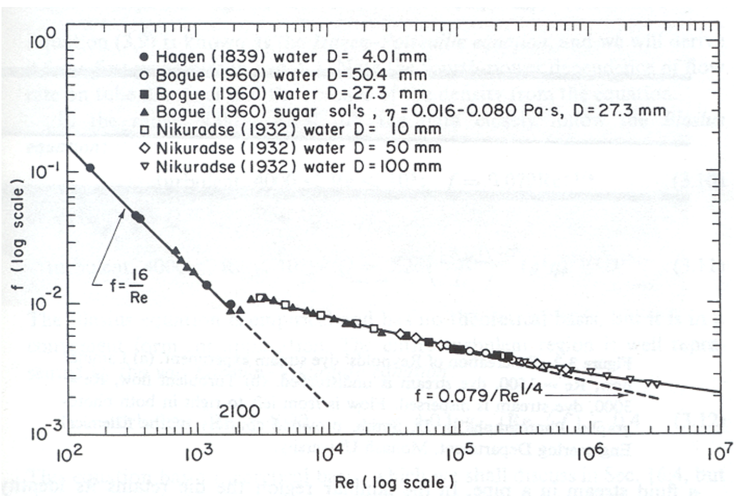
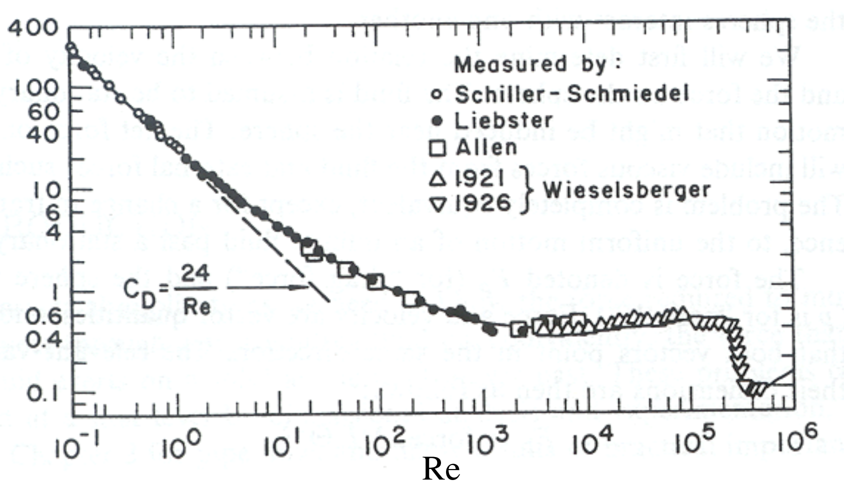
Name ____

Chemical Engineering 150A
Mid-term Examination 1 – Spring 2010

<u>Show your work.</u> Clearly identify any assumptions you are making, indicate your reasoning, and clearly identify any variables that are not identified in the problem statement.
The exam is closed book but you may use any information you have written on one sheet of 8.5 x 11 inch paper.
There are <u>3 problems</u>. Please note the point values for each problem and plan your time accordingly.



General information		
	Density (kg/m^3)	Viscosity (Pa•s)
Air (at room temp & 1 atm)	1.20	1.82 x 10^{-5}
Water (room temp & 1 atm)	1.00 x 10^3	1.00 x 10^{-3}
g	9.81 m/s^2	
p_{atm}	1.013 x 10^5 Pa	



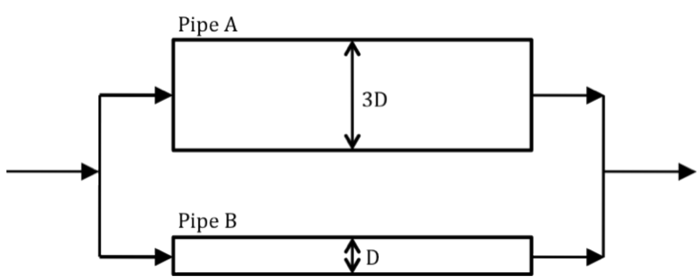
Problem	Score
1	/30
2	/40
3	/30
Total	/100

Name ____

1. (30 pts) The diameter d of droplets produced by a liquid spray nozzle is thought to depend on the nozzle diameter D, the velocity of the jet V, and the properties of the liquid, namely the density ρ, the viscosity η, and the surface tension σ.

a) Write and expression for the droplet diameter in dimensionless form. (Hint: recall that surface tension has dimensions of force per unit length.)
b) Under what conditions can results from a single experiment on a model (with nozzle diameter D_M) be used to determine the behavior of a much larger prototype nozzle with diameter D_P?
c) If D_M = 1 mm for the model and D_P = 6 mm for the prototype, can the same fluid be used for the model as will be used for the prototype for the single experiment proposed in part b?

2. (40 pts) Two pipes are connected as shown in the drawing below, both pipes are 1 m long. The pipes are smooth, have circular cross-sections, and are horizontal, and water is flowing through both pipes. The pipe marked A has a diameter that is three times the diameter of pipe B. The diameter of pipe B is 0.05 m, and the volumetric flow rate through pipe B is 7.07×10^{-5} m^3/s. What percent of the total volumetric flow rate goes through pipe B?



3. (30 pts) Water flows through a right angle valve shown below at the rate of 300 kg/s. The gage pressure just upstream of the valve is 4.5×10^5 Pa, and the gage pressure just downstream of the valve is 2.2×10^5 Pa. The inside diameters of the valve inlet and valve exit are 30 cm and 60 cm, respectively. If the flow through the valve occurs in a horizontal plane (that is, gravity acts in the –z direction), determine the x and y components (using the axes indicated on the figure) of the force exerted by the water on the surrounding solid surface. Assume that the flow at the inlet and exit are turbulent.