{\, \sigma_1,\, \sigma_2 \,\}$$

Note that, although two design variables come into play, these are subject to an *isoperimetric constraint*, and hence, the problem can be formulated in terms of a single variable.

Find the optimum values of A_1 and A_2 by means of two methods, Fibonacci numbers and golden-section search. The result should lie within an interval of uncertainty smaller than 1% of the length of your initial interval.

Hint: An expert engineer claims that, given the orientation of the load, link 2 is "more loaded" than link 1, and hence, the latter should be given an area A_1 that is "less than 50% of A, of something between 30% and 48%."

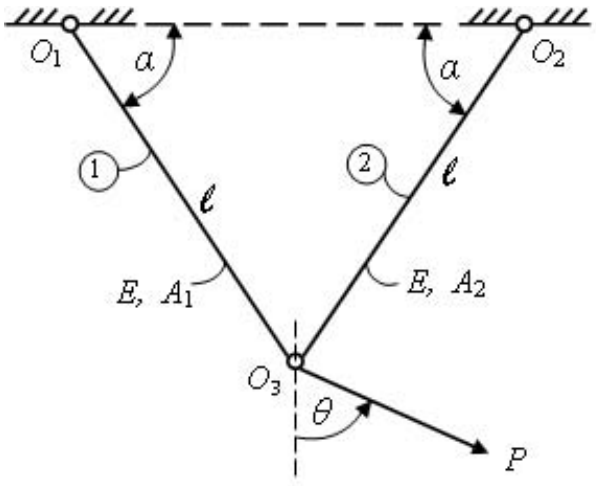

Figure 1: A triangular truss