NAME (print): _____

CVEN 311-502 Fall 2009
Examination 2
November 9, 2009
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 writing on one side only. No examples, problems, or solutions are allowed on your formula sheet. ***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. FE-type 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: _____

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)

Part FE – FE-type Multiple Choice Problems (5 problems totaling 25 points). CLEARLY circle your answer. SOLUTIONS: ADCCD

FE-1 (5 points). The velocity of flow through a segment of pipe can be fully described using the equation: $\vec{v} = -V_0 \frac{x}{l}\,\hat{\imath} + V_0\left(x + \frac{y}{l}\right)\hat{\jmath}$. What is its acceleration vector?

a) $\vec{a} = \frac{V_0^2}{l^2} x\,\hat{\imath} + \frac{V_0^2}{l^2} y\hat{\jmath}$

b) $\vec{a} = -V_0 \frac{x}{l}\,\hat{\imath} + V_0\left(x + \frac{y}{l}\right)\hat{\jmath}$

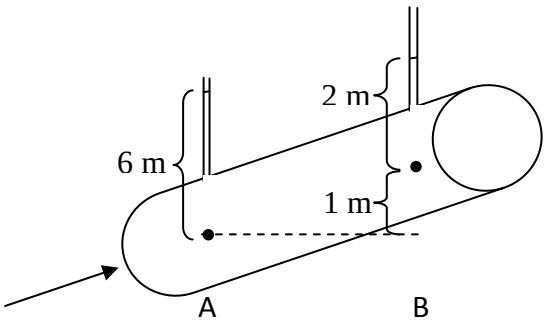
c) $\vec{a} = \frac{V_0^2}{l^2} x\,\hat{\imath} + \frac{V_0^2}{l}\left(x + \frac{y}{l}\right)\hat{\jmath}$

d) $\vec{a} = V_o\left(1 - \frac{1}{l}\right)\hat{\imath} + \left(\frac{V_o}{l}\right)\hat{\jmath}$

FE-2 (5 points). Which sentence best describes the Eulerian perspective on flow?

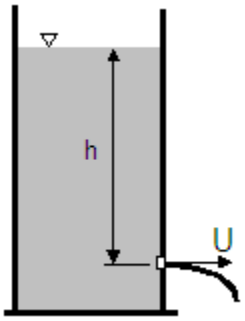
a) Fluid particles are tracked as they move through space AND it is similar to a system approach.
b) Fluid particles are tracked as they move through space AND it is similar to a control volume approach.
c) The fluid flow is monitored as it moves across a fixed reference point AND it is similar to a system approach.
d) The fluid flow is monitored as it moves across a fixed reference point AND it is similar to a control volume approach.

FE-3 (5 points). A pipe with a constant diameter of 1.5 m carries water from point A to point B. What is the head loss between the two points? Assume steady flow. (Note: Drawing not-to-scale.)



a) Not enough information is given to solve the problem.
b) 4 m
c) 3 m
d) The flow shown is in the wrong direction.

FE-4 (5 points). Consider the free jet of an incompressible fluid flowing through an orifice fitted to a constant level tank as shown. Ignoring all losses, which of the following is a correct statement about the magnitude of the initial velocity U of the jet?



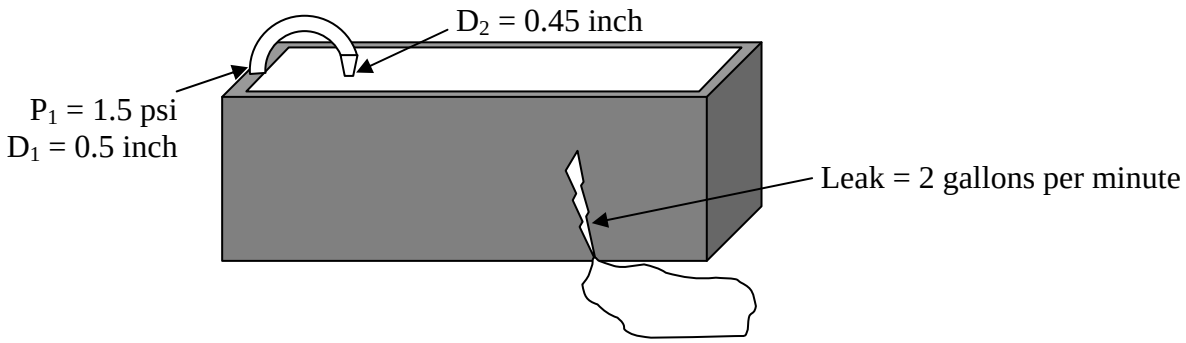
a) U is directly proportional to the orifice diameter.
b) U is inversely proportional to the fluid's density.
c) U is proportional to the square root of the depth h.
d) U is proportional to the square of the depth h.

FE-5 (5 points). The velocity field of a flow is given by $\vec{v} = (6z - 2)\hat{\imath} + (x + 3)\hat{\jmath} + 8y\hat{k}$, where x, y, and z are in meters. Determine an equation for the fluid speed along the x axis, where y=z=0.

a) $6z - 2$
b) $x + 3$
c) 0
d) $\sqrt{x^2 + 6x + 13}$

Part WO – Work Out Problems (3 problems totaling 75 points). For full credit clearly show all work and clearly mark your final answer.

