ME 350 Homework 5 Winter 2017

Complete the following problems and upload your solutions to the D2L dropbox by 9:00 PM on Friday, 3 March 2017.

1. **(10 points)** The Colebrook equation for the friction factor f in a round pipe is

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$$

where ε is the pipe roughness, D is the pipe diameter and Re is the Reynolds number. In the most common application of this formula, we want to compute f when ε, D and Re are known.

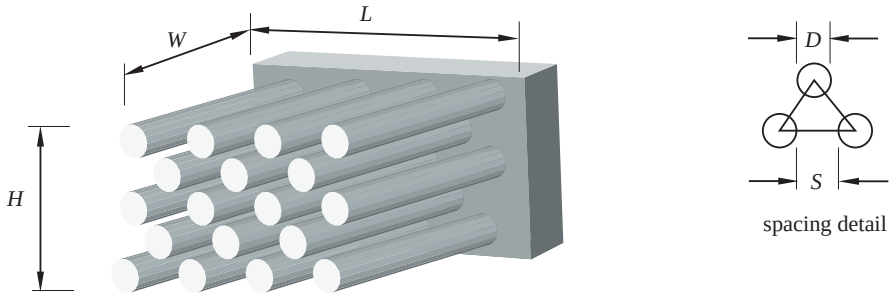
   a. Write an m-file function that returns f when the values of ε/D and Re are given. Your function should have two inputs, `eD` $= \varepsilon/D$ and `Re`. Your function should return the friction factor, f obtained by a root-finiding routine. `fzero` is recommended.

   b. On log-log axes, create a plot of f as a function of Re for $3 \times 10^3 \leq \mathrm{Re} \leq 1 \times 10^8$ and $\varepsilon/D = 1 \times 10^{-5},\ 1 \times 10^{-3}$ and 1×10^{-2}.

2. **(10 points)** Heat sinks are often attached to electronic devices to increase the cooling efficiency and thereby lower the temperature of the device. One common configuration of these heat sinks is an array of so-called pin fins, as depicted in the accompanying sketch. Given the overall dimensions L, H, and W of the array, it is desirable to know the optimal spacing and size of the fins. Adrian Bejan presents[1] the formula for the optimal spacing (S_{opt}) as

$$\frac{S_{\mathrm{opt}}}{D}\,\frac{2 + S_{\mathrm{opt}}/D}{(1 + S_{\mathrm{opt}}/D)^{2/3}} = 2.75\left(\frac{H}{D}\right)^{1/3}\mathrm{Ra}^{-1/4}$$

where D is the diameter of the fins and Ra is the Rayleigh number, a dimensionless indicator of the strength of the natural convection responsible for cooling the fins. Write a function m-file to compute S_{opt} given D, H, and Ra. Use your function to plot S_{opt} for $H/D = 20$ over the range $300 \leq \mathrm{Ra} \leq 10000$.



[1] "Geometric optimization of cooling techniques" pp. 1–45 in *Air Cooling Technology for Electronic Equipment*, S.J. Kim and J.S. Woo, eds., 1996, CRC Press