```
>> Ts=38;  T0=120; k=0.45; t=3;

>> T=round(Ts+(T0-Ts)*exp(-k*t))

T =
     59
```

Round to the nearest integer.

Sample Problem 1-4: Compounded interest

The balance B of a savings account after t years when a principal P is invested at an annual interest rate r and the interest is compounded n times a year is given by:

$$B = P\left(1+\frac{r}{n}\right)^{nt} \qquad (1)$$

If the interest is compounded yearly, the balance is given by:

$$B = P(1+r)^t \qquad (2)$$

In one account $5,000 is invested for 17 years in an account where the interest is compounded yearly. In a second account $5,000 is invested in an account in which the interest is compounded monthly. In both accounts the interest rate is 8.5%. Use MATLAB to determine how long (in years and months) it would take for the balance in the second account to be the same as the balance of the first account after 17 years.

Solution

Follow these steps:

(*a*) Calculate B for $5,000 invested in a yearly compounded interest account after 17 years using Equation (2).

(*b*) Calculate the t for the B calculated in part (*a*), from the monthly compounded interest formula, Equation (1).

(*c*) Determine the number of years and months that correspond to t.

The problem is solved by writing the following program in a script file:

```
% Solution of Sample Problem 1-4
P=5000;  r=0.085;  ta=17; n=12;
B=P*(1+r)^ta
t=log(B/P)/(n*log(1+r/n))

years=fix(t)
months=ceil((t-years)*12)
```

Step (*a*): Calculate B from Eq. (2).

Step (*b*): Solve Eq. (1) for t, and calculate t.

Step (*c*): Determine the number of years.

Determine the number of months.

When the script file is executed, the following (the value of the variables B, t, years ,and months) is displayed in the Command Window:

```
>> format short g
B =
          20011
t =
         16.374
years =
     16
months =
      5
```

The values of the variables B, t, years, and months are displayed (since a semicolon was not typed at the end of the commands that calculates the values).

1.10 PROBLEMS

The following problems can be solved by writing commands in the Command Window, or by writing a program in a script file and then executing the file.

1. Calculate:

   a) $\dfrac{28.5\cdot 3^3-\sqrt{1500}}{11^2+37.3}$

   b) $\left(\dfrac{7}{3}\right)^2\cdot 4^3\cdot 18-\dfrac{6^7}{(9^3-652)}$

2. Calculate:

   a) $23\left(-8+\dfrac{\sqrt{607}}{3}\right)+\left(\dfrac{40}{8}+4.7^2\right)^2$

   b) $509^{1/3}-4.5^2+\dfrac{\ln 200}{1.5}+75^{1/2}$

3. Calculate:

   a) $\dfrac{(24+4.5^3)}{e^{4.4}-\log_{10}(12560)}$

   b) $\dfrac{2}{0.036}\cdot\dfrac{(\sqrt{250}-10.5)^2}{e^{-0.2}}$

4. Calculate:

   a) $\cos\left(\frac{5\pi}{6}\right)\sin^2\left(\frac{7\pi}{8}\right)+\frac{\tan\left(\frac{\pi}{6}\ln 8\right)}{\sqrt{7}+2}$

   b) $\cos^2\left(\frac{3\pi}{5}\right)+\frac{\tan\left(\frac{\pi\ln 6}{5}\right)}{8\cdot\frac{7}{2}}$

5. Define the variable x as $x = 9.75$, then evaluate:

   a) $4x^3-14x^2-6.32x+7.3$

   b) $\frac{e^{\sqrt{3}}}{\sqrt[3]{0.02\cdot 3.1^2}}$

   c) $\log_{10}(x^2-x^3)^2$

6. Define the variables x and z as $x = 5.3$, and $z = 7.8$, then evaluate:

   a) $\frac{xz}{(x/z)^2}+14x^2-0.8z^2$

   b) $x^2z-z^2x+\left(\frac{x}{z}\right)^2-\left(\frac{z}{x}\right)^{1/2}$

7. Define the variables a, b, c, and d as:
   $a = -18.2$, $b = 6.42$, $c = a/b$ and $d = 0.5(cb+2a)$, and then evaluate:

   a) $d-\frac{a+b}{c}+\frac{(a+d)^2}{\sqrt{|abc|}}$

   b) $\ln[(c-d)(b-a)]+\frac{(a+b+c+d)}{(a-b-c-d)}$

8. A sphere has a radius of 15 cm.
   a) Determine the length of a side of a cube that has the same surface area as the sphere.
   b) Determine the length of a side of a cube that has the same volume as the sphere.

