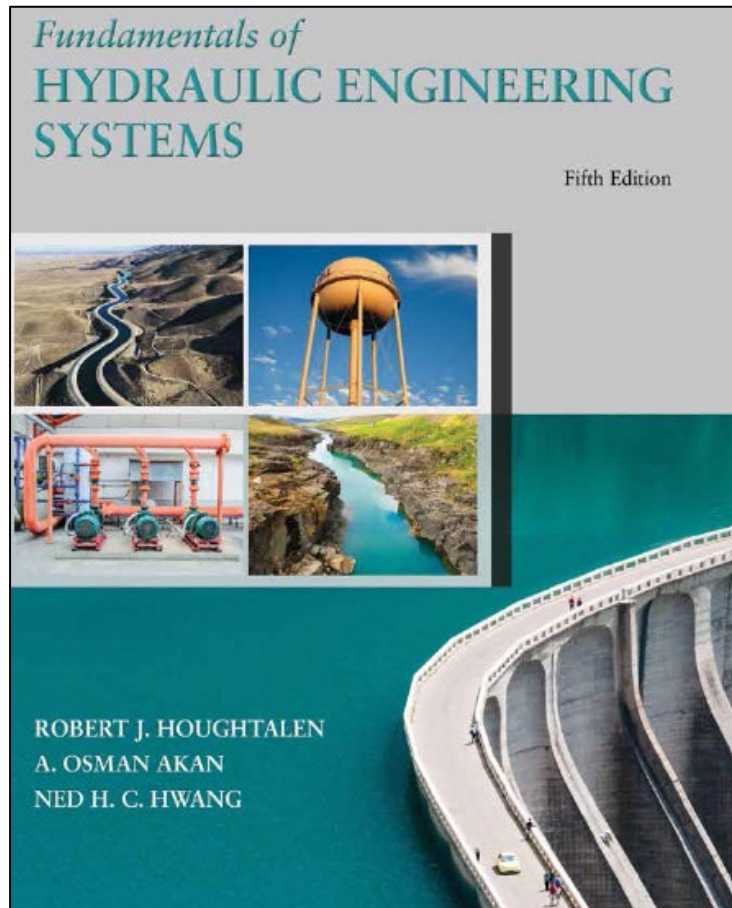


# Fundamentals of Hydraulic Engineering Systems

Fifth Edition



## Chapter 1

### Fundamental Properties of Water

# Learning Objectives

- 1.1** Understand the concepts of **atmospheric pressure** and **vapor pressure**.
- 1.2** Recognize the difference between **latent heat** and **specific heat**.
- 1.3** Explain the relationship between **density** and **specific weight** and transition between them.
- 1.4** Describe the properties of a **Newtonian fluid**.
- 1.5** Define **surface tension** and **compressibility**.
- 1.6** Calculate solutions to various problems that involve these water properties.

## Active Learning Exercise (2 of 7)

2. What is vapor pressure? (State Henry's Law of Partial Pressure.)

**Ans.** Each gas exerts a partial pressure in proportion to its percentage of the volume.

3. What is the difference between latent heat and specific heat?

**Ans.** Latent heat – the energy required to change phase

Specific heat – the energy required to change temperature



## Active Learning Exercise (3 of 7)

4. What is the relationship between density and specific weight?

**Ans.**  $\delta = \rho g$ , which is derived from  $\mathbf{F} = \mathbf{ma}$

5. What is a Newtonian fluid?

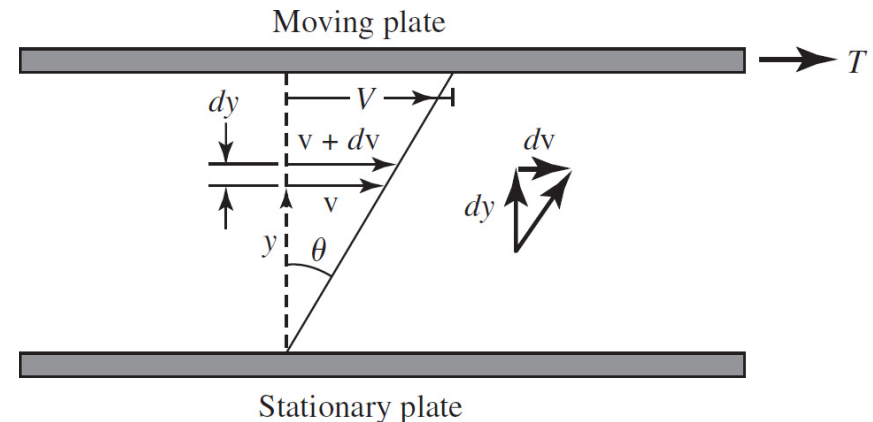
**Ans.** Any fluid that abides by:

$$\tau = \mu \left( \frac{dv}{dy} \right)$$

where,

$\tau$  = shear stress, and

$\mu$  = fluid viscosity



**Figure 1.1** Shearing stresses in fluids

## Active Learning Exercise (4 of 7)

6. Is water compressible?

**Answer.** Slightly, but under great pressure; the bulk modulus of elasticity is 300,000 psi.

7. Identify two manifestations (i.e., visual evidence) of surface tension?

**Answer.** Capillary rise in tubes, water beads on waxed cars, drop formation, floating needles, nano-fiber clothes that never need washing.



Water drops on a spider web.

## Active Learning Exercise (5 of 7)

Water is one of most unique and important substances on our planet. Three properties characterize its importance.

- a. A **high heat capacity** (it absorbs great quantities of heat without a large change in temperature).
- b. A **high dissolving capacity** (it is the universal solvent).
- c. A **unique temperature-density relationship** (its maximum density is at 4°C, unlike most substances which continue to get denser as the temperature is lowered).

# Active Learning Exercise (6 of 7)

8. Ramifications to our planet if water did not have a high heat capacity?

**Ans.** Extremes of heat and cold would exist; water moderates the earth's temperature.

9. Ramifications if water did not have a high dissolving capacity?

**Ans.** Plants and animals depend on nutrients that are dissolved in water and transported into them. Oxygen dissolved in water is critical to aquatic life.



**Painted Desert & Glacier Bay National Parks**

<http://www.nps.gov/pefo/learn/nature/environmentalfactors.htm>

<http://www.nps.gov/media/photo/gallery.htm>

# Active Learning Exercise (7 of 7)

10. Ramifications to our planet if water did not have a unique temperature-density relationship?

**Ans.** Lakes would freeze from the bottom up destroying all aquatic life each winter.



**Quiz** next class.

**Homework Problems:**

1.2.5, 1.3.1, 1.4.6,  
1.5.3, & 1.6.1

**Ice Fishing for Northern Pike**

<http://www.state.nj.us/dep/fgw/articefishpike05.htm>



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# Active Learning Exercise (1 of 7)

**In small groups, answer these questions.**



**1.** What is the cause of atmospheric pressure?

**Ans.** The atmosphere is a 1500 km thick layer of mixed gases. (Name them.) Atmospheric pressure is due to the weight of these gases.