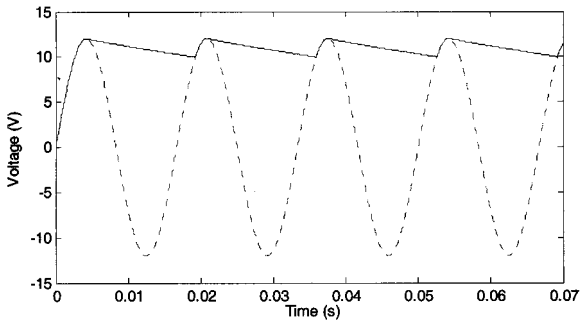
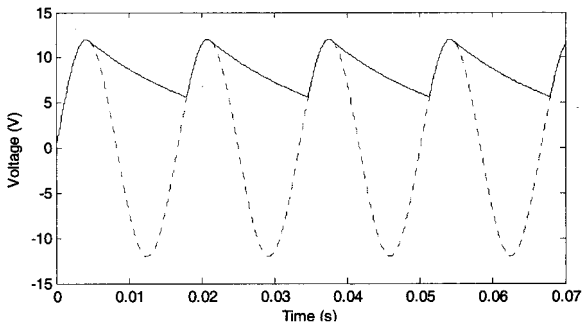
The two plots generated by the program are shown below. One plot shows the result with $C = 45$ μF and the other with $C = 10$ μF. It can be observed that with a larger capacitor the DC voltage is smoother (smaller ripple in the wave).



$C = 45$ μF



$C = 10$ μF

6.8 PROBLEMS

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

   (*a*) $5+3>32/4$ (*b*) $y = 2\times3>10/5+1>2^2$

   (*c*) $y = 2\times(3>10/5)+(1>2)^2$ (*d*) $5\times3-4\times4<=\sim 2\times4-2+\sim0$

2. Given: $a = 6$, $b = 2$, $c = -5$. Evaluate the following expressions without using MATLAB. Check the answer with MATLAB.

   (*a*) $y = a+b>a-b<c$ (*b*) $y = -6<c<-2$

   (*c*) $y = b+c> = c>a/b$ (*d*) $y = a+c==\sim(c+a\sim=a/b-b)$

3. Given: $v = [4\ -2\ -1\ 5\ 0\ 1\ -3\ 8\ 2]$ and $w = [0\ 2\ 1\ -1\ 0\ -2\ 4\ 3\ 2]$. Evaluate the following expressions without using MATLAB. Check the answer with MATLAB.

   (*a*) $\sim(\sim v)$ (*b*) $u==v$

   (*c*) $u-v<u$ (*d*) $u-(v<u)$

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

5. Evaluate the following expressions without using MATLAB. Check the answer with MATLAB.
   (*a*) 0&21 (*b*) ~-2>-1&11>=~0
   (*c*) 4-7/2&6<5|-3 (*d*) 3|-1&~2*-3|0

6. The maximum daily temperature (in °F) for Chicago and San Francisco during the month of August 2009 are given in the vectors below (data from the U.S. National Oceanic and Atmospheric Administration).
   TCH = [75 79 86 86 79 81 73 89 91 86 81 82 86 88 89 90 82 84 81 79 73 69 73 79 82 72 66 71 69 66 66]
   TSF = [69 68 70 73 72 71 69 76 85 87 74 84 76 68 79 75 68 68 73 72 79 68 68 69 71 70 89 95 90 66 69]
   Write a program in a script file to answer the following:
   (*a*) Calculate the average temperature for the month in each city.
   (*b*) How many days was the temperature above the average in each city?
   (*c*) How many days, and on which dates in the month, was the temperature in San Francisco lower than the temperature in Chicago?
   (*d*) How many days, and on which dates in the month, was the temperature the same in both cities?

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

   0, 1, 1, 2, 3, 5, 8, 13, ...

   Write a MATLAB program in a script file that determines and displays the first 20 Fibonacci numbers.

8. Use loops to create a 4×3 matrix in which the value of each element is the sum of its row number and its column number divided by the square of its column number. For example, the value of element (2,3) is $(2+3)/3^2 = 0.5555$.