9. Calculate the volume of a sphere that has a surface area of 200 in^2 in two ways:
   a) First calculate the radius of the sphere r, then substitute the radius in the formula of the volume.
   b) Write one command.

10. Two trigonometric identities are given by:

    a) $\sin 3x = 3\sin x - 4\sin^3 x$

    b) $\sin\frac{x}{2} = \sqrt{\frac{1-\cos x}{2}}$

    For each part, verify that the identity is correct by calculating each side of the equation, substituting $x = \frac{7}{20}\pi$.

11. Two trigonometric identities are given by:

    a) $\tan 3x = \frac{3\tan x-\tan^3 x}{1-3\tan^2 x}$

    b) $\tan\frac{x}{2} = \frac{\sin x}{1+\cos x}$

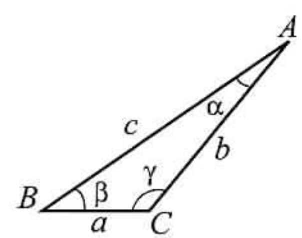
    For each part, verify that the identity is correct by calculating the values of the left and right sides of the equation, substituting $x = 27°$.

12. Define two variables: $alpha = 5\pi/9$, $beta = \pi/7$. Using these variables, show that the following trigonometric identity is correct by calculating the value of the left- and right-hand sides of the equation.

$$\sin\alpha\sin\beta = \frac{1}{2}[\cos(\alpha-\beta)-\cos(\alpha+\beta)]$$

13. Given: $\int\sin^2 x dx = \frac{1}{2}x-\frac{1}{4}\sin 2x$. Use MATLAB to calculate the following definite integral: $\int_{\frac{\pi}{3}}^{\frac{3\pi}{4}}\sin^2 x dx$.

14. In the triangle shown $a = 21$ cm, $b = 45$ cm, and $c = 60$ cm. Define a, b, and c as variables, and then:



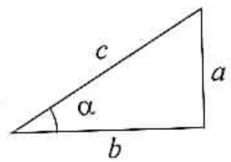
    a) Calculate the angle γ (in degrees) by substituting the variables in the Law of Cosines.

    (The Law of Cosines: $c^2 = a^2+b^2-2ab\cos\gamma$)

    b) Calculate the angles α and β (in degrees) using the Law of Sines.

    c) Check that the sum of the angles is 180°.

15. In the right triangle shown $a = 15$ cm, and $b = 35$ cm. Define a and c as variables, and then:



a) Using the Pythagorean Theorem, calculate c by typing one line in the Command Window.
b) Using c from part a), and the `acosd` function, calculate the angle α in degrees, typing one line in the Command Window.

16. The distance d from a point (x_0, y_0) to a line $Ax + By + C = 0$ is given by:

$$d = \frac{|Ax_0 + By_0 + C|}{\sqrt{A^2 + B^2}}$$

Determine the distance of the point $(3, -4)$ from the line $2x - 7y - 10 = 0$. First define the variables A, B, C, x_0, and y_0, and then calculate d. (Use the `abs` and `sqrt` functions.)

17. Eggs are packed in containers such that 18 are placed in each container. Determine how many containers are needed to pack 634 eggs. Use MATLAB built-in function `ceil`.

18. Define the following two variables:

CD_price = \$13.95   Book_price = \$44.95

Then change the display format to `bank` and calculate the following by typing one command:

a) The cost of three CDs and five books.
b) The same as part a), but add 5.75% sale tax.
c) The same as part b) but round the total cost to the nearest dollar.

19. The number of combinations $C_{n,r}$ of taking r objects out of n objects is given by:

$$C_{n,r} = \frac{n!}{r!(n-r)!}$$

A basketball team has 12 players on the roster. Determine how many different teams of 5 players can be selected out of the 12 players. (Use the built-in function `factorial`.)

20. The formula for changing the base of a logarithm is:

$$\log_a N = \frac{\log_b N}{\log_b a}$$

a) Use MATLAB's function `log(x)` to calculate $\log_5 281$.
b) Use MATLAB's function `log10(x)` to calculate $\log_7 1054$.

21. Radioactive decay is modeled with the exponential function $f(t) = f(0)e^{kt}$, where t is time, $f(0)$ is the amount of material at $t = 0$, $f(t)$ is the amount of material at time t, and k is a constant. Gallium-67, which has a half-life of 3.261 days, is used for tracing cancer. If 100 milligrams are present at $t = 0$, determine the amount (rounded to the nearest tenth of a milligram) that is left after 7 days. Solve the problem by writing a program in a script file. The program first determines the constant k, then calculates $f(7)$, and finally rounds the answer to the nearest tenth of a milligram.

