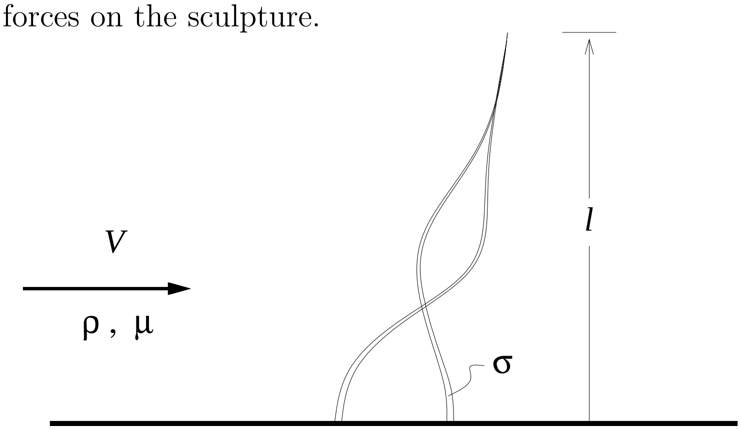
Unified Engineering Fall 2007
Fluids Problem 4-5 (worth 2 Pset questions)

An artist who wishes to build a large spindly outdoor sculpture seeks your help to ensure that the sculpture doesn't collapse in a 30 m/s the wind. To rule out material failure, you recommend that it's necessary to determine the material stress σ in its bottom leg members, caused by wind forces on the sculpture.



Because of the complex shape, computing this σ is not practical or reliable. Therefore, you recommend that a scale model will be built and placed in a wind tunnel, and σ will be measured on the model.
The wind-caused stress at any one point (e.g. in one of the legs) is expected to depend on the following parameters:

$$\sigma = f(V, \rho, \mu, \ell)$$

σ	[Pa]	material stress
V	[m/s]	wind speed
ρ	[kg/m^3]	air density
μ	[kg/m s]	air viscosity
ℓ	[m]	sculpture height

a) Derive a set of dimensionless parameters (Pi products) for this situation.

b) If the model sculpture is 1/5'th the size of the actual sculpture, specify the tunnel conditions required to ensure dynamic similarity between the full-size sculpture at 30 m/s and the model.

c) It is subsequently determined that the air viscosity μ has an almost immeasureable effect on σ. Repeat a) and b) above, using this simplifying information.

d) The artist is now concerned about the sculpture collapsing under its own weight force. Determine the set of parameters which will determine the stress from the weight of the sculpture in the absence of wind. The density of the metal ρ_m will be one of these, for example.

$$\sigma = f(\rho_m, \ldots ? \ldots)$$

e) Determine a set of dimensionless parameters for this situation. Make reasonable simplifying assumptions where possible. For example, the aerostatic air-buoyancy force on the sculpture can surely be neglected, so the air density ρ doesn't matter.

f) Can the scale model be now used to predict σ in the actual sculpture? Explain.