

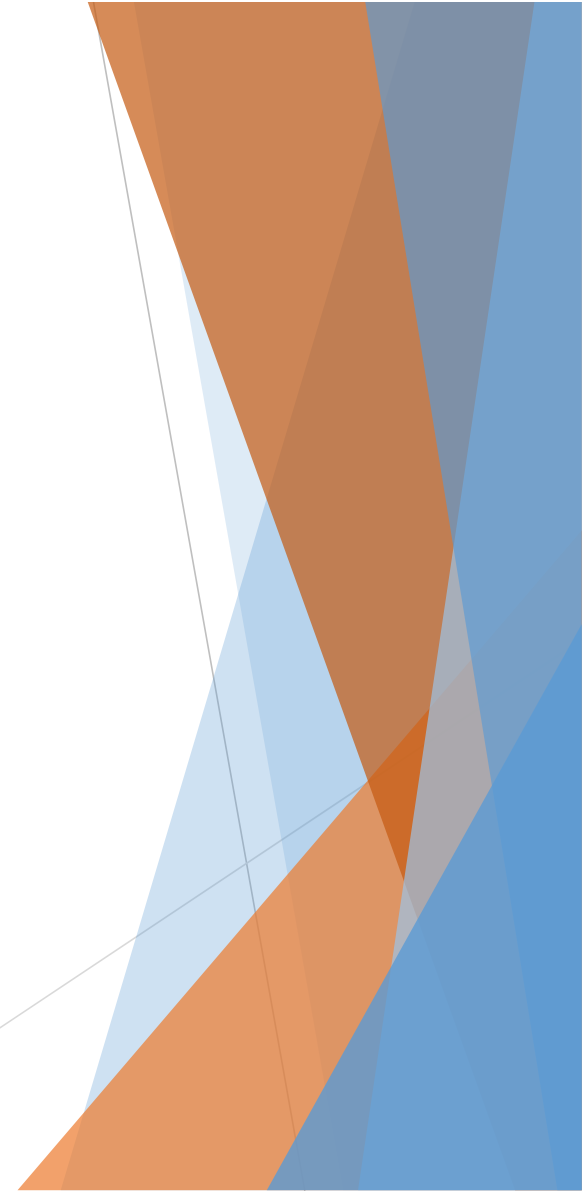


FACULTY OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING

INTRODUCTION TO CHEMICAL ENGINEERING CEN 101

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***SAMPLE PROBLEMS
WITH
SOLUTIONS***



A waste treatment pond is **50 m** long and **15 m** wide, and has an average depth of **2 m**. The density of the waste is **85.3 lbf/ft³**. Calculate the *weight of the pond contents* in ***lbf***.

Volume of the waste treatment pond

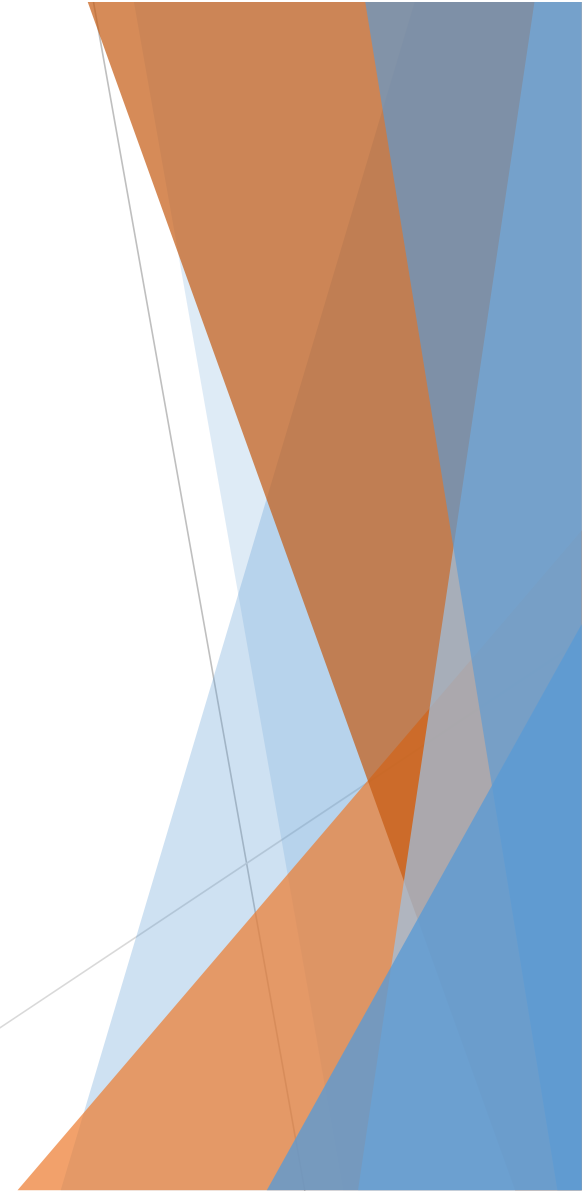
$$V = 50 \text{ m} \times 15 \text{ m} \times 2 \text{ m} = 1500 \text{ m}^3$$

$$1500 \text{ m}^3 \cdot \frac{35.288 \text{ ft}^3}{1 \text{ m}^3} = 52932 \text{ ft}^3$$

