Jadavpur University
Session 2018-19, Odd Semester
Computer Programming and Numerical Methods
Sessional Assignments (Combined)

Flow Chart and Algorithms

1. Write an algorithm to determine maximum of three numbers. Also draw the corresponding flow chart.

2. Write an algorithm to determine the sum of individual digits of a given integer. Also draw the corresponding flow chart.

3. Write an algorithm to print the reverse of a number read as input. Also draw the corresponding flow chart. **[OPTIONAL]**

4. Write an algorithm to determine whether a given number is prime or not. Also draw the corresponding flow chart.

5. Write an algorithm to generate first 100 prime numbers. Also draw the corresponding flow chart.

6. Draw a flowchart to input three numbers in the variables a, b and c and hence to find the roots of the quadratic equation $ax^2 + bx + c = 0$. Consider carefully the zero input values of the coefficients a, b and c. **[OPTIONAL]**

7. Draw a flowchart to input 10 numbers, sort the numbers in ascending order and hence to write the numbers in sorted order. **[OPTIONAL]**

Console I/O and Conditional Statements

(Any Ten assignments)

1. Write a C program that reads two values from the keyboard, swaps their values and prints out the result.

2. The length and breadth of a rectangle and radius of a circle are input through the keyboard. Write a program to calculate the area and perimeter of the rectangle, and the area and circumference of the circle.

3. If a three-digit integer is input through the keyboard, write a program to calculate the sum of its digits. (Hint: Use the modulo operator '%')

4. An integer is entered as an input through the keyboard. Write a program to find out whether it is an odd number or an even number.

5. Input two integer numbers and divide the larger number by the smaller one. Then display the result using printf() function as a fractional number first and then as a real valued number. (Example: 9 divided by 5 shall yield " 4/5" and "1.8" respectively.)

6. Write a C program to find the maximum and minimum of three numbers.

7. Accept three integer numbers and find their average. Next display which numbers are below and above the average value.

8. Temperature of a city in Fahrenheit degrees is input through the keyboard. Write a program to convert this temperature into Centigrade degrees.

9. Write a C program which accepts basic salary as input and prints the gross salary, which is sum of the basic, dearness allowance (60% of basic salary), and house rent allowance (15% of basic salary).

10. A cashier has currency notes of denominations 10, 50 and 100. Write a C program which accepts an amount to be withdrawn, and prints the total number of currency notes of each denomination the cashier will have to give to the withdrawer. **[OPTIONAL]**

11. If the marks obtained by a student in five different subjects are input through the keyboard, find out the aggregate marks and percentage marks obtained by the student. Assume that the maximum marks that can be obtained by a student in each subject is 100. Input error should be checked. **[OPTIONAL]**

12. The length and breadth of a rectangle are input through the keyboard. Write a programme to determine (i) radius of a circle and ratio of perimeters of the rectangle and the circle if the areas of the rectangle and the circle are equal (ii) radius of the circle and the ratio of the areas of the rectangle and the circle if the perimeters of the rectangle and the circle are equal. **[OPTIONAL]**

13. In a town, the percentage of men is 52. The percentage of total literacy is 48. If total percentage of literate men is 35 of the total population, write a program to find the total number of illiterate men and women if the population of the town is 80,000. **[OPTIONAL]**

14. If a five-digit integer is input through the keyboard, write a program to print a new number by adding one to each of its digits. For example if the number that is input is 12391 then the output should be displayed as 23402. **[OPTIONAL]**

15. Write a program to find the grace marks for a student using switch. The user should enter the class obtained by the student and the number of subjects he has failed in.

    • If the student gets first class and the number of subjects he failed in is greater than 3, then he does not get any grace. If the number of subjects he failed in is less than or equal to 3 then the grace is of 5 marks per subject.

    • If the student gets second class and the number of subjects he failed in is greater than 2, then he does not get any grace. If the number of subjects he failed in is less than or equal to 2 then the grace is of 4 marks per subject.

    • If the student gets third class and the number of subjects he failed in is greater than 1, then he does not get any grace. If the number of subjects he failed in is equal to 1 then the grace is of 5 marks per subject.   **[OPTIONAL]**

16. Read a five-letter word into the computer, then encode the word on a letter-by-letter basis by subtracting 30 from the numerical value that is used to represent each letter. Thus if the ASCII character set is being used, the letter a (which is represented by the value 97)would become a C (represented by the value 67),etc. Write out the encoded version of the word. **[OPTIONAL]**

17. Read into the computer a five-letter word that has been encoded using the scheme described above. Decode the word by reversing the above procedure, then write out the decoded word. **[OPTIONAL]**

18. Any year is input through the keyboard. Write a program to determine whether the year is a leap year or not. (Hint: Use the % (modulus) operator)

19. Write a program to check whether a triangle is valid or not, when (i) the three angles of the triangle are entered through the Keyboard (ii) three sides of the triangle are entered through the keyboard. **[OPTIONAL]**

20. Given three points (x1, y1), (x2, y2) and (x3, y3), write a program to check if all the three points fall on one straight line. **[OPTIONAL]**

21. Given the coordinates (x, y) of a center of a circle and its radius, write a program which will determine whether a point lies inside the circle, on the circle or outside the circle. (Hint: #include <math.h>. Use sqrt( ) and pow( ) functions)

22. Any character is entered through the keyboard, write a program to determine whether the character entered is a capital letter, a small case letter, a digit or a special symbol.

