Chapter 1

Introduction & Identification of Units

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Mass, Weight & Force

- Mass is a measure of the quantity of fluid, and it is a measure of its inertia, or resistance to a change in motion.
- Weight is the force that gravity exerts on a mass. Thus, w = mg
  - Where g = 32 ft/s^2 or g = 9.81 m/s^2

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SI Units

- Length = meter (m)
- Time = second (s)
- Mass = kilogram (kg) or N-s^2/m
- Force = newton (N) or kg-m/s^2

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Force in SI Units

- F = ma = kg x m/s^2 = newton
- 1.0 newton is the force required to give a mass of 1.0 kg an acceleration of 1.0 m/s^2

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Example of Force (SI Units)

- A steel block with a mass of 1000 kg is suspended on a wire rope from a crane. What is the force on the wire rope?
- w = mg = 1000 kg x 9.81 m/s^2 = 9810 kg-m/s^2
- w = 9810 N = 9.81 kN force (tension) in the rope
- Note that since w = mg, m = w/g, which gives us mass in the units of N-s^2/m (= kg).

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Common prefixes for SI Units

- Most SI quantities are given in engineering notation. In other words, most units are in powers of three, as in these examples:
- 1000 N = 1 kN and 10,000 N = 10 kN
- 0.001 m = 1 mm and .050 m = 50 mm
- 15,500,000 Pa = 15.5 MPa

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English Units [and SI equivalent]

- Length = foot (ft) [meter]
- Time = second (s) [second]
- Force = pound (lb or lbf) [newton]
- Mass = slug or lb-s^2/ft [kilogram]

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Force in English Units

- F = ma = lbm/g_c x ft/s^2 = lbf
- g_c = 32.2 lbm-ft/(lbf-s^2)
- g_c is used when converting from lbm. It's not needed if mass is already in slugs.
- One slug of material exerts a force of 32.2 lbf on earth.
- m = F/a = lbf/(ft/s^2) = lbf - s^2/ft

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Example of Force (English Units)

- A steel block with a mass of 2200 lbm is suspended on a wire rope from a crane. What is the force on the wire rope?
- w = F = mg/g_c = 2200 lbm x 32.2 ft/s^2 /(g_c) = 2200 lbf

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Example of Force (with slugs)

- A steel block with a mass of 68.3 slugs is suspended on a wire rope from a crane. What is the force on the wire rope?
- w = F = mg = 68.3 slugs x 32.2 ft/s^2 = 2200 lbf
- Note that a change in gravity would affect the answer (like on the moon).

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Keeping Units Consistent

- Maintaining units throughout a problem is top priority.
- Carry units through entire formula.
- Use conversion factors to obtain desired answer
- Wait until all algebra is done before entering numbers into the calculator.

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The Definition of Pressure

- The amount of force exerted on a unit area of a substance.
  - Pressure acts uniformly within the fluid
  - Pressure acts perpendicular to the boundary of the vessel.
- P = F/A = Force / Area (psi or Pa)

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Sample Problem of Pressure

- A piston rests on a fluid in a cylinder that is 4.0 inches in diameter. The piston pushes down with a force of 1000 lbf. How mush pressure is in the fluid?
- $P = F/A = 1000 \text{ lbf}/(3.14 \times 4^2/4)$
- $P = 79.6 \text{ psi } (\text{lbf/inch}^2)$

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Compressibility

- Compressibility is the change in volume of a fluid relative to its change in pressure.
- Called Bulk Modulus of Elasticity, or just Bulk Modulus (E, psi)
- Due to high E, we will consider fluids in this class as incompressible.

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Density, Spec. Wt, & Sp. Gravity

- Density: $\rho = m/V$ (kg/m^3 or $slugs/ft^3$)
- Specific Weight: $\gamma = w/V$ (N/m^3)
- Specific Gravity: A ratio of a material compared to water at 4 degree C. It can be either a ratio of density or specific weight.
- $sg = \gamma_s / \gamma_w$ @ 4 C $= \rho_s / \rho_w$ @ 4 C

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Values for Water @ 4 C

- Values in SI and English Units
- $\gamma_w = 9.81 \text{ kN/m}^3$ or 62.4 lbf/ft^3
- $\rho_w = 1000 \text{ kg/m}^3$ or 1.94 slugs/ft^3

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Relationship between γ and ρ

- Specific weight is found by multiplying density by gravity
- $\gamma = \rho g$
- When going from mass to force units, use the proper conversion: $1 \text{ kg} = 1 \text{ N-s}^2/\text{m}$

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Example of Sp. Wt. and Density

- Gasoline has a density of 600 kg/m^3. Calculate the sp wt.
- $600 \text{ kg/m}^3 \times 9.81 \text{ m/s}^2 = 5886 \text{ kg/m}^2\text{-s}^2 \times (\text{N-s}^2)/\text{kg-m} = 5.89 \text{ kN/m}^3$ (which = sp.wt.)
- Note that $(\text{N-s}^2)/\text{kg-m}$ is the conversion factor equal to 1.

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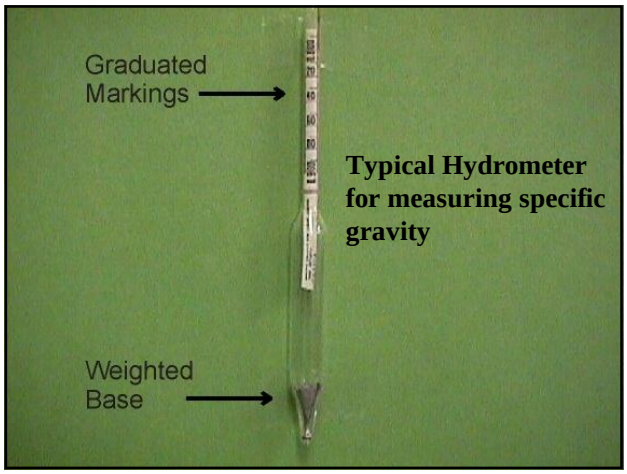
Specific Gravity in Degrees API

- API Scale uses 60 F as reference.
- Sp. Gr. is determined with both fluids at 60 F, then corrected for other temps.
- API Scale designates sp. gr. in terms of deg API = (141.5/s.g.)-131.5
- deg API range is from 10 to 80 deg.
- deg API 20 to 70 = sp. gr. 0.93 to 0.70



Typical Hydrometer for measuring specific gravity

Hydrometers

- Calibrated to float in water reading 1.000
- Insert and spin (to remove air bubbles) and read scale
- The hydrometer will float higher in denser fluids (sp gr > 1.000)
- Charts used to correct for temperatures other than 60 F

Chapter 1 Homework

- Problems:
- 3, 41, 53, 63, 77, 85 & 93