22. Fractions can be added by using the smallest common denominator. For example, the smallest common denominator of 1/4 and 1/10 is 20. Use the MATLAB Help Window to find a MATLAB built-in function that determines the least common multiple of two numbers. Then use the function to show that the least common multiple of:

a) 4 and 14 is 28.
b) 8 and 42 is 168.

23. The magnitude M of an earthquake on the Richter scale is given by $M = \frac{2}{3}\log_{10}\left(\frac{E}{E_0}\right)$, where E is the energy released by the earthquake, and $E_0 = 10^{4.4}$ Joules is a constant (energy of a small reference earthquake). Determine how many times more energy is released from an earthquake that registers 7.1 on the Richter scale than an earthquake that registers 6.9.

8.5 = r

24. The balance B of a savings account after t years when a principal P is invested at an annual interest rate r and the interest is compounded yearly is given by $B = P(1+r)^t$. If the interest is compounded continuously the balance is given by $B = Pe^{rt}$. In one account \$20,000 is invested for 18 years in an account where the interest is compounded yearly. In a second account \$5,000 is invested in an account in which the interest is compounded continuously. In both accounts the interest rate is 8.5%. Use MATLAB to determine how long in years and days (e.g. 17 years and 251 days) it would take for the balance in the second account to be the same as the balance of the first account after 18 years.

25. The temperature dependence of vapor pressure p can be estimated by the Antoine equation:

$$\ln(p) = A - \frac{B}{C + T}$$

where ln is the natural logarithm, p is in mm Hg, T is in Kelvin, and A, B, and C are material constants. For toluene ($C_6H_5CH_3$) in the temperature range from 280 to 410 K the material constants are: $A = 16.0137$, $B = 3096.52$, and $C = -53.67$. Calculate the vapor pressure of toluene at 315 and 405 K.

26. Sound level L_p in units of decibels (dB) is determined by:

$$L_P = 20\log_{10}\left(\frac{p}{p_0}\right)$$

where p is the sound pressure of the sound, and $p_0 = 20 \times 10^{-6}$ Pa is a reference sound pressure (the sound pressure when $L_P = 0$ dB). Determine the sound pressure of 90 dB noise (noise generated by a passing truck). By how many times the sound pressure of the truck is larger (louder) than the sound pressure during a normal conversation where the loudness is 65 dB?

Chapter 2
Creating Arrays

The array is a fundamental form that MATLAB uses to store and manipulate data. An array is a list of numbers arranged in rows and/or columns. The simplest array (one-dimensional) is a row, or a column of numbers. A more complex array (two-dimensional) is a collection of numbers arranged in rows and columns. One use of arrays is to store information and data, as in a table. In science and engineering, one-dimensional arrays frequently represent vectors, and two-dimensional arrays often represent matrices. Chapter 2 shows how to create and address arrays while Chapter 3 shows how to use arrays in mathematical operations. In addition to arrays that are made of numbers, arrays in MATLAB can also be made of a list of characters, which are called strings. Strings are discussed in Section 2.10.

2.1 *Creating a One-Dimensional Array (Vector)*

A one-dimensional array is a list of numbers that is placed in a row or a column. One example is the representation of the position of a point in space in a three-dimensional Cartesian coordinate system. As shown in Figure 2-1, the position of point A is defined by a list of three numbers 2, 4, and 5, which are the coordinates of the point.

The position of point A can be expressed in terms of a position vector:

$$\mathbf{r}_A = 2\mathbf{i} + 4\mathbf{j} + 5\mathbf{k}$$

where **i**, **j**, and **k** are unit vectors in the direction of the x, y, and z axis, respectively. The numbers 2, 4, and 5 can be used to define a row or a column vector.

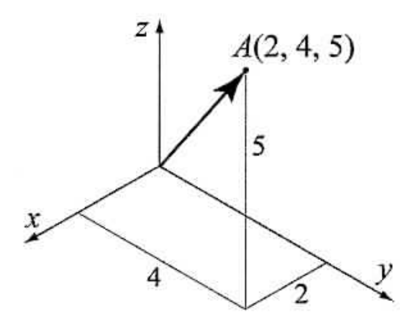


Figure 2-1: Position of a point.

Any list of numbers can be set up as a vector. For example, Table 2-1 contains population growth data that can be used to create two lists of numbers; one of the years and the other of the population. Each list can be entered as elements in a vector with the numbers placed in a row or in a column.