CENG101A: Introductory Fluid Mechanics Fall Quarter 2006
http://maecourses.ucsd.edu/mae210a

Name: ____

Quiz V

Theodor Von Kármán (1881–1963)

This is a 50 minute closed-book exam. Please put your name on the top sheet. Answer all four questions. Explain your working and state any assumptions you have made.

1 (3 points) Circle the correct answer.

1. In a boundary layer,
   - pressure vanishes at the wall.
   - there is no pressure gradient normal to the boundary.
   - viscosity is negligible.
   - velocity satisfies Laplace's equation.
   - the Reynolds number is always small.
2. The Reynolds stress
   - depends on mean velocity gradients.
   - vanishes in two-dimensional flows.
   - is the turbulent contribution to shear stress.
   - is proportional to the Reynolds number.
   - appears in the mean continuity equation.
3. The Fanning friction factor
   - can be found by solving a differential equation.
   - applies only to irrotational flows.
   - is independent of Reynolds number.
   - is a non-dimensional version of head loss.
   - has units of length.

2 (5 points) Describe the Reynolds tube experiment, explaining the different regimes and the role of the Reynolds number.

3 (10 points) Water at 49 °F flows through a straight section of a 6-in.-ID cast-iron pipe with an average velocity of 4 fps. The pipe is 1200 ft long, and there is an increase in elevation of 3 ft from the inlet of the pipe to its exit. Find the power required to produce this flow rate for the specified conditions. [Material properties: $\rho = 62.3\ \mathrm{lb_m\ ft^{-3}}$, $\nu = 1.22\times10^{-5}\ \mathrm{ft^2\ s^{-1}}$. Use the transition formula

$$\frac{1}{\sqrt{f_f}} = 4\log_{10}\frac{D}{e} + 2.28 - 4\log_{10}\left(4.67\frac{D/e}{\mathrm{Re}\sqrt{f_f}} + 1\right).$$

Cast iron: $e = 0.00085$ ft. Also 1 hp = $550\ \mathrm{lb_f\ ft\ s^{-1}}$.]

4 (12 points) Carry out the momentum integral analysis for the case of no pressure gradient with $v_x = a \sin by$ (you will have to solve for a and b.) Compute the momentum and displacement thicknesses. [The governing equation is

$$\tau = \mu \left. \frac{\partial u}{\partial y} \right|_{y=0} = \rho U^2 \frac{\mathrm{d}}{\mathrm{d}x} \int_0^\delta \frac{u}{U} \left(1 - \frac{u}{U}\right) \mathrm{d}y.$$

You may find the following integrals useful:

$$\begin{aligned} \int_0^d \sin\frac{\pi y}{2d}\left(1 - \sin\frac{\pi y}{2d}\right) \mathrm{d}y &= d\frac{4-\pi}{2\pi}, \\ \int_0^d \left(1 - \sin\frac{\pi y}{2d}\right) \mathrm{d}y &= d\frac{\pi - 2}{\pi}.\text{]} \end{aligned}$$