1. A closed system containing an ideal gas initially at P_1 and v_1 expands to P_2 and v_2. The expansion could be accomplished by either of the two following quasi-static processes:

   Process A is an isothermal expansion to state 2.

   Process B consists of a constant-Pressure expansion to volume v_2, following by a constant-volume expansion to Pressure P_2.

   (a) Sketch these two Process on a P-v and T-s diagram and complete the following questions. Explain your responses. (5%)

   (b) The internal change for process A is (greater than, equal to, less than) the internal energy change for Process B. (3%)

   (c) The work for process A is (greater than, equal to, less than) the work for Process B (3%)

   (d) The heat transfer for Process A is (greater than, equal to, less than) the heat transfer for process B. (3%)

2. An aluminum block (C_p=400 j/kg-^oK) with a mass of 5 kg is initially at 40^{o}C in room air at 20^{o}C. It is cooled by natural convection to room temperature. Compute

   (a) The change in entropy for the block. (3%)

   (b) The change in entropy for the room air (5%)

   (c) The net change in entropy for the universe. (3%)

   (d) Explain whether the process is reversible or irreversible. (3%)

3. An insulated, rigid 1-m^3 tank containts air at 800 KPa, 25^{o}C. A valve on the tank is now opened and the pressure inside quickly drops to 150 KPa, at which point the valve is closed.

   (a) Assuming that the air remaining inside the tank has undergone a reversible adiabatic expansion, calculate the mass withdrawn during the process. (5%)

   (b) Calculate the mass withdrawn by a first law, control volume analysis, and compare the result with part (a). (12%)

4. A certain gas indicate that the P-v-T behavior of the gas can be described by the equation

   $$P\ (v - a) = RT$$

   where a is a constant, use the general equation for du, dh and ds to derive expressions for the changes in internal energy, enthalpy, and entropy of the gas. Assume that the specific heats of the gas are constant. (15%)

5. Answer as Indicated

   (a) Define the following (6%)

   (1) Streakline

   (2) Stagnation Properties

   (3) Dynamic Similarity

   (b) Briefly describe the basic difference between the Eulerian and Lagrangian descriptions of the fluid motion. (4%)

   (c) Show that for incompressible inviscid flow, the streamlines and potential lines are orthogonal. (4%)

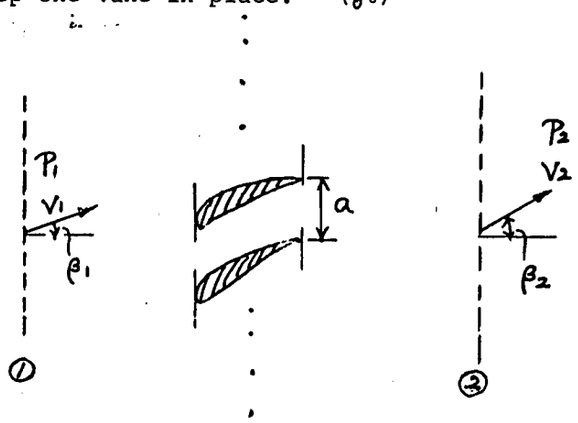
   (d) List the basic assumptions of the boundary layer approximation. (4%)

6. The governing equation for fully developed flow in a circular tube of radius R is

   $$\frac{\partial^2 u}{\partial r^2} + \frac{1}{r}\frac{\partial u}{\partial r} = \frac{1}{\mu}\frac{dp}{dx}$$

   Find appropriate dimensionless parameters. (7%)

7. An incompressible fluid flows steadily through a two-dimensional infinite row of fixed vanes as shown in the sketch. The vane spacing is a. The velocities and pressures are constant along stations (1) and (2), and are given by v_1, v_2, P_1, and P_2. Find the x- and y- component of the force necessary to keep one vane in place. (8%)



8. Consider the flow normal to a right circular cylinder. Use the following free stream velocity profile

$$\frac{u}{u_\infty} = 1.814\phi - 0.271\phi^3 - 0.0471\phi^5$$

to develop an expression for the angle where the boundary layer separates from the cylinder. (7%)