In-Class Quiz : Monotonicity Principles and Surrogate Modeling

ME7129 Optimization in Engineering,
National Taiwan University.

Practice : Matlab curve fitting

- Install and run Matlab in your computer.
- Arrange your working environment
- Find the syntax of basic operations, let's try $\sin 35^o$
- Find the result of $1.7x^5 - 6.2x^4 + 6.3x^3 - 2.3x + 1.1$ when $x = 1, 2, 3$
- Write a function named 'TestFunc' as $y = \text{TestFunc}(x) = 1.7x^5 - 6.2x^4 + 6.3x^3 - 2.3x + 1.1$
- Generate 10 samples of x randomly and find their corresponding y values.
- Time to turn to our Practice-OneDimensional-polyfit

Practice : Hydraulic cylinder design

Consider Fig.1 showing a hydraulic cylinder, a device for lifting heavy loads as in a car hoist or elevator, or for positioning light ones as in an artificial limb. In the most general design context, it has five design variables: inside diameter i, wall thickness t, material stress s, force f , and pressure p. It is desired to select i, t, and s to minimize the outside diameter $(i + 2t)$ subject to bounds on the wall thickness, $t \geq 0.3$ cm, the force, $f \geq 98$ Newtons, and the pressure, $p \leq 2.45(10^4)$ Pascals. There are two physical relations. The first relates force, pressure, and area $f = (\pi/4)i^2p$. The second gives the wall stress $s = ip/2t$. The model is summarized as follows:

$$
\begin{array}{rll}
\min & g_0 & := i + 2t \\
\text{subject to} & g_1 & : t \geq 0.3 \\
& g_2 & : f \geq 98 \\
& g_3 & : p \leq 2.45(10^4) \\
& g_4 & s \leq 6(10^5) \\
& h_1 & : f = (\pi/4)i^2p \\
& h_2 & : s = ip/2
\end{array}
$$

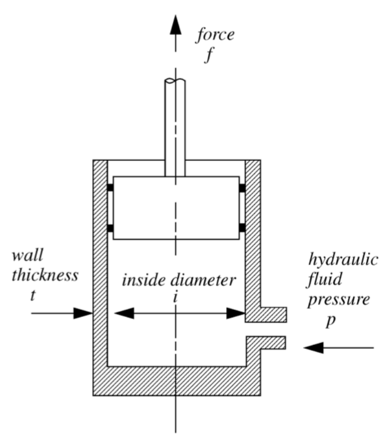

Figure 1: Hydraulic Cylinder Design

Problem 1

Consider the air tank problem as follows

$$\begin{aligned}
&\min f = \pi(2rsl + s^2 l + 2C_h r^2 h) \quad \text{(metal volume)}\\
&\text{subject to}\\
&h \geq K_h r \quad \text{(head thickness)}\\
&s \geq K_s r \quad \text{(shell thickness)}\\
&v \geq V \quad \text{(minimum capacity)}\\
&l \geq L_l \quad \text{(minimum shell length)}\\
&l \geq L_u \quad \text{(maximum shell length)}\\
&t = l + 2K_l r + 2h \quad \text{(total length)}\\
&r + s \leq R_0 \quad \text{(maximum outside radius)}\\
&t \leq L_0 \quad \text{(maximum total length)}
\end{aligned}$$

Please reformulate the problem using monotonicity principles and see if you can obtain the optimal solution.

Problem 2

Please use monotonicity principles in solving the problem.

$$\begin{array}{rll}
\min & f & : x_3 x_4 + 10 x_5\\
\text{s. to.} & g_1 & : x_1 x_4 \leq 100\\
& g_2 & : x_2 = x_3 + x_4\\
& g_3 & : x_3 \geq x_4\\
& g_4 & : 1/x_1 + x_4 = x_5
\end{array}$$

Problem 3

Find if the problem is well constrained

$$
\begin{aligned}
\max \quad & f && : x_1 - x_2 \\
\text{s.t.} \quad & g_1 && : 2x_1 + 3x_2 - 10 \leq 0 \\
& g_2 && : -5x_1 - 2x_2 + 2 \leq 0 \\
& g_3 && : -2x_1 + 7x_2 - 8 \leq 0
\end{aligned}
$$

Problem 4

Use monotonicity analysis and consider several cases to solve

$$
\begin{aligned}
\min \quad f \quad &: 100x_3^2 + x_4^2 \\
\text{s.t. } x_3 \quad &= \quad x_2 - x_1^2 \\
x_4 \quad &= \quad 1 - x_1
\end{aligned}
$$