Simple filtration using porous media.
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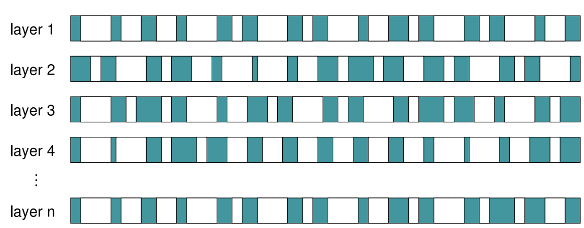
Problem 1: Filtration through a collection of sparse, linear channels.

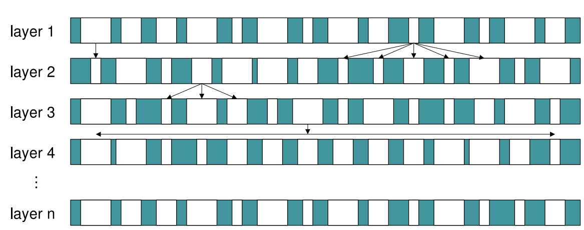
A particle-laden fluid flows through a porous material under a constant pressure difference which serves as a filter. The porous material can be modeled as many thin layers with linear pores. In the layered case (problems 4-6), there is no lateral flow, so particles must pass through consecutive channels. The thin porous material is perforated with narrow linear channels which will facilitate different flow rates. If a particle of radius r_p tries to pass through a channel of radius r_c and $r_p > r_c$, the particle is trapped and the fluid will no longer flow through the channel. A common measurement of filter performance is its retention curve $r(t)$ which is the fraction of particles retained by the filter as a function of time. A desireable filter retains 100% of the particles for some duration of time, but in practice this never happens because some large pores are present due to manufacturing limitations.

Questions of interest:

1. Given particle laden flow with a known distribution of particle sizes flowing through a filter with a single pore, what is the expected retention curve?
2. Given a distribution of two particle sizes and two channel sizes, what is the retention curve?
3. Given a general distribution of particle sizes and channel sizes, what is the retention curve?
4. Given a general distribution of particle sizes and channel sizes, what is the retention curve for n layers of porous media? What would be the effective PDF of the n layer structure?



5. Given a general distribution of particle sizes and channel sizes, what is the retention curve for an array of n layers of porous media with complete mixing between layers? What would be the effective PDF of the n layer structure?



6. Given a general distribution of particle sizes and channel sizes, what is the retention curve for an array of n layers of porous media with partial mixing between layers? What would be the effective PDF of the n layer structure?

Problem 2: Filtration through a rectilinear collection of pipes.

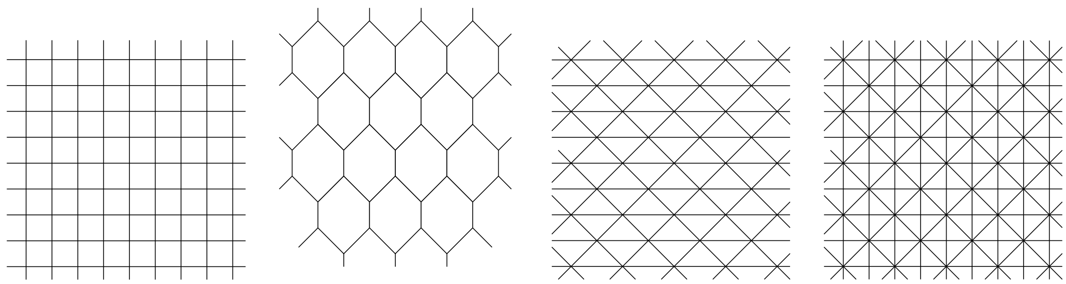
A particle-laden fluid flows under a constant pressure difference through a network of pipes. The pipes are of different sizes and so permit different flow rates. When a particle of radius r_p travels into a pipe of radius r_l and $r_p > r_l$, the particle is trapped and fluid will no longer flow through the channel.

Questions of interest:

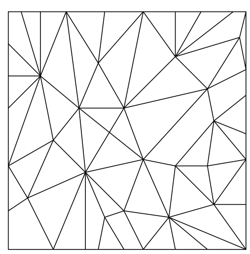
1. Given a distribution of two particle sizes and two channel sizes on a rectangular lattice network, what is the retention curve?

2. Given a general distribution of particle sizes and channel sizes on a rectangular lattice network, what is the retention curve?

3. What are the key differences between networks on a rectangular lattices ($n = 4$) versus other regular lattices ($n = 3, 6, 8, ...$)?



4. What are the key differences between networks on a regular lattices versus networks on unstructured lattices?



5. The particle path minimum pore size is the minimum pore size a particle encounters as it travels from one end of the network to the other. The particle path minimum pore size can be measured experimentally for a porous matrix. What is the connection between the network pore size PDF and the particle path minimum pore size PDF?