2^{nd} *Mid-Term Exam* **Time: 50 min**

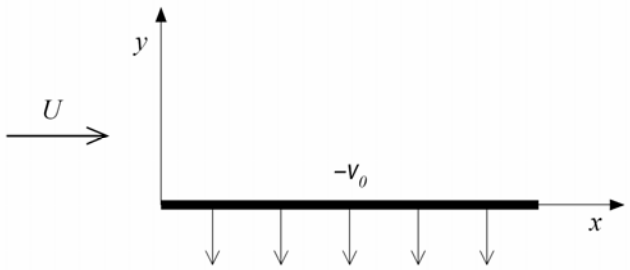
Course: *58:160, Fall 2006*

Name:---------- **Fluid I.D. :**----------

Problem 1 is required and you need to select either problem 2 or 3.

1. (**50 points**) A prototype water pump has an impeller diameter of 2 ft and is designed to pump 8ft^3/s at 600 r/min. A 1-ft diameter model pump is tested in 20^{0}C air at 1500r/min, and Reynolds number effects are found to be negligible. (a) For similar conditions, what will the volume flow of the model be in ft^3/s? (b) If the model pump requires 0.082 hp to drive it, what horsepower is required for the prototype?

2. (**50 points**) Consider a steady flow at velocity U (at $y=\infty$) past an infinite plate (y=0) as shown in the figure below. Let the plate be porous and has a constant suction velocity $v=-v_0$ (v_0 is magnitude of the suction velocity). Assume that pressure is constant and $v=-v_0$ everywhere in the flow. (a) Verify u=u(y) only. (b) By applying proper boundary conditions, solve the Navier-Stokes equation for u(y). (c) Sketch u(y) roughly.
(Hint: for solving differential equation $au_{yy}+bu_y+c=0$ with constant coefficients a, b, and c, assume that the solution is $e^{\lambda y}$ and find λ.)



3. (**50 points**) Consider a viscous film of liquid draining uniformly down the side of a vertical rod of radius a, and length L, as shown in figure. Assume that $v_\theta=v_r=0$ and the atmosphere offers no shear resistance to the film motion. (a) Verify $v_z=v_z(r)$ only. (b) Verify $\frac{dp}{dz}=0$. (c) Drive a differential equation for $v_z(r)$, state the proper boundary conditions, and solve for the film velocity distribution. (d) Find the force for keeping the rod. (e) How does the film radius b relate to the total film volume flow rate Q?