entering a series of instructions defined by program lines, one line at a time. The program lines are entered into memory by typing the appropriate codes and pressing the return (enter) key. Typed codes, although they appear on the screen, will not be entered into the computer's memory unless the return key is pressed. To clear the screen, type "CLS" and enter. To determine what has been loaded into memory, type "LIST" and enter. Stored programs may also be loaded into memory by typing "LOAD *filename*" and enter. The filename is what the file was called when it was stored.

BASIC executes program lines consecutively; therefore, make sure that the variables have been defined and their values are known before using them in a program line. Data may be entered using the "input" command, by defining values of variables in the opening lines of the program, or by using the "data" statement followed by a "read" statement. The following example illustrates the use of BASIC in an iterative procedure for determining the root of a function:

EXAMPLE: Determine the positive root of the function $x^2 + 109.3x^{1.35} - 20000 = 0$. The solution is based on substitution of various values of x. The BASIC program is:

```
10 Assume x = 40 and increment it by 1 to x = 60
20 for x = 40 to 60
30 fx = x^2 + 109.3 * x^1.35 - 20000
40 print "x = "; x , "fx = "; fx
50 next x
```

Type "run" and enter to run the program. The screen with display values of *fx* for the different values of x.

The value of *fx* changes from negative (-620) at $x = 43$ to positive (19.44) at $x = 44$. Thus, the root must be just slightly below and close to 44. To narrow the value of x to the nearest tenth, line 10 in the program is changed to substitute values of x between 43 and 44 in increments of 0.1. Edit line 10 in the program, converting it to 10 for $x = 43$ to 44 step 0.1. Running the revised program will give $F(x) = -44.8$ at $x = 43.9$ and $F(x) = 19.44$ at $x = 44$. Thus x is greater than 43.9 and is closer to 44. The root of the equation to the nearest tenth is $x = 44.0$.

Solution: Using the Newton-Raphson iteration technique, $F'(x) = 2x + 147.555x^{0.35}$. The BASIC program is:

```
10 x = 40
20 fx = x^2 + 109.3 * x^1.35 - 20000
30 fxp = 2 * x + 147.555 * x^0.35
40 x2 = x - (fx / fxp)
50 if abs(fx) < 0.1 then goto 80
```

$$\left[\frac{da_w}{dx}\right] = [(0.7)(2)(1 - 0.7)(0.7)(2.303) + 1][10]^{-0.7(1-0.7)^2}$$

$$= 1.6769(10)^{-0.063} = 1.450$$

a_w will be changing faster as x is incremented at $x = 0.7$ compared to $x = 0.9$.

EXAMPLE 4: Differentiate:

$$y = \frac{3x + 2}{x + 3}$$

Using the formula for the derivative of a quotient:

$$dy = \frac{(x + 3)d(3x + 2) - (3x + 2)d(x + 3)}{(x + 3)^2}$$

$$= \frac{(x + 3)(3\,dx) - (3x + 2)\,dx}{(x + 3)^2} = \frac{(3x + 9 - 3x - 2)\,dx}{(x - 3)^2}$$

$$\frac{dy}{dx} = \frac{7}{(x + 3)^2}$$

EXAMPLE 5: The growth of microorganisms expressed as cell mass is represented by the following:

$$\log\left(\frac{C}{C_0}\right) = kt$$

Determine the rate of increase of cell mass at $t = 10$ h if it took 1.5 h for the cell mass to double and the initial cell mass at time zero (C_0) is 0.10 g/L.

Soiution: The value of k is determined from the time required for the cell mass to double. $k = (\log 2)/1.5 = 0.200\ \mathrm{h}^{-1}$. The expression to be differentiated to determine the rate is $\log(C/0.10) = 0.200\,t$. Differentiating using the formula for derivative of a logarithmic function:

where f_i = mole fraction of component i in a solution containing only component i and all the water present in the mixture.

$$f_i = 1 - \left[\frac{x_i/M_i}{(x_i/M_i) + (1 - x_1 - x_2)/18}\right]$$

10. Determine the slope of the following functions:

$$f(x) = 2x^4 - 3x^2 + 7x \qquad \text{at } x = 2$$

$$xy = (0.5x + 3)(x + 2) \qquad \text{at } x = 1$$

11. Determine the maximum and minimum values of the functions in problem 10.

12. Determine the slope of the following function at the indicated point:

$$x = (0.5\,xy + 3)(3 + x^2) \qquad \text{at } x = 1$$

13. Write a computer program in BASIC which can be used to determine the boiling temperature of a liquid in an evaporator as it is being concentrated. The boiling point of a liquid is the temperature at which the vapor pressure equals the atmospheric pressure. A solution will exhibit a boiling point rise because the solute will lower the water activity, resulting in a higher temperature to be reached before boiling occurs. The vapor pressure of water ($P°$) as a function of temperature is expressed by the following equation:

$$\ln(P°) = \left(\frac{H}{R}\right)\left(\frac{1}{T}\right) + C$$

where $P°$ is the vapor pressure in kiloPascals. H/R is the ratio of the latent heat of vaporization and the gas constant, C is a constant, and T is the absolute temperature in °K. The value for H/R is 4950, and C is 17.86.

