Name: _____

CVEN 311-503 – Fluid Dynamics
Fall Semester 2011
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Midterm Exam #2

Closed-book, Closed-notes, Formula sheet allowed (4 pages, 3 questions)
Time allowed: 60 minutes

Reference tables

Approximate Physical Properties of Some Common Liquids (BG Units)

Liquid	Temperature (°F)	Density, ρ (slugs/ft^3)	Specific Weight, γ (lb/ft^3)	Dynamic Viscosity, μ (lb · s/ft^2)	Kinematic Viscosity, ν (ft^2/s)	Surface Tension,[a] σ (lb/ft)	Vapor Pressure, p_v [lb/in.^{2} (abs)]	Bulk Modulus,[b] E_v (lb/in.^{2})
Carbon tetrachloride	68	3.09	99.5	2.00 E − 5	6.47 E − 6	1.84 E − 3	1.9 E + 0	1.91 E + 5
Ethyl alcohol	68	1.53	49.3	2.49 E − 5	1.63 E − 5	1.56 E − 3	8.5 E − 1	1.54 E + 5
Gasoline[c]	60	1.32	42.5	6.5 E − 6	4.9 E − 6	1.5 E − 3	8.0 E + 0	1.9 E + 5
Glycerin	68	2.44	78.6	3.13 E − 2	1.28 E − 2	4.34 E − 3	2.0 E − 6	6.56 E + 5
Mercury	68	26.3	847	3.28 E − 5	1.25 E − 6	3.19 E − 2	2.3 E − 5	4.14 E + 6
SAE 30 oil[c]	60	1.77	57.0	8.0 E − 3	4.5 E − 3	2.5 E − 3	—	2.2 E + 5
Seawater	60	1.99	64.0	2.51 E − 5	1.26 E − 5	5.03 E − 3	2.26 E − 1	3.39 E + 5
Water	60	1.94	62.4	2.34 E − 5	1.21 E − 5	5.03 E − 3	2.26 E − 1	3.12 E + 5

TABLE 1.7
Approximate Physical Properties of Some Common Gases at Standard Atmospheric Pressure (BG Units)

Gas	Temperature (°F)	Density, ρ (slugs/ft^3)	Specific Weight, γ (lb/ft^3)	Dynamic Viscosity, μ (lb · s/ft^2)	Kinematic Viscosity, ν (ft^2/s)	Gas Constant,[a] R (ft · lb/slug · °R)	Specific Heat Ratio,[b] k
Air (standard)	59	2.38 E − 3	7.65 E − 2	3.74 E − 7	1.57 E − 4	1.716 E + 3	1.40
Carbon dioxide	68	3.55 E − 3	1.14 E − 1	3.07 E − 7	8.65 E − 5	1.130 E + 3	1.30
Helium	68	3.23 E − 4	1.04 E − 2	4.09 E − 7	1.27 E − 3	1.242 E + 4	1.66
Hydrogen	68	1.63 E − 4	5.25 E − 3	1.85 E − 7	1.13 E − 3	2.466 E + 4	1.41
Methane (natural gas)	68	1.29 E − 3	4.15 E − 2	2.29 E − 7	1.78 E − 4	3.099 E + 3	1.31
Nitrogen	68	2.26 E − 3	7.28 E − 2	3.68 E − 7	1.63 E − 4	1.775 E + 3	1.40
Oxygen	68	2.58 E − 3	8.31 E − 2	4.25 E − 7	1.65 E − 4	1.554 E + 3	1.40

[a]Values of the gas constant are independent of temperature.
[b]Values of the specific heat ratio depend only slightly on temperature.

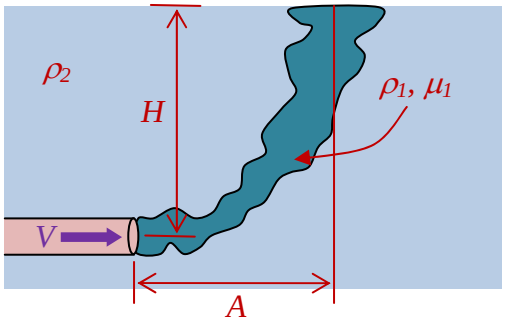
1 ft^3 = 7.841 gal

1 W = 0.7376 $^{ft \cdot lb}/_{sec}$

1. Listed below are 10 key fluid mechanics concepts in words (left side) and mathematical expressions (right side). *Draw a line connecting each verbal expression to its mathematical match.*
(10 points)

VELOCITY HEAD	$\frac{1}{2}\rho V^2$
MOMENTUM FLUX	γQ
DYNAMIC PRESSURE	$\dot{m}$ or ρQ
LOCAL ACCELERATION	$\frac{\partial V}{\partial t}$
STATIC PRESSURE	z
WEIGHT FLUX	$\frac{V^2}{2g}$
PRESSURE HEAD	$\frac{p}{\gamma}$
MASS FLUX	p
STAGNATION PRESSURE	$\left(\vec{V}\cdot\nabla\right)\vec{V}$
ELEVATION HEAD	ρQV or $\dot{m}V$
CONVECTIVE ACCELERATION	$p+\frac{1}{2}\rho V^2$

2. Coastal cities often discharge their treated wastewater into the sea through long outfall pipes that extend several miles offshore. The treated wastewater then rises from the pipe since its density is less than that of seawater. An engineer wishes to study the behavior of such discharge plumes by experimentation. She hypothesizes that the distance a plume will travel before surfacing A can be expressed by a function including: H, the depth of seawater above the outfall; V the velocity of the wastewater leaving the outfall; ρ_1, the density of the wastewater; ρ_2, the density of the seawater; and μ_1, the viscosity of the wastewater (see figure below). *Use dimensional analysis to determine a generalized function of dimensionless ratios that can be used to analyze the experimental data.* (45 points)



3. A large pump is installed in a pump station by anchoring it to the station's concrete slab floor with several bolts. The pump has an inflow pipe diameter of 12 inches and an outflow pipe diameter of 10 inches. The pump operates at a power consumption of 440 kW and gross efficiency of 54%. Flowrate through the pump is 4000 gal/min, and the fluid being pumped is water. Static pressure at the pump inflow is 37.8 psi.

What is the total shearing force (lb) that the anchor bolts must bear? (45 points)