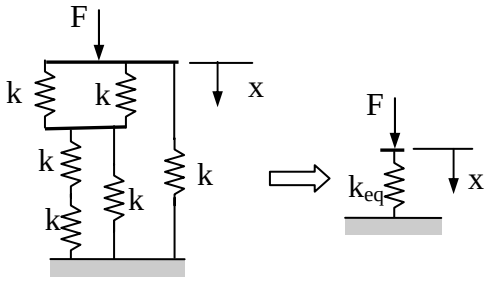
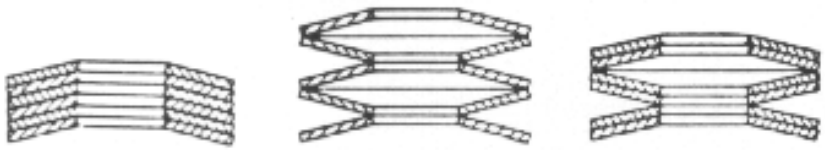
Lecture 1
Homework

Problem 1.1
Consider the system of springs as shown. Find the equivalent spring constant.



Problem 1.2

A **Belleville washer**, also known as a cupped spring washer, is a type of non-flat washer. It has a slight conical shape which gives the washer a spring characteristic. Belleville washers are typically used as springs, or to apply a pre-load or flexible quality to a bolted joint. These springs can be stacked in parallel, series or a combination of parallel and series as shown below.



a) Stacked in Parallel b) Stacked in Series c) Stacked in Series and Parallel

Belleville washers are useful for adjustments because different thicknesses can be swapped in and out and they can be configured differently to achieve essentially infinite tunability of spring rate. They are ideal in situations where a heavy spring force is required with minimal free length and compression before reaching solid height. The downside, though, is weight, and they are severely travel limited compared to a conventional coil spring when free length is not an issue. (From Wikipedia, the free encyclopedia).

Assuming each Belleville washer has a spring constant, K, answer the following questions.

a) What would the spring constants be for the three arrangements shown above?
b) How could you stack the washers to obtain a spring constant of 1.5 K?

Problem 1.3
The beam shown below has a length L = 20 in., elastic modulus E = 15 x 10^6 lb/in^2, a weight of 2 lbf and mass moment of inertia of I = 7.2x10^{-3} in^4. A spring of stiffness k = 450 lb/in is located under the beam at its midpoint. Replace the beam and spring with an equivalent spring mass system as shown. Note: x is measured from the static equilibrium point.