9. The elements of the symmetric Pascal matrix are obtained from:

$$P_{ij} = \frac{(i+j-2)!}{(i-1)!(j-1)!}$$

   Write a MATLAB program that creates an $n \times n$ symmetric Pascal matrix. Use the program to create 4×4 and 7×7 Pascal matrices.

10. A Fibonacci sequence is a sequence of numbers beginning with 0 and 1, where the value of each subsequent element is the sum of the previous two elements:

$$a_{i+1} = a_i + a_{i-1}, \text{ i.e. } 0, 1, 1, 2, 3, 5, 8, 13, \ldots$$

Related sequences can be constructed with other beginning numbers. Write a MATLAB program in a script file that construct an $n \times n$ matrix such that the first row contains the first n elements of a sequence, the second row contains the $n+1$ through $2n$th elements and so on. The first line of the script should show the order n of the matrix followed by the values of the first two elements. These two elements can be any two integers, except they cannot both be zero. A property of matrices thus constructed is that their determinants are always zero. Run the program for $n = 4$ and $n = 6$ and for different values of the first two elements. Verify that the determinant is zero in each case (use MATLAB's built-in function `det`).

11. Write a program in a script file that determines the real roots of a quadratic equation $ax^2 + bx + c = 0$. Name the file `quadroots`. When the file runs, it asks the user to enter the values of the constants a, b, and c. To calculate the roots of the equation the program calculates the discriminant D, given by:

$$D = b^2 - 4ac$$

If $D > 0$, the program displays message "The equation has two roots," and the roots are displayed in the next line.
If $D = 0$, the program displays message "The equation has one root," and the root is displayed in the next line.
If $D < 0$, the program displays message "The equation has no real roots."
Run the script file in the Command Window three times to obtain solutions to the following three equations:

(*a*) $2x^2 + 8x + 8 = 0$
(*b*) $-5x^2 + 3x - 4 = 0$
(*c*) $-2x^2 + 7x + 4 = 0$

12. Write a program in a script file that finds the smallest odd integer that is divisible by 11 and whose square root is greater than 132. Use a loop in the program. The loop should start from 1 and stop when the number is found. The program prints the message "The required number is:" and then prints the number.

13. Write a program (using a loop) that determines the expression:

$$\sqrt{12} \sum_{n=0}^{m} \frac{(-1/3)^n}{2n+1}$$

Run the program with $m = 5$, $m = 10$, and $m = 20$. Compare the result with π. (Use format long.)

14. Write a program (using a loop) that determines the expression:

$$2\prod_{n=1}^{m}\frac{(2n)^2}{(2n)^2-1} = 2\left(\frac{4}{3}\cdot\frac{16}{15}\cdot\frac{36}{35}\cdot\ldots\right)$$

Run the program with $m = 100$, $m = 100{,}000$, and $m = 1{,}0000{,}000$. Compare the result with π. (Use format long.)

15. A vector is given by x = [–3.5 –5 6.2 11 0 8.1 –9 0 3 –1 3 2.5]. Using conditional statements and loops, write a program that creates two vectors from x—one (call it P) that contains the positive elements of x, and a second (call it N) that contains the negative elements of x. In both P and N, the elements are in the same order as in x.

16. A vector is given by x = [–3.5 5 –6.2 11.1 0 7 –9.5 2 15 –1 3 2.5]. 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`.

17. The following is a list of 20 exam scores. Write a computer program that calculates the average of the top 8 scores.

Exam scores: 73, 91, 37, 81, 63, 66, 50, 90, 75, 43, 88, 80, 79, 69, 26, 82, 89, 99, 71, 59

18. The Taylor series expansion for $\sin(x)$ is

$$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \ldots = \sum_{n=0}^{\infty}\frac{(-1)^n}{(2n+1)!}x^{2n+1}$$

where x is in radians. Write a MATLAB program that determines $\sin(x)$ using the Taylor series expansion. The program asks the user to type a value for an angle in degrees. Then the program uses a loop for adding the terms of the Taylor series. If a_n is the nth term in the series, then the sum S_n of the n terms is $S_n = S_{n-1} + a_n$. 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 $E \le 0.000001$. The program displays the value of $\sin(x)$. Use the program for calculating:
(*a*) $\sin(45°)$ (*b*) $\sin(195°)$.
Compare the values with those obtained by using a calculator.

