1. Evaluate the following expressions without using MATLAB. Check the answers with MATLAB.

   (*a*) $6 \times 4 > 32 - 3$ (*b*) $y = 4 \times 3 - 7 < 15 / 3 > -1$

   (*c*) $y = 2 \times (3 < 8 / 4 + 2)^2 < (-2)^3$ (*d*) $(5 + \sim 0) / 3 == 3 - \sim(10 / 5 - 2)$

2. Given: $d = 6$, $e = 4$, $f = -2$. Evaluate the following expressions without using MATLAB. Check the answers with MATLAB.

   (*a*) $y = d + f >= e > d - e$ (*b*) $y = e > d > f$

   (*c*) $y = e - d <= d - e == f / f$ (*d*) $y = (d / e * f < f) > -1 * (e - d) / f$

3. Given: $v = [-2\ \ 4\ \ 1\ \ 0\ \ 2\ \ 1\ \ 2\ ]$ and $w = [2\ \ 5\ \ 0\ \ 1\ \ 2\ \ -1\ \ 3\ ]$. Evaluate the following expressions without using MATLAB. Check the answers with MATLAB.

   (*a*) $\sim v == \sim w$ (*b*) $w >= v$

   (*c*) $v > \sim -1 * w$ (*d*) $v > -1 * w$

4. Use the vectors *v* and *w* from Problem 3. Use relational operators to create a vector *u* that is made up of the elements of *v* that are smaller than or equal to the elements of *w*.

5. Evaluate the following expressions without using MATLAB. Check the answers with MATLAB.
   (*a*) 0|7&9&–3 (*b*) 7>6&~0<=2
   (*c*) ~4<5|0>=12/6 (*d*) – 7<–5<–2&2+3<=15/3

6. Use loops to create a 4×6 matrix in which the value of each element is two times its row number minus three times its column number. For example, the value of element (2,5) is $2 \times 2 - 3 \times 5 = -11$.

7. Write a program that generates a vector with 30 random integers between –20 and 20 and then finds the sum of all the elements that are divisible by 3.

8. Write a program that asks the user to input a vector of integers of arbitrary length. Then, using a for-end loop the program examines each element of the vector. If the element is positive, its value is doubled. If the element is negative, its value is tripled. The program displays the vector that was entered and the modified vector. Execute the program, and when the program ask the user to input a vector type `randi([-10 20],1,19)`. This creates a 19-element vector with random integers between –10 and 20.

9. Write a program that asks the user to input a vector of integers of arbitrary length. Then, using a for-end loop the program eliminates all the negative elements. The program displays the vector that was entered and the modified vector, and a message that says how many elements were eliminated. Execute the program and when the program ask the user to input a vector type `randi([-15 20],1,25)`. This creates a 25-element vector with random integers between –15 and 20.

10. The daily high temperature (°F) in New York City and Denver, Colorado, during the month of January 2014 is given in the vectors below (data from the U.S. National Oceanic and Atmospheric Administration).
    NYC = [33 33 18 29 40 55 19 22 32 37 58 54 51 52 45 41 45 39 36 45 33 18 19 19 28 34 44 21 23 30 39]
    DEN = [39 48 61 39 14 37 43 38 46 39 55 46 46 39 54 45 52 52 62 45 62 40 25 57 60 57 20 32 50 48 28]
    where the elements in the vectors are in the order of the days in the month. Write a program in a script file that determines and displays the following information:
    (*a*) The average temperature for the month in each city (rounded to the nearest degree).

(*b*) The number of days that the temperature was above the average in each city.

(*c*) The number of days that the temperature in Denver was higher than the temperature in New York.

11. The Pascal triangle can be displayed as elements in a lower-triangular matrix as shown on the right. Write a MATLAB program that creates a $n \times n$ matrix that displays n rows of Pascal's triangle. Use the program to create 4 and 7 rows Pascal's triangles. (One way to calculate the value of the elements in the lower portion of the matrix is $C_{ij} = \frac{(i-1)!}{(j-1)!(i-j)!}$.)

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 2 & 1 & 0 & 0 & 0 \\ 1 & 3 & 3 & 1 & 0 & 0 \\ 1 & 4 & 6 & 4 & 1 & 0 \\ 1 & 5 & 10 & 10 & 5 & 1 \end{bmatrix}$$

12. Fibonacci numbers are the numbers in a sequence in which the first three elements are 0, 1, and 1, and the value of each subsequent element is the sum of the previous three elements:

0, 1, 1, 2, 4, 7, 13, 24, ...