Atmospheric pressure is 101 kiloPascals. The vapor pressure of a solution is $P = a_w P°$. The water activity (a_w) is given by:

$$\log\left(\frac{a_w}{f_1}\right) = -k(1 - f_1)^2$$

f_1 is the mole fraction of water and is calculated by:

$$f_1 = \frac{(1 - x_1)/18}{(1 - x_1)/18 + x_1/M_1}$$

Assume that the solute is only sucrose, with a molecular weight (M_1) of 342 and a k value of 2.7. Have the program display the value of the boiling point when the sucrose concentration is 20% and at concentrations in 5% intervals to a final concentration of 60%.

where G = mass flux of air in $\text{lb}/(\text{ft}^2 \cdot \text{h})$ and h = heat transfer coefficient in $\text{BTU}/(\text{h} \cdot \text{ft}^2 \cdot \text{F})$. Derive an equivalent equation in SI.

The dimensional equation is:

$$\frac{\text{BTU}}{h \cdot \text{ft}^2 \cdot \text{F}} = (\text{---}) \left(\frac{\text{lb}}{\text{ft}^2 \cdot h}\right)^{0.8}$$

An equation must be dimensionally consistent; therefore, the constant 0.0128 in the above equation must have units of

$$\frac{\text{BTU}}{\text{h} \cdot \text{ft}^2 \cdot \text{F}} \left(\frac{\text{ft}^{1.6}\text{h}^{0.8}}{\text{lb}^{0.8}}\right) = \frac{\text{BTU}}{h^{0.2}\text{ft}^{0.4}\text{lb}^{0.8}\text{F}}$$

Converting the equation involves conversion of the coefficient. The equivalent SI unit for $h = \text{W}/(\text{m}^2 \cdot \text{K})$ and $G = \text{kg}/(\text{m}^2 \cdot \text{s})$. Thus, the coefficient will have units of $\text{J}/(\text{s}^{0.2}\text{m}^{0.4}\text{kg}^{0.8}\text{K})$. The dimensional equation for the conversion is:

$$\begin{aligned}\frac{\text{J}}{\text{s}^{0.2}\text{m}^{0.4}\text{kg}^{0.8}\text{K}} &= \frac{0.0128\ \text{BTU}}{\text{h}^{0.2}\text{ft}^{0.4}\text{lb}^{0.8}\text{F}} \frac{1054.8\ \text{J}}{\text{BTU}} \frac{\text{ft}^{0.4}}{(0.3048)^{0.4}\text{m}^{0.4}} \\ &\quad \frac{\text{h}^{0.2}}{(3600)^{0.2}\text{s}^{0.2}} \frac{(2.2048)^{0.8}\ \text{lb}^{0.8}}{\text{kg}^{0.8}} \frac{1.8\ \text{F}}{\text{K}} \\ &= 14.305\end{aligned}$$

The converted equation is:

$$h = 14.305\ G^{0.8}$$

where both h and G are in SI units. To check: If $G = 100\ \text{lb}/(\text{ft}^2 \cdot \text{h})$ and $h = 0.0128(100)^{0.8}$, $h = 0.5096\ \text{BTU}/(\text{h} \cdot \text{ft}^2 \cdot {}^\circ\text{F})$. The equivalent SI value is:

$$\frac{0.5096\ \text{BTU}}{\text{h} \cdot \text{ft}^2\text{F}} \frac{5.678263\ \text{W}/(\text{m}^2 \cdot \text{K})}{\text{BTU}/(\text{h} \cdot \text{ft}^2 \cdot {}^\circ\text{F})} = 2.893 \frac{\text{W}}{(\text{m}^2 \cdot \text{K})}$$

In SI, $G = [100\ \text{lb}/(\text{ft}^2 \cdot \text{h})]\ [\text{ft}^2/(0.3048)^2\text{m}^2]\ (\text{h}/3600\ \text{s})\ (\text{kg}/2.2046\ \text{lb}) = 0.1356$. Using the converted equation, $h = 14.305\ (0.1356)^{0.8} = 2.893\ \text{W}/(\text{m}^2 \cdot \text{K})$.