19. 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 1000 whose three digits are identical. As output the program displays the integer n and the corresponding sum.

20. The following are formulas for calculating the training heart rate (*THR*) for men and women

For men (Karvonen formula): $THR = [(220 - AGE) - RHR] \times INTEN + RHR$

For women: $THR = [(206 - 0.88 \times AGE) - RHR] \times INTEN + RHR$

where *AGE* is the person's age, *RHR* 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. Use the program for determining the training heart rate for the following two individuals:

(*a*) A 21-years-old male, resting heart rate of 62, and low fitness level.

(*b*) A 19-years-old female, resting heart rate of 67, and high fitness level.

21. Write a program that determines the center and the radius of a circle that passes through three given points. The program asks the user to enter the coordinates of the points one at a time. The program displays the coordinate of the center and the radius, and makes a plot of the circle and the three points displayed on the plot with asterisk markers. Execute the program to find the circle that passes through the points (13, 15), (4, 18), and (19, 3).

22. 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.

23. Write a program in a script file that calculates the cost of a telephone call according to the following price schedule:

Time the call made	Duration of call		
	1–10 min	10–30 min	More than 30 min
Day: 8 A.M. to 6 P.M.	\$0.10/min	\$1.00 + \$0.08/min for additional min above 10.	\$2.60 + \$0.06/min for additional min above 30.
Evening: 6 P.M. to 12 A.M.	\$0.07/min	\$0.70 + \$0.05/min for additional min above 10.	\$1.70 + \$0.04/min for additional min above 30.
Night: 12 A.M. to 8 A.M.	\$0.04/min	\$0.40 + \$0.03/min for additional min above 10.	\$1.00 + \$0.02/min for additional min above 13.

The program asks the user to enter the time the call is made (day, evening, or night) and the duration of the call (a number that can have one digit to the right of the decimal point). If the duration of the call is not an integer, the program rounds up the duration to the next integer. The program then displays the cost of the call.

Run the program three times for the following calls:

(*a*) 8.3 min at 1:32 P.M. (*b*) 34.5 min at 8:00 P.M. (*c*) 29.6 min at 1:00 A.M.

24. 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 \$20. The program generates a random number between 0.01 and 20.00 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, or one \$20 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.

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

$$Cp = \frac{D_G}{V_d}\frac{k_a}{(k_a - k_e)}(e^{-k_e t} - e^{-k_a t})$$

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: $D_G = 150$ mg, $V_d = 50$ L, $k_a = 1.6\ h^{-1}$, and $k_e = 0.4\ h^{-1}$.

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

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

26. One numerical method for calculating the square root of a number is the Babylonian method. In this method $\sqrt{P}$ is calculated in iterations. The solution process starts by choosing a value x_1 as a first estimate of the solution. Using this value, a second, more accurate solution x_2 can be calculated with $x_2 = (x_1 + P/x_1)/2$, which is then used for calculating a third, still more accurate solution x_3, and so on. The general equation for calculating the value of the solution x_{i+1} from the solution x_i is $x_{i+1} = (x_i + P/x_i)/2$. Write a MATLAB program that calculates the square root of a number. In the program use $x = P$ for the first estimate of the solution. Then, by using the general equation in a loop, calculate new, more accurate solutions. 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*) $\sqrt{110}$ (*b*) $\sqrt{93,443}$ (*c*) $\sqrt{23.25}$

27. A twin primes is a pair of prime numbers such that the difference between them is 2 (for example, 17 and 19). Write a computer program that finds all the twin primes between 10 and 500. The program displays the results in a two-column matrix in which each row is a twin prime.

28. Write a program in a script file that converts a measure of volume given in units of either m^3, L, ft^3, or gat (U.S. gallons) to the equivalent quantity in different units specified by the user. The program asks the user to enter the amount of volume, its current units, and the desired new units. The output is the specification of volume in the new units. Use the program to:
(*a*) Convert 3.5 m^3 to gal.
(*b*) Convert 200 L to ft^3.
(*c*) Convert 480 ft^3 to m^3.

29. 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 $B = 10$.

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

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

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

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

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.

31. There are 12 teams in a league, numbered 1 through 12. Six games are planned for the weekend. Write a MATLAB program that randomly assign the teams for each game. Display the results in a two-column table where each row contains the two teams that play each other.

