5.13 The velocity v of a falling parachutist is given by

$$v = \frac{gm}{c}\left(1 - e^{-(c/m)t}\right)$$

where $g = 9.81\,\text{m/s}^2$. For a parachutist with a drag coefficient $c = 15$ kg/s, compute the mass m so that the velocity is $v = 36$ m/s at $t = 10$ s

5.15 As depicted in Fig. P5.15, the velocity of water, v (m/s), discharged from a cylindrical tank through a long pipe can be computed as

$$v = \sqrt{2gH}\tanh\left(\frac{\sqrt{2gH}}{2L}t\right)$$

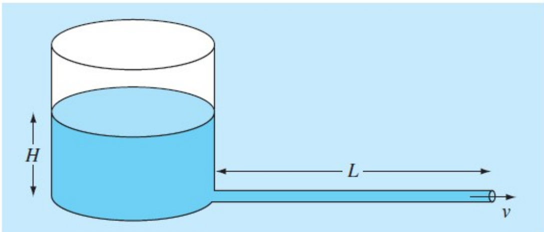

FIGURE P5.15

where $g = 9.81$ m/s^2, H = initial head (m), L = pipe length (m), and t = elapsed time (s). Determine the head needed to achieve $v = 5$ m/s in 2.5 s for a 4-m-long pipe

5.17 You are designing a spherical tank (Fig. P5.17) to hold water for a small village in a developing country. The volume of liquid it can hold can be computed as

$$V = \pi h^2 \frac{[3R - h]}{3}$$

where V = volume (m^3), h = depth of water in tank (m), and R = the tank radius (m).

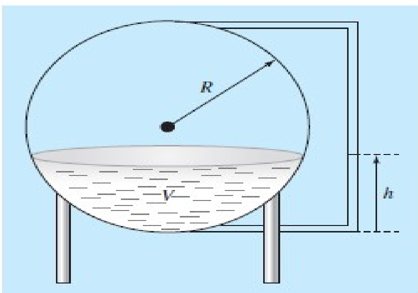

FIGURE P5.17

If $R = 3$ m, to what depth must the tank be filled so that it holds 30 m^3?

5.18 The saturation concentration of dissolved oxygen in freshwater can be calculated with the equation (APHA, 1992)

$$\ln o_{sf} = -139.34411 + \frac{1.575701 \times 10^5}{T_a} - \frac{6.642308 \times 10^7}{T_a^2} + \frac{1.243800 \times 10^{10}}{T_a^3} - \frac{8.621949 \times 10^{11}}{T_a^4}$$

where o_{sf} = the saturation concentration of dissolved oxygen in freshwater at 1 atm (mg/L) and T_a = absolute temperature (K). Remember that $T_a = T + 273.15$, where T = temperature (°C). According to this equation, saturation decreases with increasing temperature. For typical natural waters in temperate climates, the equation can be used to determine that oxygen concentration ranges from 14.621 mg/L at 0°C to 6.413 mg/L at 40°C.

Encontre a temperatura da água quando a saturação de oxigênio é de 8,10 e 12 mg/L.

5.19 According to *Archimedes principle*, the *buoyancy* force is equal to the weight of fluid displaced by the submerged portion of an object. For the sphere depicted in Fig. P5.19, use bisection to determine the height h of the portion that is above water. Employ the following values for your computation: r = 1 m, ρ_s = density of sphere = 200 kg/m^3, and ρ_w = density of water = 1000 kg/m^3. Note that the volume of the above-water portion of the sphere can be computed with

$$V = \frac{\pi h^2}{3}(3r - h)$$

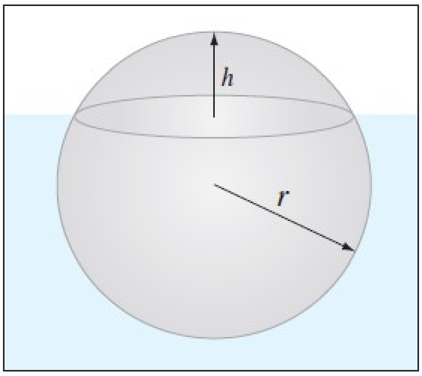

FIGURE P5.19

6.20 The Manning equation can be written for a rectangular open channel as

$$Q = \frac{\sqrt{S}(BH)^{5/3}}{n(B + 2H)^{2/3}}$$

where Q = flow [m^3/s], S = slope [m/m], H = depth [m], and n = the Manning roughness coefficient. Develop a fixed-point iteration scheme to solve this equation for H given $Q = 5$, $S = 0.0002$, $B = 20$, and $n = 0.03$. Prove that your scheme converges for all initial guesses greater than or equal to zero.

of x = 0.5025 and ε_s = 0.01%. Explain your results.

