Module 1: The Nature of Fluids/Pressure Measurement (CIVL 318)

Some useful results:

Pressure:	P	$=$	$\dfrac{F}{A}$		$\left(\dfrac{\text{Force}}{\text{Area}}\right)$
Pascal's Laws:	Pressure acts uniformly in all directions on a small volume of liquid. Pressure acts perpendicularly to the solid boundaries of a fluid.				
Density:	ρ (rho)	$=$	$\dfrac{m}{V}$		$\left(\dfrac{\text{Mass}}{\text{Volume}}\right)$
Specific Weight:	γ (gamma)	$=$	$\dfrac{w}{V}$		$\left(\dfrac{\text{Weight}}{\text{Volume}}\right)$
Specific Gravity:	sg	$=$	$\dfrac{\rho_s}{\rho_w@4°\text{C}}$	$=$	$\dfrac{\gamma_s}{\gamma_w@4°\text{C}}$
Density & Specific Weight:	γ	$=$	ρg		
Pressure Relationship:	p_{abs}	$=$	$p_{atm} + p_{gauge}$		
Pressure-Elevation Relationship:	Δp	$=$	γh		

Table A: Properties of Water

Temperature	Specific Weight	Density	Dynamic Viscosity
	γ	ρ	η
(°C)	(kN/m^3)	(kg/m^3)	(Pa $\cdot$ s)
0	9.81	1000	1.75×10^{-3}
5	9.81	1000	1.52×10^{-3}
10	9.81	1000	1.30×10^{-3}
15	9.81	1000	1.15×10^{-3}
20	9.79	998	1.02×10^{-3}
25	9.78	997	8.91×10^{-4}
30	9.77	996	9.00×10^{-4}
35	9.75	994	7.18×10^{-4}
40	9.73	992	6.51×10^{-4}
45	9.71	990	5.94×10^{-4}
50	9.69	988	5.41×10^{-4}
55	9.67	986	4.98×10^{-4}
60	9.65	984	4.60×10^{-4}
65	9.62	981	4.31×10^{-4}
70	9.59	978	4.02×10^{-4}
75	9.56	975	3.73×10^{-4}
80	9.53	971	3.50×10^{-4}
85	9.50	968	3.30×10^{-4}
90	9.47	965	3.11×10^{-4}
95	9.44	962	2.92×10^{-4}
100	9.40	958	2.82×10^{-4}

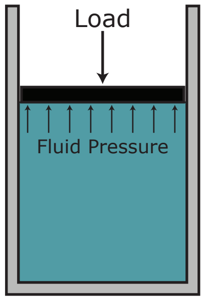
Table B: Properties of Common Liquids

(at 101 kPa and 25°C)

Liquid	Specific Gravity	Specific Weight	Density	Dynamic Viscosity
		γ	ρ	η
		(kN/m^3)	(kg/m^3)	(Pa $\cdot$ s)
Acetone	0.787	7.72	787	3.16×10^{-4}
Alcohol, Ethyl	0.787	7.72	787	1.00×10^{-3}
Alcohol, Methyl	0.789	7.74	789	5.60×10^{-4}
Alcohol, Propyl	0.802	7.87	802	1.92×10^{-3}
Benzene	0.876	8.59	876	6.03×10^{-4}
Carbon Tetrachloride	1.590	15.60	1590	9.10×10^{-4}
Castor Oil	0.960	9.42	960	6.51×10^{-1}
Ethylene Glycol	1.100	10.79	1100	1.62×10^{-2}
Gasoline	0.68	6.67	680	2.87×10^{-4}
Glycerine	1.258	12.34	1258	9.60×10^{-1}
Kerosene	0.823	8.07	823	1.64×10^{-3}
Linseed Oil	0.930	9.12	930	3.31×10^{-2}
Mercury	13.54	132.8	13540	1.53×10^{-3}
Propane	0.495	4.86	495	1.10×10^{-4}
Seawater	1.030	10.10	1030	1.03×10^{-3}
Turpentine	0.870	8.53	870	1.37×10^{-3}
Fuel Oil, medium	0.852	8.36	852	2.99×10^{-3}
Fuel Oil, heavy	0.906	8.89	906	1.07×10^{-1}

Example 1:

Solution:



A piston confines oil in a closed circular cylinder. The maximum operating pressure for the piston is 17.8 MPa. The piston has a diameter of 62.5 mm. What is the maximum load that the piston can support?

Exercise 1:

Solution:

A press used to produce coins requires a force of 8.20 kN.
The hydraulic cylinder has a diameter of 63.5 mm.

What is the oil pressure needed to generate this force?

Example 2:

An empty barrel with an inside diameter of 900 mm weighs 205 N.

What does the barrel weigh when it is filled to a depth of 750 mm with water at 25°C?

Solution:

Example 3:

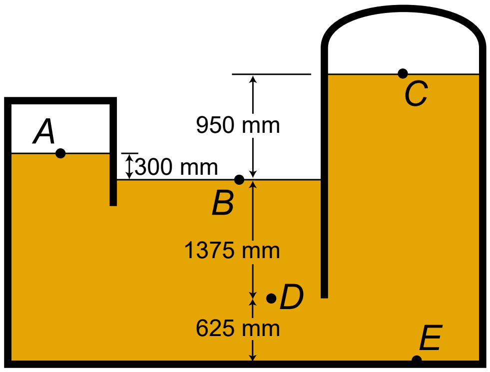
Calculate the density and the specific weight of benzene if it has a specific gravity of 0.876.

Solution:

Example 5:
An open cylindrical tank with diameter 5.75 m and depth 3.30 m is filled to the top with water at 10°C. The water is heated to 55°C. Assuming that the tank dimensions remain constant and there are no losses due to evaporation, calculate the mass of water that overflows.

Solution:

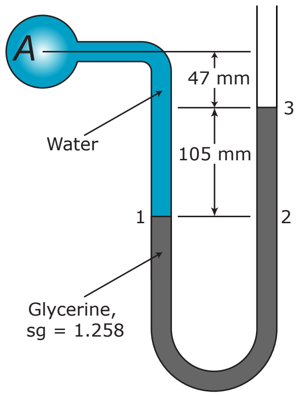
Example 6:



A tank, open to the atmosphere in the centre, contains medium fuel oil. Atmospheric pressure is 102.1 kPa. Calculate the gauge pressure and the absolute pressure for locations *A*, *B*, *C*, *D* and *E*.

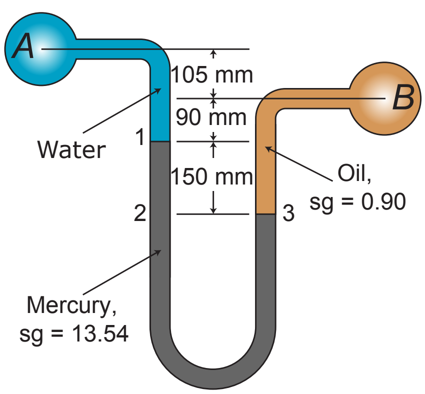
Solution:

Example 7:
Determine the pressure at A given that the temperature of the water is 25°C.



Solution:

Example 8:
Find the pressure difference between A and B



Solution: