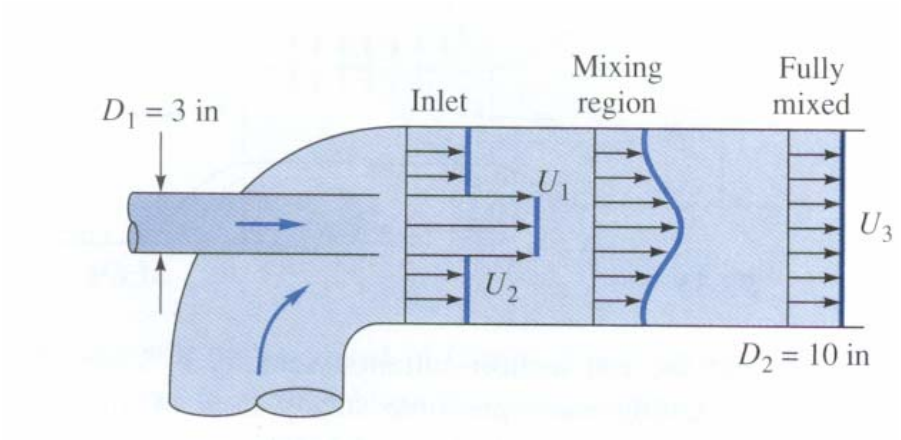
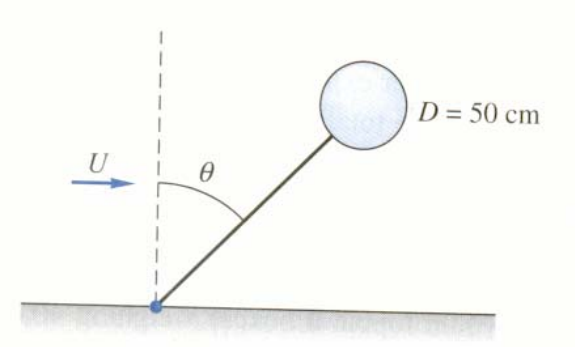
58:160 Intermediate Mechanics of Fluids
FINAL EXAM – 12/ 15/ 04

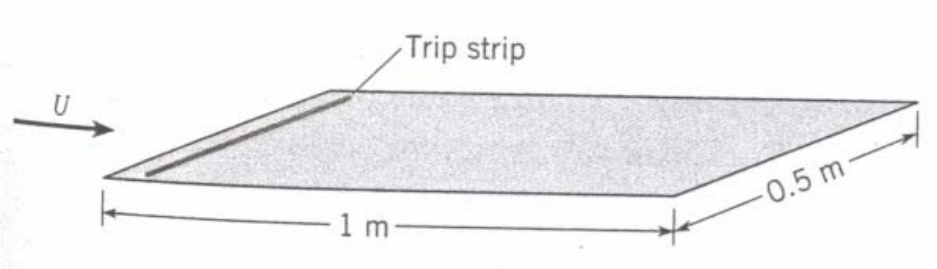
1. The jet pump in the figure injects water at U_1= 40 m/s through a 3-in-pipe and entrains a secondary flow of water U_2= 3 m/s in the annular region around the small pipe. The outer pipe diameter is 10 inches. The two flows become fully mixed downstream, where U_3 is approximately constant. For steady incompressible flow, compute U_3 in m/s. If pressures p_1= p_2 = 172.4 kPa, and the distance between sections 1 and 3 is 80 inches. and the average wall shear stress between sections 1 and 3 is 335 Pa, estimate the pressure p_3. Why is it higher than p_1?



2. A helium-filled balloon is tethered at 20°C and atmospheric pressure with a string of negligible weight and drag. The diameter is 50 cm. the balloon material weighs 0.2 N not including the helium. The density of helium in the balloon is 0.197 kg/m^3. Estimate the tilt angle θ if the air-stream velocity is a) 5 m/s and b) 20 m/s.



3. A smooth flat pate is oriented parallel to a 3 m/s air flow at 20^{o} C and atmospheric pressure. The plate is 1 m long in the flow direction and 0.5 m wide. On one side of the plate the boundary layer is tripped at the leading edge to stimulate turbulence. On the other side there is no tripping device. Find the total drag force on the whole plate.



4. Consider water at 20^{o}C at 200 kPa flowing at 6 m/s past a 1-m-diameter circular cylinder with circulation. What is the required vortex strength K in m^{2}/s to place stagnation points at θ = 35^{o} and 145^{o}. Compute the resulting pressure and surface velocity at a) the stagnation points and b) the upper and lower shoulders.