NAME (print): _____

Instructor (Circle One): 501/Brumbelow 502/Kanta 503/Miller

CVEN 311
Examination 2
November 9, 2010
7:00 pm – 8:40 pm

This is a closed-book examination. You are allowed to use one letter-sized (8 ½" x 11") formula sheet with hand-writing on both sides. ***To receive full credit on this examination, you must turn in your formula sheet with your examination.*** The formula sheet will be returned to you with your graded exam.

All exam problems have the value indicated. ***The total number of points is 100 for the 100 minute exam duration.*** For full credit, you must show ALL work for workout problems, including free-body diagrams, general and specific forms of equations, and all assumptions; be sure your work is legible and CLEARLY indicate your final answer. Multiple choice problems will be graded solely on your selected multiple choice responses.

Be sure to sign the Aggie Honor statement below and that you print your name above and on your formula sheet. Good luck!

I pledge that I have neither given nor received aid in completing this exam. I have followed the strictures of the Texas A&M University Aggie Code of Honor during this test period.

Signature: _____

Grading

Part 1 _____ / 33 Total _____ / 100

Part 2 _____ / 33

Part 3 _____ / 33

Bonus 1 / 1

Properties of Liquids (BG Units)

Liquid	Temp. (^{0}F)	Density ρ (slugs/ft^3)	Specific Wt. γ (lb/ft^3)	Dyn. Viscosity μ (lb-s/ft^2)	Surface Tension σ (lb/ft)
Carbon Tetrachloride	68.0	3.09	99.50	2.00E-5	1.84E-3
Ethyl Alcohol	68.0	1.53	49.30	2.49E-5	1.56E-3
Gasoline	60.0	1.32	42.50	6.50E-6	1.50E-3
Glycerin	68.0	2.44	78.60	3.13E-2	4.34E-3
Mercury	68.0	26.30	847.00	3.28E-5	3.19E-2
SAE 30 motor oil	60.0	1.77	57.00	8.00E-3	2.50E-3
Seawater	60.0	1.99	64.00	2.51E-5	5.03E-3
Water	60.0	1.94	62.40	2.34E-5	5.03E-3

Properties of Liquids (SI Units)

Liquid	Temp. (^{0}C)	Density ρ (kg/m^3)	Specific Wt. γ (kN/m^3)	Dyn. Viscosity μ (N-s/m^2)	Surface Tension σ (N/m)
Carbon Tetrachloride	20.0	1590	15.60	9.58E-4	2.69E-2
Ethyl Alcohol	20.0	789	7.74	1.19E-3	2.28E-2
Gasoline	15.6	680	6.67	3.10E-4	2.20E-2
Glycerin	20.0	1260	12.40	1.50E+0	6.33E-2
Mercury	20.0	13600	133.00	1.57E-3	4.66E-1
SAE 30 motor oil	15.6	912	8.95	3.80E-1	3.60E-2
Seawater	15.6	1030	10.10	1.20E-3	7.34E-2
Water	15.6	999	9.80	1.12E-3	7.34E-2

Properties of Air:

Density at standard atmospheric pressure ρ: 2.38E-3 slugs/ft^3 (BG)
1.23E+0 kg/m^3 (SI)

