UNIVERSITY OF CALIFORNIA, BERKELEY
MECHANICAL ENGINEERING
ME106 Fluid Mechanics
2nd Test, S10 *Prof S. Morris*

Mean: 144/200
Standard Deviation: 44

1. (65) In a manufacturing process, incompressible viscous polymer is squeezed between a stationary die, and descending mold. As a result, polymer is squeezed axisymmetrically from the gap; all 3 Cartesian components v_x, v_y and v_z of the velocity vector are non–zero. The x and y velocity components are given by the expressions

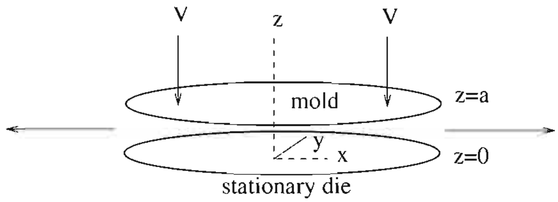
$$v_x = kx(az - z^2), \quad v_y = ky(az - z^2).$$

Mean: 50/65
Standard Deviation: 18

Using the continuity equation, namely

$$\frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{\partial v_z}{\partial z} = 0$$

and the boundary conditions on v_z, derive the expression giving v_z as a function of z, a and the (positive) speed V. (The parameter k must **not** enter into your final answer.)



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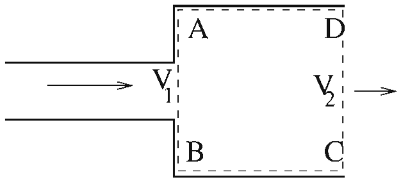
FULL CREDIT FOR CORRECT FINAL RESULT WITH COHERENT ARGUMENT

2. (65) Mass conservation requires an incompressible fluid to decelerate as it flows through a sudden expansion in a duct, so that the pressure rises from AB to CD. Assuming that everywhere on AB, $p = p_1$, and that on CD, $p = p_2$, where $p_1 - p_2 = \rho V_2(V_2 - V_1)$, and using the control volume shown, derive the expression giving the mechanical energy loss ΔE per unit mass flowing through the expansion in terms of V_1 and V_2. **Your answer must show explicitly that $\Delta E \geq 0$.**



Mean: 53/65
Standard Deviation: 16

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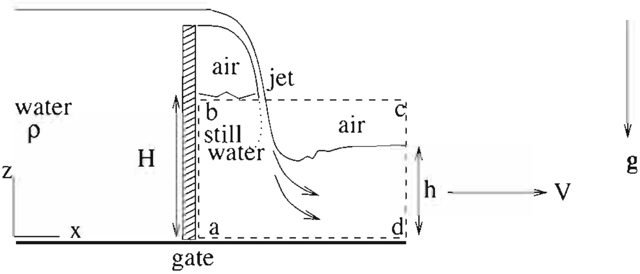
FULL CREDIT FOR CORRECT FINAL RESULT WITH COHERENT ARGUMENT

3. (70) Water flowing over a tall sluice gate in a river re-enters the river downstream almost vertically. Because there is a net flow of horizontal momentum out of the control volume illustrated, a horizontal force must act on the material within the control volume. As a result, water backs up to depth H between the gate and the vertical jet; the horizontal force results because $H > h$. Assuming that the water of depth H is stagnant, and that the flow downstream is purely horizontal with speed V, derive the equation giving H in terms of h, V and g.



Mean: 42/70
Standard Deviation: 2