Write a MATLAB program in a script file that determines and displays the first 25 Fibonacci numbers.

13. The reciprocal Fibonacci constant ψ is defined by the infinite sum:

$$\psi = \sum_{n=1}^{\infty} \frac{1}{F_n}$$

where F_n are the Fibonacci numbers 1, 1, 2, 3, 5, 8, 13, ... Each element in this sequence of numbers is the sum of the previous two. Start by setting the first two elements equal to 1, then $F_n = F_{n-1} + F_{n-2}$. Write a MATLAB program in a script file that calculates ψ for a given n. Execute the program for $n = 10$, 50, and 100.

14. The value of π can be estimated from:

$$\frac{\pi^3}{32} = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)^3}$$

Write a program (using a loop) that determines π for a given n. Run the program with $n = 10$, $n = 100$, and $n = 1{,}000$. Compare the result with `pi`. (Use `format long`.)

15. The value of π can be estimated from the expression:

$$\frac{2}{\pi} = \frac{\sqrt{2}}{2} \cdot \frac{\sqrt{2+\sqrt{2}}}{2} \cdot \frac{\sqrt{2+\sqrt{2+\sqrt{2}}}}{2} \cdot \ldots$$

Write a MATLAB program in a script file that determine π for any number of terms. The program asks the user to enter the number of terms, and then calculates the corresponding value of π. Execute the program with 5, 10, and 40 terms. Compare the result with `pi`. (Use `format long`.)

16. Write a program that (*a*) generates a vector with 20 random integer elements with integers between 10 and 30, (*b*) replaces all the elements that are not even integers with random integers between 10 and 30, and (*c*) repeats (*b*) until all the elements are even integers. The program should also count how many times (*b*) is repeated before all the elements are even integers. When done, the program displays the vector and a statement that states how many iterations were needed for generating the vector.

17. A vector is given by $x = [9\ \ -1.5\ \ 13.4\ \ 13.3\ \ -2.1\ \ 4.6\ \ 1.1\ \ 5\ \ -6.1\ \ 10\ \ 0.2]$. Using conditional statements and loops, write a program that rearranges the elements of x in order from the smallest to the largest. Do not use MATLAB's built-in function `sort`.

18. The Pythagorean theorem states that $a^2 + b^2 = c^2$. Write a MATLAB program in a script file that finds all the combinations of triples a, b, and c that are positive integers all smaller or equal to 50 that satisfy the Pythagorean theorem. Display the results in a three-column table in which every row corresponds to one triple. The first three rows of the table are:

3	4	5
5	12	13
6	8	10

19. Write a MATLAB program in a script file that finds and displays all the numbers between 100 and 999 whose product of digits is 6 times the sum of the digits. [e.g. 347 since $3 \times 4 \times 7 = 6(3 + 4 + 7)$]. Use a for-end loop in the program. The loop should start from 100 and end at 999.

20. A safe prime is a prime number that can be written in the form $2p + 1$ where p is also a prime number. For example, 47 is a safe prime since $47 = 2 \times 23 + 1$ and 23 is also a prime number. Write a computer program that finds and displays all the safe primes between 1 and 1,000. Do not use MATLAB's built-in function `isprime`.

21. Sexy primes are two prime numbers that the difference between them is 6. For example, 23 and 29 are sexy primes since $29 - 23 = 6$. Write a computer program that finds all the sexy primes between 1 and 300. The numbers should be displayed in a two-column matrix where each row displays one pair. Do not use MATLAB's built-in function `isprime`.

22. A Mersenne prime is a prime number that is equal to $2^n - 1$, where n is an integer. For example, 31 is a Mersenne prime since $31 = 2^5 - 1$. Write a computer program that finds all the Mersenne primes between 1 and 10,000. Do not use MATLAB's built-in function `isprime`.

23. A perfect number is a positive integer that is equal to the sum of its positive divisors except the number itself. The first two perfect numbers are 6 and 28 since $6 = 1 + 2 + 3$ and $28 = 1 + 2 + 4 + 7 + 14$. Write a computer program that finds the first four perfect numbers.