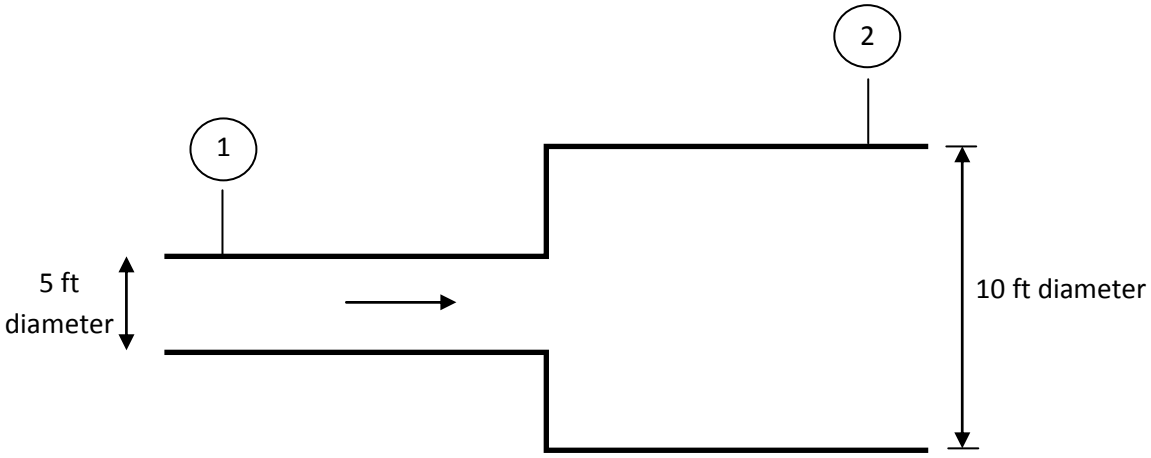
Specific Weight at standard atmospheric pressure γ: 7.65E-2 lb/ft^3 (BG)
1.20E+1 N/m^3 (SI)

Gas Constant *R*: 1.716E+3 ft-lb/slug-^{o}R (BG)
2.869E+2 J/kg-^{o}K (SI)

Standard Atmospheric Pressure: 2116.2 lb/ft^2, abs (BG)
101.33 kPa, abs (SI)

Problem 1 Score: _____ /33

Problem 1. As you know, in a hydroelectric power plant power is generated by allowing water to flow from a reservoir through tunnels and penstocks in the dam to turn turbines located in a powerhouse. The large difference in elevation between the intake (reservoir) and the powerhouse causes high-energy flow through the turbine to generate power. To dissipate the high-energy flow of water downstream of the turbine, abrupt expansions are commonly used. Suppose an abrupt expansion is to be used to dissipate the high-energy flow of water in a 5 ft diameter penstock as shown in the figure below. The flow velocity at section 1 is 25 ft/s.



Part A) What power (in horsepower) is lost through the expansion? (11 points)

Assume the head loss due to a sudden expansion can be expressed as:

$$H_{loss} = \frac{(V_{upstream} - V_{downstream})^2}{2g}$$

where $V_{upstream}$ is the velocity of flow upstream of the expansion, $V_{downstream}$ is the velocity downstream of the expansion, and g is gravitational acceleration.

Part B) If the pressure at section 1 is 5 psi (pounds per square inch), what is the pressure at section 2? (11 points)

Part C) What force is needed to hold the expansion in place? (11 points)

Problem 2 Score: _____ /33

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Problem 2. In a now classic You Tube video, a group of firemen lift a car off the ground using only jets of water from their fire-hoses. When the Mythbusters tried to replicate the experiment, they found that it could be done, but that the car would have to be lighter than standard (i.e., the engine and transmission had been removed). In the original video, the firemen use eight hoses, anchored to a frame which supports the car. Note that in order for the car to be lifted off the ground, the forces generated by the water on the nozzle anchors have to be greater than the weight of the car. The diameter of the hose is 2.5 inches and the diameter of the nozzle is 1 inch. Assume that all of hoses produce the same water pressure and that the weight of the harness keeping the hoses attached to the car is negligible.

Conversion Factors: 0.13368 ft^3/gal, 144 in^2/ft^2,
1 lb = 1 slug-ft/s^2

Part A) Draw two free-body diagrams: one showing the car and one showing the control volume of water in a single hose nozzle. Include the velocity and normal vectors on the CV diagram. (5 points)

Part B) Develop an equation to find the maximum weight of the car based on the flow rate and the pressure of water inside a hose, just before the water enters the nozzle. (14 points)

Part C) Fire engines can generally produce water at a flow rate of 500 gal/min and a pressure of 250 psi. Assume each hose is hooked to a separate engine and that the flow rate is per engine. In this example, the water must travel from the engine, though a 100 ft hose that is lying flat on the ground, to the nozzle. This produces a head loss of 1.3 ft per foot of hose due to friction. Given these values, what is the pressure at the nozzle entrance and the maximum weight of the car? (14 points)

Problem 3 Score: _____ /33

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Problem 3. A personal watercraft (PWC, a.k.a., "Sea-Doo" or "Jet Ski") propels itself by use of an axial flow pump (see Figure 3-1). Water enters the pump through an inlet grate on the underside of the PWC hull, flows through a spinning axial flow impeller (that performs shaft work), and exits out a nozzle at the rear of the PWC.