Weight of the waste water

$$W = 85.3 \text{ lbm/ft}^3 \times 52932 \text{ ft}^3 = 4515100 \text{ lbm}$$

$$4.515 \times 10^6 \text{ lbm} \times 32.174 \text{ ft/s}^2 = \mathbf{116566 \text{ lbf}}$$



The specific gravity of gasoline is approximately **0.70**

- a) Determine the mass (kg) of **50 liters** of gasoline.
- b) The mass flow rate of gasoline exiting a refinery tank is **1150 kg/min**. Estimate the *volumetric flow rate* in **m³/min**.

Reference density of water is assumed to be 1000 kg/m³

Density of the gasoline;

$$SG_{gasoline} = 0.7 = \frac{\rho_{gasoline}}{\rho_{ref(water)}}$$
$$\Rightarrow \rho_{gasoline} = 1000 \frac{kg}{m^3} \cdot 0.7 = 700 \frac{kg}{m^3}$$

Mass of the 50 L gasoline;

$$700 \frac{kg}{m^3} \cdot 50L \cdot \frac{1 m^3}{1000 L} = 35 kg$$

Volumetric flow rate, q (m³/min)

$$q = \frac{1150 \frac{kg}{min}}{700 \frac{kg}{m^3}} = \mathbf{1.64 \frac{m^3}{min}}$$

A pressure gauge on a welder's tank gives a reading of **22.4 psig**. The barometric pressure is **28.6 in Hg**. Calculate the *absolute pressure in the tank* in;

- a) **lbf/ft²**.
- b) **N/m²**.

Absolute pressure in the tank is the sum of the gauge and atmospheric (barometric) pressures, and they should be in the same units.

Barometric pressure is 28.6 in Hg.

$$P_{atm} = 28.6 \text{ in. Hg} \cdot \frac{1 \text{ psi}}{2.036 \text{ in. Hg}} = 14.05 \text{ psi}$$

Absolute pressure in the tank :

$$P_{absolute} = 14.05 \text{ psi} + 22.4 \text{ psig} = 36.45 \text{ psia}$$

$$P_{absolute} = 36.45 \text{ psi} \cdot \frac{144 \frac{\text{lbf}}{\text{ft}^2}}{1 \text{ psi}} = 5249 \frac{\text{lbf}}{\text{ft}^2}$$

$$P_{absolute} = 36.45 \text{ psi} \cdot \frac{6894.75 \frac{\text{N}}{\text{m}^2}}{1 \text{ psi}} = 251314 \frac{\text{N}}{\text{m}^2}$$

The enthalpy values of the vapour phase of the saturated water vapour at different temperature are given in the table.

Calculate the enthalpy of the saturated vapour at 90 °C.

Table. Temperature-enthalpy values for saturated vapour

T, °C	65	80	95	105
H, kJ/kg	2618.3	2643.7	2668.1	2683.8

Enthalpy of water at 90 °C **cannot** be read from the table directly. The desired enthalpy value is in the range of 2643.7 - 2668.1 kJ/kg, which corresponds to a temperature range of 80 to 95 °C.

It is assumed that the temperature changes **linearly** with the enthalpy in the 80 - 95 °C temperature range and the value sought is calculated by interpolation.

$$x_1 = 80 \text{ }^\circ\text{C} \quad \Rightarrow \quad y_1 = 2643.7 \text{ kJ/kg}$$

$$x_2 = 95 \text{ }^\circ\text{C} \quad \Rightarrow \quad y_2 = 2668.1 \text{ kJ/kg}$$

$$x = 90 \text{ }^\circ\text{C} \quad \Rightarrow \quad y = ?$$

$$H = 2643.7 + \frac{90 - 80 \text{ (}^\circ\text{C)}}{95 - 80 \text{ (}^\circ\text{C)}} (2668.1 - 2643.7) \text{ (kJ/kg)} = \mathbf{2660 \text{ kJ/kg}}$$