Name: ______________________________

CVEN 311 – Fluid Dynamics
Fall Semester 2008
Dr. Kelly Brumbelow, Texas A&M University

Midterm Exam #2

Closed-book, Closed-notes, Formula sheet allowed (6 pages, 3 questions)
Time allowed: 75 minutes

Reference tables

Approximate Physical Properties of Some Common Liquids (BG Units)

Liquid	Temperature (°F)	Density, ρ (slugs/ft³)	Specific Weight, γ (lb/ft³)	Dynamic Viscosity, μ (lb · s/ft²)	Kinematic Viscosity, ν (ft²/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/ft³)	Specific Weight, γ (lb/ft³)	Dynamic Viscosity, μ (lb · s/ft²)	Kinematic Viscosity, ν (ft²/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

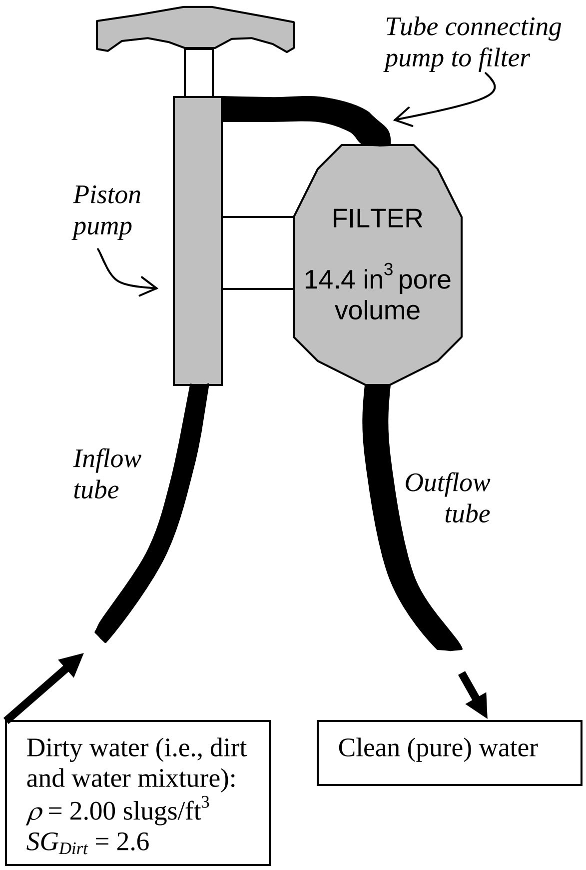
[a]Values of the gas constant are independent of temperature.
[b]Values of the specific heat ratio depend only slightly on temperature.

1 gallon = 0.1337 ft^3; 1 ft^3 = 7.481 gallons
1 gallon = 768 teaspoons (tsp); 1 tsp = 0.001302 gallons

1. A portable water filter system is sketched below. Water is pumped through the system by a piston pump that sucks water into the piston as the handle is pulled up and forces water out of the piston and through the filter as the handle is pushed down.

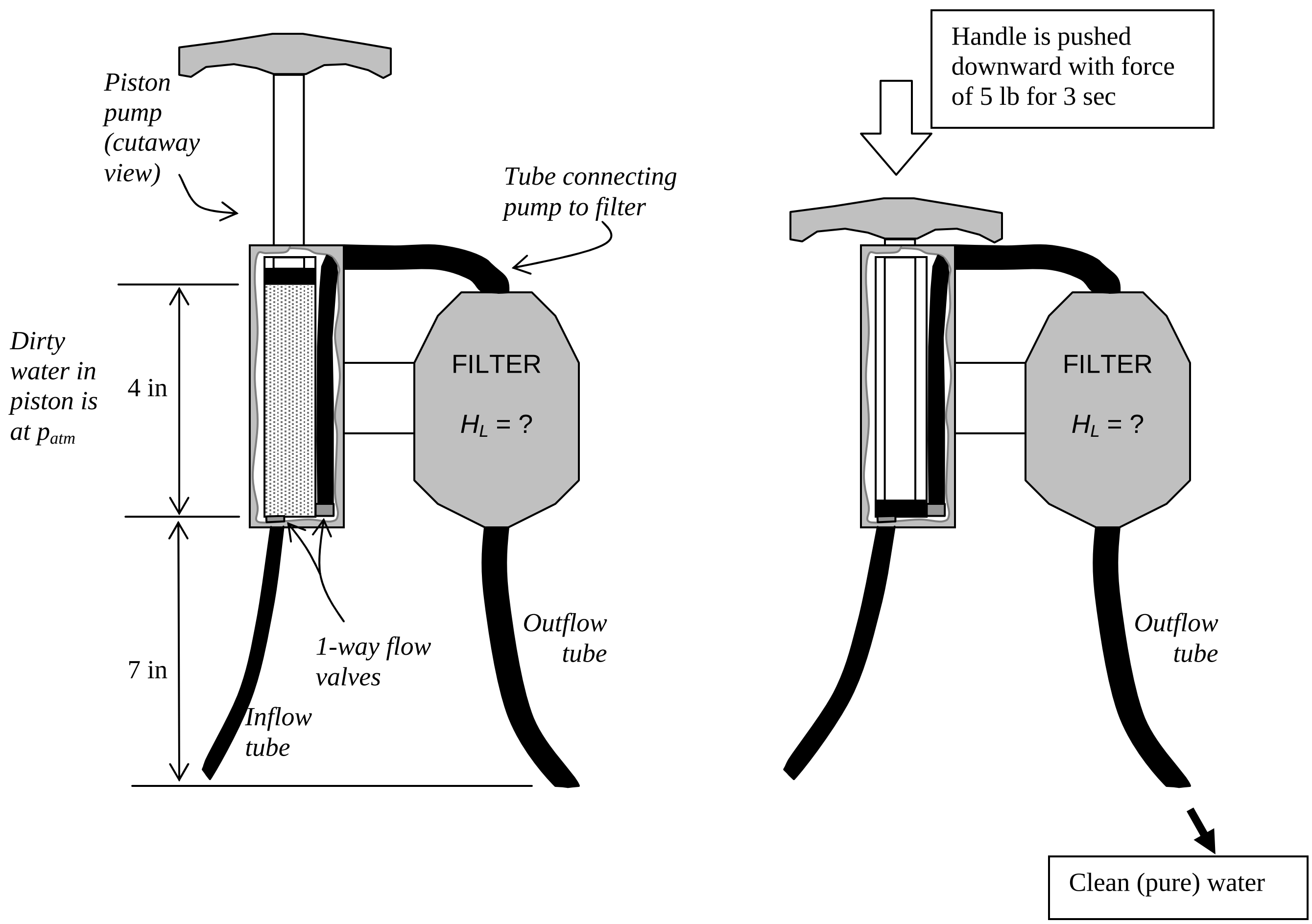
The filter is composed of a porous ceramic matrix that captures dirt and allows water to pass through. The matrix has a total pore volume of 14.4 in^3 – that is, there is 14.4 in^3 of pore (empty) space in the filter. When dirt is captured by the filter, the dirt is retained in the pore space and fills it in. The manufacturer recommends cleaning the filter when 65% of the pore space has been filled.