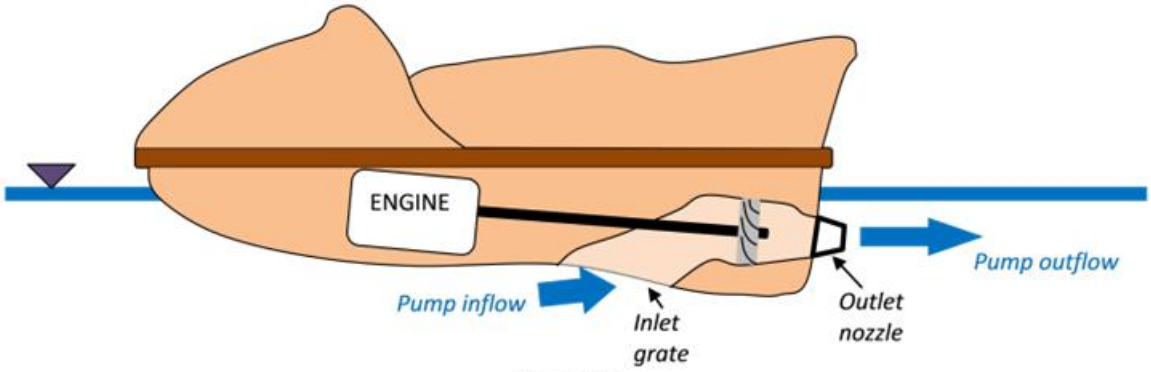

Figure 3-1

Details for a typical PWC propulsion system are shown in Figure 3-2 (the impeller and driveshaft are omitted). The velocity of the inflow is equal to the speed that the PWC is traveling through the water.

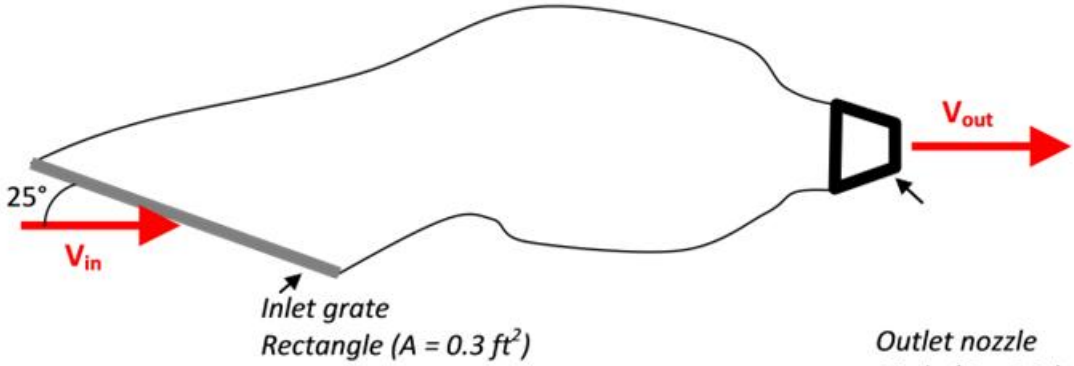

Figure 3-2

A PWC has a 70 hp engine, and its overall efficiency for the engine, driveshaft, and impeller is 67%. All other head losses can be considered negligible. If the PWC is traveling at 30 mi/hr in freshwater:

Part A) What is the reactive force generated by change in momentum flux in the propulsion unit? (14 points)

Part B) What is the reactive force generated by increased pressure at the outlet nozzle? (14 points)

Part C) What is the total propulsive force (i.e., sum of the two forces above)? (5 points)

Useful conversions: 1 mi = 5280 ft; 1 hp = 550 ft·lb/sec; 1 US dollar = 6.678 Chinese yuan; 1 hr spent helping your friend move to a new apartment = 2 beers