24. A list of exam scores (S) (in percent out of 100%) is given: 72, 81, 44, 68, 90, 53, 80, 75, 74, 65, 50, 92, 85, 69, 41, 73, 70, 86, 61, 65, 79, 94, 69.
Write a computer program that calculates the average (Av) and standard deviation (Sd) of the scores, which are rounded to the nearest integer. Then, the program determines the letter grade of each of the scores according to the following scheme:

Score (%)	$S > Av + 1.3Sd$	$Av + 0.5Sd < S < Av + 1.3Sd$
Letter grade	A	B
Score (%)	$Av - 0.5Sd \le S < Av + 0.5Sd$	$Av - 1.3Sd < S < Av - 0.5Sd$
Letter grade	C	D
Score (%)	$S < Av - 1.3Sd$	
Letter grade	F	

The program displays the values of Av and Sd followed by a list that shows the scores and the corresponding letter grade (e.g., 72% Letter grade C).

25. The Taylor series expansion for a^x is:

$$a^x = \sum_{n=0}^{\infty} \frac{(\ln a)^n}{n!} x^n$$

Write a MATLAB program that determines a^x using the Taylor series expansion. The program asks the user to type a value for x. Use a loop for adding the terms of the Taylor series. If c_n is the nth term in the series, then the sum S_n of the n terms is $S_n = S_{n-1} + c_n$. In each pass calculate the estimated error E given by $E = \left|\frac{S_n - S_{n-1}}{S_{n-1}}\right|$. Stop adding terms when $E < 0.000001$.
The program displays the value of a^x. Use the program to calculate:
(*a*) $2^{3.5}$ (*b*) $6.3^{1.7}$
Compare the values with those obtained by using a calculator.

26. Write a MATLAB program in a script file that finds a positive integer n such that the sum of all the integers $1 + 2 + 3 + \ldots + n$ is a number between 100 and 1,000 whose three digits are identical. As output, the program displays the integer n and the corresponding sum.

27. The following are formulas for calculating the training heart rate (THR):

$$THR = (MHR - RHR) \times INTEN + RHR$$

where MHR is the maximum heart rate given by (https://en.wikipedia.org/wiki/Heart_rate):

For males: $MHR = \dfrac{203.7}{1+e^{0.033(age-104.3)}}$, for females: $MHR = \dfrac{190.2}{1+e^{0.0453(age-107.5)}}$,

RHR is the resting heart rate, and $INTEN$ the fitness level (0.55 for low, 0.65 for medium, and 0.8 for high fitness). Write a program in a script file that determines the THR. The program asks users to enter their gender (male or female), age (number), resting heart rate (number), and fitness level (low, medium, or high). The program then displays the training heart rate (rounded to the nearest integer). Use the program for determining the training heart rate for the following two individuals:

(*a*) A 19-year-old male, resting heart rate of 64, and medium fitness level.
(*b*) A 20-year-old female, resting heart rate of 63, and high fitness level.

28. Body mass index (BMI) is a measure of obesity. In standard units, it is calculated by the formula

$$BMI = 703\frac{W}{H^2}$$

where W is weight in pounds, and H is height in inches. The obesity classification is:

BMI	Classification
Below 18.5	Underweight
18.5 to 24.9	Normal
25 to 29.9	Overweight
30 and above	Obese

Write a program in a script file that calculates the BMI of a person. The program asks the person to enter his or her weight (lb) and height (in.). The program displays the result in a sentence that reads: “Your BMI value is XXX, which classifies you as SSSS,” where XXX is the BMI value rounded to the nearest tenth, and SSSS is the corresponding classification. Use the program for determining the obesity of the following two individuals:

(*a*) A person 6 ft 2 in. tall with a weight of 180 lb.
(*b*) A person 5 ft 1 in. tall with a weight of 150 lb.

29. Write a program in a script file that calculates the cost of renting a car according to the following price schedule:

Duration of rent	**Sedan**			**SUV**		
	Daily rate	**Free miles (per day)**	**Cost of additional mile**	**Daily rate**	**Free miles (per day)**	**Cost of additional mile**
1-6 days	\$79	80	\$0.69	\$84	80	\$0.74
7-29 days	\$69	100	\$0.59	\$74	100	\$0.64
30 or more days	\$59	120	\$0.49	\$64	120	\$0.54

The program asks the user to enter the type of car (sedan or SUV), the number of days, and the number of miles driven. The program then displays the cost (rounded to cents) for the rent. Run the program three times for the following cases:

(*a*) Sedan, 10 days, 769 miles. (*b*) SUV, 32 days, 4,056 miles.
(*c*) Sedan, 3 days, 511 miles.