If a brand-new and clean filter is used to filter dirty water as described below, *how many gallons of clean water will be produced before the filter must be cleaned?* (25 points)



2. The portable water filter system of problem 1 is sketched again below. Water is pumped through the system by a piston pump that sucks water into the piston as the handle is pulled up and forces water out of the piston and through the filter as the handle is pushed down. Work done in each of these actions is the product of the force applied to the handle and the piston length (the distance the handle travels). The up and down actions are separate and must be analyzed with separate energy equations.

The 2 drawings describe the system at the beginning and the end of the down action of the pump handle (water moving from piston through filter and outflow tube). If the volumetric flowrate during this action is 1.5 teaspoon/sec, *what is the head loss (in feet) for the flow through the filter?* (25 points)



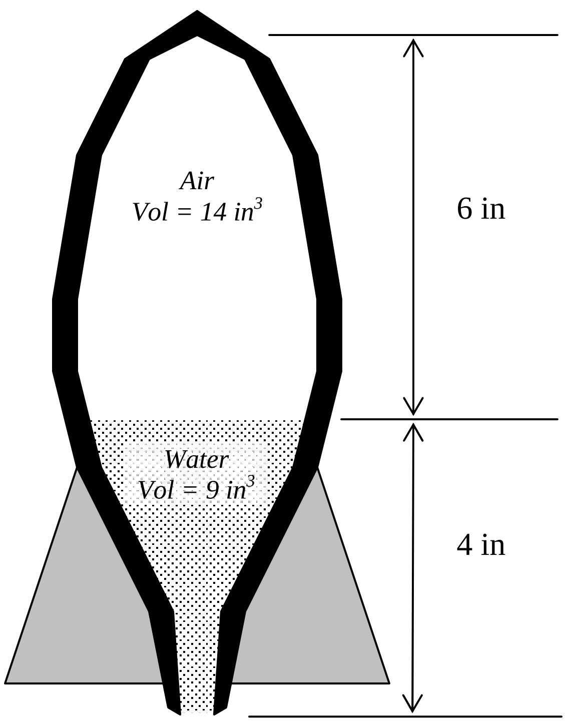
{Work space for #2}

3. A "water rocket" is sketched below. An air pump is used to pressurize the air pocket at the top of the internal cavity while the outlet is sealed shut. When the outlet seal is released, the pressurized air forces the water out of the outlet, and reactive force makes the rocket move upward. The rocket body weighs 1.4 oz.

One fine November morning, the rocket is used at standard atmospheric conditions. While the outlet is sealed, an air pump works to double the mass of air in the air pocket while temperature remains constant.

(a) *At the instant the outlet seal is released, what will be the upward reactive force on the rocket, and what will be the rocket's acceleration?* {Don't forget weight}
(b) *Assuming quasi-steady conditions for the first 0.05 sec after the seal is released, what will be the upward reactive force and acceleration at 0.05 sec after the seal is released?*

(50 points)



Outlet nozzle cross-sectional area = 0.2 in²
Discharge coeff. = 1.0

{Work space for #3}