WO-1 (35 points): Bathroom Fluid Mechanics, Revisited, Part I
SOLUTION: 12.6 gal/min



You want to take a bath, but sadly, your bathtub leaks. The tub is rectangular, has an area of 7.8 ft^2, and should be filled to a depth of 1.2 ft. It leaks at a constant rate of 2 gal per minute. Your faucet acts as a free jet, with a pipe diameter of 0.5 inch and an outlet diameter of 0.45 inch. The water pressure to your faucet is 1.5 psi. Neglect the fact that your landlord will be mad at you for flooding your apartment.

a) Determine the flow rate from the faucet, in gal/min, assuming friction losses are very small. (13 points)

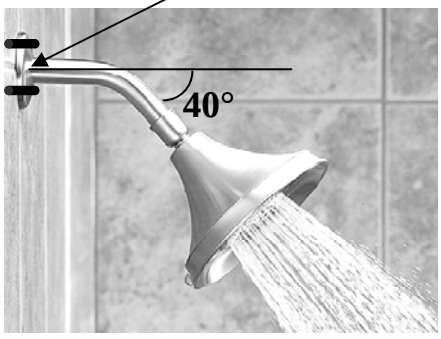
b) Write an equation describing the change in height of water in the bathtub as it fills. Calculate how long it takes to fill. If you don't have an answer from part one, use a flow rate of 10 gallons per minute. (15 points) SOLUTION: 6.6 min

c) Show how your starting equation would change if the rate of the leak depended on the height of the water in the bathtub. (*Just set up, do not solve!*) Assume the leak is a free jet that originates from a hole in the bottom of the tub and has a diameter *D*. (7 points)

WO-2 (20 points): Bathroom Fluid Mechanics, Revisited, Part II

After flooding your bathroom one too many times, you decide to take showers instead. What vertical and horizontal anchoring forces are the screws on your showerhead subjected to while keeping it attached to the wall? The average velocity entering the shower head at Point 1 is 5 m/s, where the diameter of the pipe is 1.25 cm and the pressure is 41.9 kPa. The total combined area of the small, individual nozzles is 0.75 cm^2, and the head tilts down at an angle of 40 degrees from horizontal. Assume the difference in height between the inlet and the outlet is neglible. SOLUTION: FAX = -4.365N, FAY = -3.24 N acting on CV

P_1 = 41.9 kPa, v_1 = 5 m/s

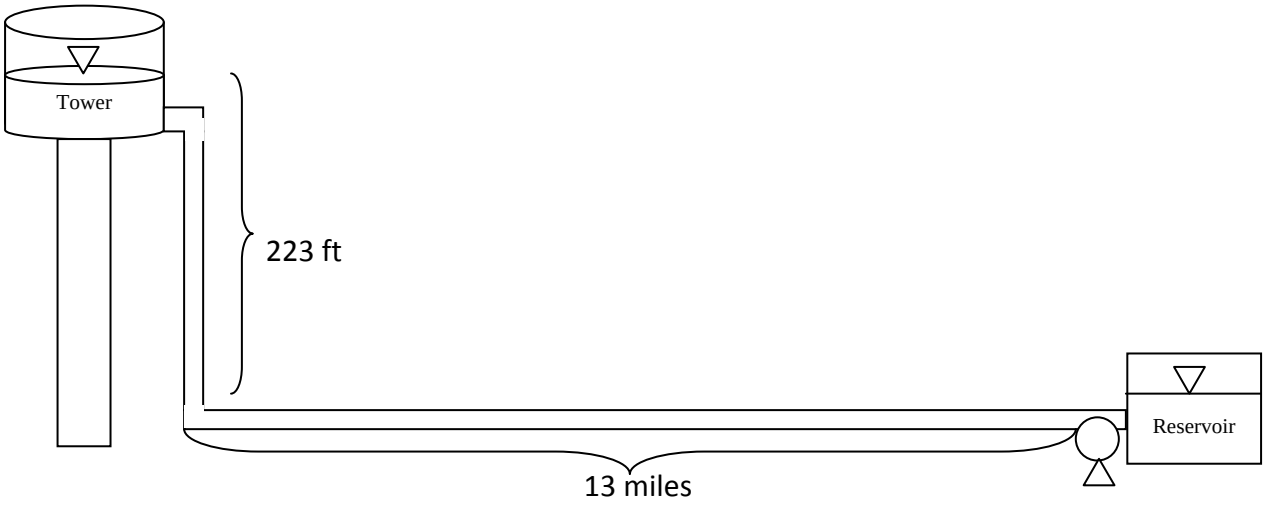


a) Draw a representative control volume and label all relevant parameters and forces. (5 pts)

b) Find the vertical and horizontal forces on the bolts. (15 pts)

WO-3 (20 points): Water Supply

Someone has to supply all this water you've been using. In order to do this, the City of College Station extracts groundwater and moves it 13 miles (68,640 ft) to town. It then stores the water in several water towers, each 223 ft tall. At its peak in the summer, it moves 24 million gallons per day.



a) Determine the horsepower it takes to pump water, at a flow rate of 24 million gallons per day, from a reservoir at the groundwater wells to the top of a water tower, assuming no head loss to friction. (5 points) SOLUTION: 940 hp

b) No head loss to friction is a bad assumption, and the College Station engineers are smarter than that. Calculate a new power requirement if the major head losses are equal to $0.1\ LV^2/2g$, where L is the length of the pipe in ft and the coefficient 0.1 has the units of ft^{-1}, making the whole term in ft. Assume the diameter of the transmission pipe is 2 ft. (15 points) SOLUTION: 63704 hp

c) On the diagram on the previous page, draw the energy and hydraulic grade lines for the system in Part B. (5 points extra credit)