1. A reversible chemical reaction

$$2\text{A} + \text{B} \rightleftarrows \text{C}$$

can be characterized by the equilibrium relationship

$$K = \frac{c_c}{c_a^2 \, c_b}$$

where the nomenclature c_i represents the concentration of constituent i. Suppose that we define a variable x as representing the number of moles of C that are produced. Conservation of mass can be used to reformulate the equilibrium relationship as

$$K = \frac{(c_{c,0} + x)}{(c_{a,0} - 2x)^2(c_{b,0} - x)}$$

where the subscript 0 designates the initial concentration of each constituent. If $K = 0.016$, $c_{a,0} = 42$, $c_{b,0} = 28$, and $c_{c,0} = 4$, determine the value of x.

(a) Obtain the solution graphically.

(b) On the basis of **(a)**, solve for the root with initial guesses of $x_l = 0$ and $x_u = 20$ to $\varepsilon_s = 0.5\%$. Choose either bisection or false position to obtain your solution. Justify your choice.

2. For fluid flow in pipes, friction is described by a dimensionless number, the *Fanning friction factor f*. The Fanning friction factor is dependent on a number of parameters related to the size of the pipe and the fluid, which can all be represented by another dimensionless quantity, the *Reynolds number* Re. A formula that predicts f given Re is the *von Karman equation:*

$$\frac{1}{\sqrt{f}} = 4 \log_{10}\left(\mathrm{Re}\sqrt{f}\right) - 0.4$$

Typical values for the Reynolds number for turbulent flow are 10,000 to 500,000 and for the Fanning friction factor are 0.001 to 0.01. Develop a function that uses bisection to solve for f given a user-supplied value of Re between 2500 and 1,000,000. Design the function so that it ensures that the absolute error in the result is $E_{a,d} < 0.000005$.

3. According to *Archimedes' principle*, the *buoyancy* force is equal to the weight of fluid displaced by the submerged portion of the object. For the sphere depicted in Fig. 1. 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

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

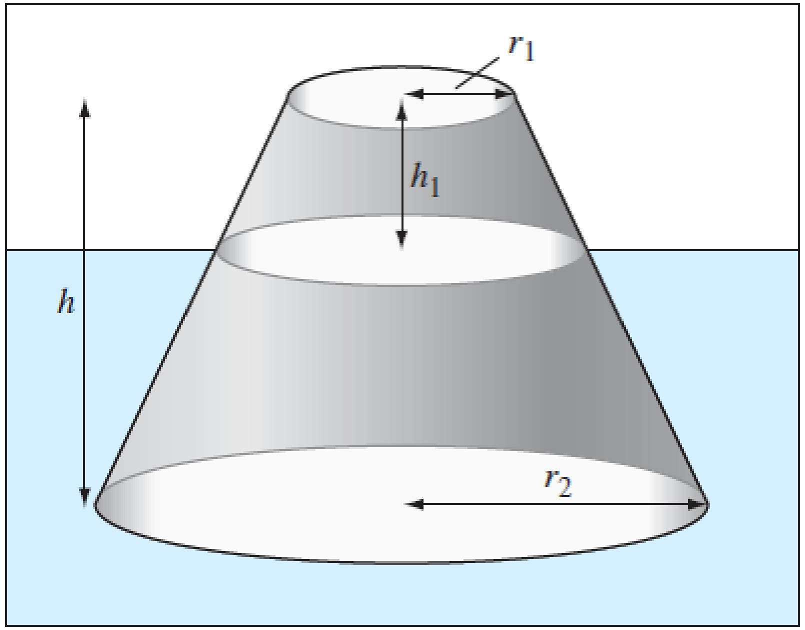

Fig. 1.