32. The temperature dependence of the heat capacity C_p of many gases can be described in terms of a cubic equation:

$$C_p = a + bT + cT^2 + dT^3$$

The following table gives the coefficients of the cubic equation for four gases. C_p is in J/(g mol)(°C) and T is in °C.

Gas	a	b	c	d
SO_2	38.91	3.904×10^{-2}	-3.105×10^{-5}	8.606×10^{-9}
SO_3	48.50	9.188×10^{-2}	-8.540×10^{-5}	32.40×10^{-9}
O_2	29.10	1.158×10^{-2}	-0.6076×10^{-5}	1.311×10^{-9}
N_2	29.00	0.2199×10^{-2}	-0.5723×10^{-5}	-2.871×10^{-9}

Write a program that does the following:

- Prints the four gases on the screen and asks the user to select which gas to find the heat capacity for.
- Asks the user for a temperature.
- Asks the user if another temperature is needed (enter yes or no). If the answer is yes, the user is asked to enter another temperature. This process continues until the user enters no.
- Display a table containing the temperatures entered and the corresponding heat capacities.

(*a*) Use the program for determining the heat capacity of SO_3 at 100° and 180°.

(*b*) Use the program for finding the heat capacity of N_2 at 220° and 300°.

33. The overall grade in a course is determined from the grades of 5 quizzes, 3 midterms, and a final, using the following scheme:
Quizzes: Quizzes are graded on a scale from 0 to 10. The grade of the lowest quiz is dropped and the average of the 4 quizzes with the higher grades constitutes 25% of the course grade.
Midterms: Midterms are graded on a scale from 0 to 100. If the average of the midterm scores is higher than the score on the final, the average of the midterms is 35% of the course grade. If the final grade is higher than the average of the midterms, then the lowest midterm is dropped and the average of the two midterms with the higher grades is 35% of the course grade.
Final: Finals are graded on a scale from 0 to 10. The final is 40% 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 five quiz grades (in a vector), the three 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). Finally, the program assigns a letter grade according to the following key: *A* for $\text{Grade} \geq 90$, *B* for $80 \leq \text{Grade} \leq 90$, *C* for $70 \leq \text{Grade} \leq 80$, *D* for $60 \leq \text{Grade} \leq 70$, and *E* for a grade lower than 60. Execute the program for the following cases:
(*a*) Quiz grades: 7, 9, 4, 8 , 7. Midterm grades: 93, 83, 87. Final grade: 89.
(*b*) Quiz grades: 8, 6, 9, 6 , 9. Midterm grades: 81, 75, 79. Final grade: 72.

34. The handicap differential (*HCD*) for a round of golf is calculated from the formula:

$$HCD = \frac{(Score - Course\ \ Rating)}{Course\ \ Slope} \times 113$$

The course rating and the slope are measures of how difficult a particular course is. A golfers handicap is calculated from a certain number *N* of their best (lowest) handicap scores according to the following table.

# Rounds played	*N*	# Rounds played	*N*
5-6	1	15-16	6
7-8	2	17	7
9-10	3	18	8
11-12	4	19	9
13-14	5	20	10

For example, if 13 rounds have been played, only the best five handicaps are used. A handicap cannot be computed for fewer than five rounds. If more than 20 rounds have been played, only the 20 most recent results are used.

Once the lowest N handicap differentials have been identified, they are averaged and then rounded down to the nearest tenth. The result is the player's handicap. Write a program in a script file that calculates a persons handicap. The program asks the user to enter the golfers record in a three columns matrix where the first column is the course rating, the second is the course slope, and the third is the players score. Each row corresponds to one round. The program displays the person's handicap. Execute the program for players with the following records.

(*a*)

Rating	Slope	Score
71.6	122	85
72.8	118	87
69.7	103	83
70.3	115	81
70.9	116	79
72.3	117	91
71.6	122	89
70.3	115	83
72.8	118	92
70.9	109	80
73.1	132	94
68.2	115	78
74.2	135	103
71.9	121	84

(*b*)

Rating	Slope	Score
72.2	119	71
71.6	122	73
74.0	139	78
68.2	125	69
70.2	130	74
69.6	109	69
66.6	111	74