CHEN.3030 Fluid Mechanics (Section 202)

Homework Assignment #1 Spring 2017

Fluid Properties and Units Consistency

1. Prof. White's pickup truck weighs about 100 lbf more when the fuel tank is full versus when it is empty. If the specific gravity of gasoline is about 0.726 and the price of gas is about $2.30 per gallon, estimate the maximum cost to "fill it up".

2. A tank contains air at a temperature of 15 C and an absolute pressure of 210 kPa. The volume of the tank is 5 m^3. If the temperature of the air rises to 30 C, determine the mass of air that must be removed from the tank to maintain the same initial pressure.

3. The efficiency, η, of a pump is defined as the dimensionless ratio of the power delivered to the fluid (P_A = power added) to the power required to drive the pump (P_I = power input),

$$\eta = \frac{P_A}{P_I} = \frac{Q\Delta p}{P_I}$$

where Q is the volume flow rate and Δp is the pressure rise produced by the pump.

Suppose that a certain pump develops a pressure rise of 35 psi when its flow rate is 40 L/s. If the input power is 16 hp, what is the pump efficiency?

4. This problem has two parts, as follows:

a. The velocity profile for a moving fluid near the surface of a flat plate can often be described with a quadratic relationship of the form

$$u(y) = c_1 y + c_2 y^2$$

where y is the distance from the plate surface and u is the fluid velocity. In a particular situation, $u = 10y - 0.25y^2$, where y is in mm and u has units of mm/s. For this situation, what are the units of the constants $c_1 = 10$ and $c_2 = -0.25$?

b. The force, F, that is exerted on a small object moving slowly through a liquid is proportional to the fluid viscosity, μ, the object's effective diameter, D, and the particle velocity, v. This can be represented mathematically as

$$F = c\mu Dv$$

where c is the proportionality constant. For example, for the case of a small spherical particle, the numerical value of the constant is $c = 3\pi$ and the force expression is given by $F = 3\pi\mu Dv$.

What are the units of the constant $c = 3\pi$? Can this specific equation for the spherical particle with $c = 3\pi$ be used with both British and SI units? Explain/justify your answer.

5. A compressed air tank contains 8 kg of air at a temperature of 80 C. A pressure gage on the tank reads 300 kPa. Determine the volume of the tank.