30. Write a program that determines the change given back to a customer in a self-service checkout machine of a supermarket for purchases of up to \$50. The program generates a random number between 0.01 and 50.00 and displays the number as the amount to be paid. The program then asks the user to enter payment, which can be one \$1 bill, one \$5 bill, one \$10 bill, one \$20 bill, or one \$50 bill. If the payment is less than the amount to be paid, an error message is displayed. If the payment is sufficient, the program calculates the change and lists the bills and/or the coins that make up the change, which has to be composed of the least number each of bills and coins. For example, if the amount to be paid is \$2.33 and a \$10 bill is entered as payment, then the change is one \$5 bill, two \$1 bills, two quarters, one dime, one nickel, and two pennies. Execute the program three times.

31. The concentration of a drug in the body C_P can be modeled by the equation:

$$C_P = \frac{D_G}{V_{dP}} \frac{k_a}{k_a - k_{ae}} (e^{-k_e t} - e^{-k_a t})$$

where D_G is the dosage administered (mg), V_d is the volume of distribution (L), k_a is the absorption rate constant (h^{-1}), k_e is the elimination rate constant (h^{-1}), and t is the time (h) since the drug was administered. For a certain drug, the following quantities are given: $D_G = 150\,\text{mg}$, $V_d = 50\,\text{L}$, $k_a = 1.6\,\text{h}^{-1}$, and $k_e = 0.4\,\text{h}^{-1}$.

(*a*) A single dose is administered at $t = 0$. Calculate and plot C_P versus t for 10 h.

(*b*) A first dose is administered at $t = 0$, and subsequently four more doses are administered at intervals of 4 h (i.e., at $t = 4, 8, 12, 16$). Calculate and plot C_P versus t for 24 h.

32. One numerical method for calculating the cubic root of a number, $\sqrt[3]{P}$ is Halley's method. The solution process starts by choosing a value x_1 as a first estimate of the solution. Using this value, a second, more accurate value x_2 is calculated with $x_2 = x_1(x_1^3 + 2P) / (2x_1^3 + P)$, which is then used for calculating a third, still more accurate value x_3, and so on. The general equation for calculating the value of x_{i+1} from the value of x_i is $x_{i+1} = x_i(x_i^3 + 2P) / (2x_i^3 + P)$. Write a MATLAB program that calculates the cubic root of a number. In the program use $x_1 = P$ for the first estimate of the solution. Then, by using the general equation in a loop, calculate new, more accurate values. Stop the looping when the estimated relative error E defined by $E = \left|\frac{x_{i+1} - x_i}{x_i}\right|$ is smaller than 0.00001. Use the program to calculate:

    (*a*) $\sqrt[3]{800}$ (*b*) $\sqrt[3]{59071}$ (*c*) $\sqrt[3]{-31.55}$

33. Write a program in a script file that converts a measure of area given in units of either m^2, cm^2, in^2, ft^2, yd^2, or acre to the equivalent quantity in different units specified by the user. The program asks the user to enter a numerical value for the size of an area, its current units, and the desired new units. The output is the size of the area in the new units. Use the program to:

    (*a*) Convert 55 $in.^2$ to cm^2. (*b*) Convert 2400 ft^2 to m^2.
    (*c*) Convert 300 cm^2 to yd^2.

34. In a one-dimensional random walk, the position x of a walker is computed by:

$$x_j = x_j + s$$

    where s is a random number. Write a program that calculates the number of steps required for the walker to reach a boundary $x = \pm B$. Use MATLAB's built-in function `randn(1,1)` to calculate s. Run the program 100 times (by using a loop) and calculate the average number of steps when $B = 10$.

35. The Sierpinski triangle can be implemented in MATLAB by plotting points iteratively according to one of the following three rules that are selected randomly with equal probability.

    Rule 1: $x_{n+1} = 0.5x_n$, $y_{n+1} = 0.5y_n$

    Rule 2: $x_{n+1} = 0.5x_n + 0.25$, $y_{n+1} = 0.5y_n + (\sqrt{3}) / 4$

    Rule 3: $x_{n+1} = 0.5x_n + 0.5$, $y_{n+1} = 0.5y_n$

    Write a program in a script file that calculates the x and y vectors and then plots y versus x as individual points [use `plot(x,y,'^')`]. Start with

$x_1 = 0$ and $y_1 = 0$. Run the program four times with 10, 100, 1,000, and 10,000 iterations.