6.15 The "divide and average" method, an old-time method for approximating the square root of any positive number a, can be formulated as

$$x = \frac{x + a/x}{2}$$

Prove that this is equivalent to the Newton-Raphson algorithm.

8.3 In a chemical engineering process, water vapor (H_2O) is heated to sufficiently high temperatures that a significant portion of the water dissociates, or splits apart, to form oxygen (O_2) and hydrogen (H_2):

$$H_2O \rightleftharpoons H_2 + \tfrac{1}{2}O_2$$

If it is assumed that this is the only reaction involved, the mole fraction x of H_2O that dissociates can be represented by

$$K = \frac{x}{1-x}\sqrt{\frac{2p_t}{2+x}} \tag{P8.3.1}$$

where K = the reaction equilibrium constant and p_t = the total pressure of the mixture. If p_t = 3 atm and K = 0.05, determine the value of x that satisfies Eq. (P8.3.1).

8.4 The following equation pertains to the concentration of a chemical in a completely mixed reactor:

$$c = c_{\text{in}}(1 - e^{-0.04t}) + c_0 e^{-0.04t}$$

If the initial concentration $c_0 = 4$ and the inflow concentration $c_{\text{in}} = 10$, compute the time required for c to be 93 percent of c_{in}.

8.9 The volume V of liquid in a spherical tank of radius r is related to the depth h of the liquid by

$$V = \frac{\pi h^2(3r - h)}{3}$$

Determine h given r = 1 m and V = 0.5 m^3.

8.10 For the spherical tank in Prob. 8.9, it is possible to develop the following two fixed-point formulas:

$$h = \sqrt{\frac{h^3 + (3V/\pi)}{3r}}$$

and

$$h = \sqrt[3]{3\left(rh^2 - \frac{V}{\pi}\right)}$$

If r = 1 m and V = 0.5 m^3, determine whether either of these is stable, and the range of initial guesses for which they are stable.

8.14 In structural engineering, the *secant formula* defines the force per unit area, P/A, that causes a maximum stress σ_m in a column of given slenderness ratio L/k:

$$\frac{P}{A} = \frac{\sigma_m}{1 + (ec/k^2)sec[0.5\sqrt{P/(EA)}(L/k)]}$$

where ec/k^2 = the eccentricity ratio and E = the modulus of elasticity. If for a steel beam, E = 200,000 MPa, $ec/k^2 = 0.2$, and σ_m = 250 MPa, compute P/A for $L/k = 100$. Recall that $\sec x = 1/\cos x$.

8.21 In ocean engineering, the equation for a reflected standing wave in a harbor is given by $\lambda = 16$, $t = 12$, $v = 48$:

$$h = h_0\left[\sin\left(\frac{2\pi x}{\lambda}\right)\cos\left(\frac{2\pi tv}{\lambda}\right) + e^{-x}\right]$$

Solve for the lowest positive value of x if $h = 0.4h_0$.

8.36 Mechanical engineers, as well as most other engineers, use thermodynamics extensively in their work. The following polynomial can be used to relate the zero-pressure specific heat of dry air, c_p kJ/(kg K), to temperature (K):

$$c_p = 0.99403 + 1.671 \times 10^{-4}T + 9.7215 \times 10^{-8}T^2$$
$$-9.5838 \times 10^{-11}T^3 + 1.9520 \times 10^{-14}T^4$$

Determine the temperature that corresponds to a specific heat of 1.2 kJ/(kg K).

8.35 Real mechanical systems may involve the deflection of nonlinear springs. In Fig. P8.35, a mass m is released a distance h above a nonlinear spring. The resistance force F of the spring is given by

$$F = -(k_1 d + k_2 d^{3/2})$$

Conservation of energy can be used to show that

$$0 = \frac{2k_2 d^{5/2}}{5} + \frac{1}{2}k_1 d^2 - mgd - mgh$$

Solve for d, given the following parameter values: k_1 = 40,000 g/s^2, k_2 = 40 g/(s^2 m$^{0.5}$), m = 95 g, g = 9.81 m/s^2, and h = 0.43 m.

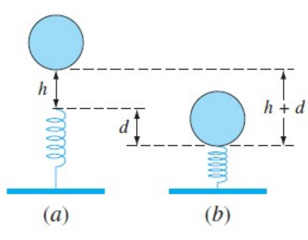

FIGURE P8.35