36. The roots of a cubic equation $a_3x^3 + a_2x^2 + a_1x + a_0 = 0$ can be calculated using the following procedure:
Set: $A = a_2 / a_3$, $B = a_1 / a_3$, and $C = a_0 / a_3$.
Calculate: $D = Q^3 + R^2$,
where $Q = \left(3B - A^2\right) / 9$ and $R = \left(9AB - 27C - 2A^3\right) / 54$.
If $D > 0$ the equation has complex roots.
If $D = 0$ all roots are real and at least two are equal. The roots are given by:
$x_1 = 2\sqrt[3]{R} - A / 3$, $x_2 = -\sqrt[3]{R} - A / 3$, and $x_3 = -\sqrt[3]{R} - A / 3$.
If $D < 0$ all roots are real and are given by:
$x_1 = 2\sqrt{-Q}\cos(\theta / 3) - A / 3$, $x_2 = 2\sqrt{-Q}\cos(\theta / 3 + 120°) - A / 3$, and
$x_3 = 2\sqrt{-Q}\cos(\theta / 3 + 240°) - A / 3$, where $\cos\theta = R / \sqrt{-Q^3}$.
Write a MATLAB program that determines the real roots of a cubic equation. As input the program asks the user to enter the values of a_3, a_2, a_1, and a_0 as a vector. The program then calculates the value of D. If the equations have complex roots, the message "The equation has complex roots" is displayed. Otherwise the real roots are calculated and displayed. Use the program to solve the following equations:
(*a*) $5x^3 + -34.5x^2 + 36.9x + 8.8 = 0$ (*b*) $2x^3 + -10x^2 + 24x - 15 = 0$
(*c*) $2x^3 + -1.4x^2 - 20.58x + 30.87 = 0$

37. The overall grade in a course is determined from the grades of 10 homework assignments, 2 midterms, and a final exam, using the following scheme:
Homework: Homework assignments are graded on a scale from 0 to 80. The grade of the two lowest assignments is dropped and the average of the eight assignments with the higher grades constitutes 20% of the course grade.
Midterms and final exam: Midterms and final exams are graded on a scale from 0 to 100. If the average of the midterm scores is higher than, or the same as, the score on the final exam, the average of the midterms constitutes 40% of the course grade and the grade of the final exam constitutes 40% of the course grade. If the final exam grade is higher than the average of the midterms, the average of the midterms constitutes 30% of the course grade and the grade of the final exam constitutes 50% of the course grade.
Write a computer program in a script file that determines the course grade for a student. The program first asks the user to enter the 10 homework assignment grades (in a vector), two midterm grades (in a vector), and the grade of the final. Then the program calculates a numerical course grade (a number between 0 and 100). Execute the program for the following cases:
(*a*) Homework assignment grades: 65, 79, 80, 50, 71, 73, 61, 70, 69, 74. Mid-

term grades: 83, 91. Final exam: 84.

(*b*) Homework assignment grades: 70, 69, 83, 45, 90, 89, 52, 78, 100, 87. Midterm grades: 87, 72. Final exam: 90.

38. A Keith number is a number (integer) that appears in a Fibonacci-like sequence that is based on its own decimal digits. For two-decimal digit numbers (10 through 99) a Fibonacci-like sequence is created in which the first element is the tens digit and the second element is the units digit. The value of each subsequent element is the sum of the previous two elements. If the number is a Keith number, then it appears in the sequence. For example, the first two-decimal digit Keith number is 14, since the corresponding Fibonacci-like sequence is 1, 4, 5, 9, 14. Write a MATLAB program that determines and displays all the Keith numbers between 10 and 99.

39. The following MATLAB commands create a sine-shaped signal $y(t)$ that contains random noise:

```
t = 0:.05:10;
y = sin(t)-0.1+0.2*rand(1,length(t));
```

Write a MATLAB program that uses these commands to create a noisy sine-shaped signal. Then the program smooths the signal by using the three-points moving-average method. In this method the value of every point i, except the first and last, is replaced by the average of the value of three adjacent points (i–1, i, and i+1). Make a plot that display the noisy and smoothed signals.