23. Given as input an integer number of seconds, write a program to print as output the equivalent time in hours, minutes and seconds. Recommended output format is something like 7322 seconds is equivalent to 2 hours 2 minutes 2 seconds.

24. Write a program which accepts two number X, Y and creates a third number Z by appending Y after X. Example: if X=12 and Y=345 then Z=12345. **[OPTIONAL]**

25. A certain grade of steel is graded according to the following conditions:

    Hardness must be greater than 50

    Carbon content must be less than 0.7

    Tensile strength must be greater than 5600

    The grades are as follows:

    Grade is 10 if all three conditions are met

    Grade is 9 if conditions (i) and (ii) are met

    Grade is 8 if conditions (ii) and (iii) are met

    Grade is 7 if conditions (i) and (iii) are met

    Grade is 6 if only one condition is met

    Grade is 5 if none of the conditions are met

    Write a program, which will require the user to give values of hardness, carbon content and tensile strength of the steel under consideration and output the grade of the steel. **[OPTIONAL]**

Loops

(Any ten assignments)

1. Write a C program which prints all integers divisible by n between 1 and 100 where value of n is provided by the user.

2. Write a C program to find out sum of digits of a given number.

3. Write a C program to find the reverse of a given number. **[OPTIONAL]**

4. Write a C program to find out sum of the following series.

   S=1+2+3+4+ ... +n

5. Write a C program to find out sum of the following series.

   S=1.2+2.3+3.4+4.5+ ... +n.(n+1)

6. Write a C program to find out factorial of a given number.

7. C program to find out sum of the following series.

   S=1!+2!+3!+4!+ ... +n!

8. Write a C program to find out sum of the following series.

   S = 1@ + 2@ + 3@ + 4@ + … + n@

   where, n@ is the sum of all factors of n. Example: 6@ = 1+2+3+6 = 12 **[OPTIONAL]**

9. Write a C program which prints all prime numbers between 1 and 100.

10. Write a program which accepts a number n and prints all prime factors of n. **[OPTIONAL]**

11. Write a program to generate all combinations of digit 1, 2 and 3 using `for` loop. **[OPTIONAL]**

12. Write a program to print the multiplication table of the number entered by the user. The table should get displayed in the following form.

    29 * 1 = 29

    29 * 2 = 58

    … … …

13. Write a menu driven program to accept a number in any Number System [from Binary, Decimal, Octal, and Hex] and convert and display the same in any other amongst these.

14. Write a menu-driven program for displaying log-series results for an input number for different log bases. **[OPTIONAL]**

15. Write a program named SINE to find the sine of an angle. The angle and its unit (degree, radian or grade) should be provided as command line arguments. For the units, short forms as d/D (for degree), r/R (for radian) or g/G (for grade) may be used. The program should use the series
$$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \cdots,$$
for evaluation. Take care of negative angles and angles in all the quadrants. **[OPTIONAL]**

16. Write a C program which accepts 100 integers and displays the counts of positives, negatives and zeros entered.

17. Write a C program to print the first n numbers of the Fibonacci sequence. The Fibonacci sequence is constructed by adding the last two numbers of the sequence so far to get the next number in the sequence. The first and second numbers of the sequence are defined as 0 and 1. We get:

    0, 1, 1, 2, 3, 5, 8, 13, 21…

18. Write a program to print out all Armstrong numbers between 1 and 500. If the sum of cubes of each digit of the number is equal to the number itself, then the number is called an Armstrong number. For example, 153 = (1^3) + (5^3) + (3^3). **[OPTIONAL]**

19. Write a C program which prints the first 10 happy numbers. If you iterate the process (assume maximum 100 iterations) of summing the squares of the decimal digits of a number and if the process terminates in 1, then the original number is called a Happy number. For example 7 is a happy number as 7 → 49 → 97 → 130 → 10 → 1. **[OPTIONAL]**

20. An important property of square numbers: If a natural number is a square number, then it has to be the sum of Successive Odd Numbers starting from 1.

    For example:

Perfect Square	Sum of Odd Numbers
4	1 + 3
9	1 + 3 + 5
16	1 + 3 + 5 + 7
25	1 + 3 + 5 + 7 + 9
36	1 + 3 + 5 + 7 + 9 + 11
49	1 + 3 + 5 + 7 + 9 + 11 + 13
64	1 + 3 + 5 + 7 + 9 + 11 + 13 + 15

    Now using this property, find the square root of any perfect square. **[OPTIONAL]**

21. Write a program which reads a positive integer value, and compute the following sequence: if the number is even, halve it; if it's odd, multiply by 3 and add 1. Repeat this process until the value is 1, printing out each intermediate value. Finally the program should print how many of these operations were performed. Typical output might be:

<div align="center">

Inital value is   3

Next value is   10

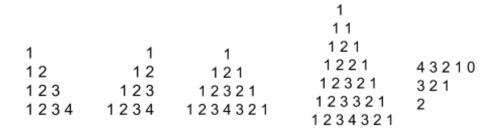Next value is   5

Next value is   16

Next value is   8

Next value is   4

Next value is   2

Next value is   1

Number of operations is 7 **[OPTIONAL]**

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22. Write a program to print all the ASCII values and their equivalent characters using a `while` loop. The ASCII values vary from 0 to 255.

23. Write a program to find the octal equivalent of the entered integer.

24. Write a C program that prints the following patterns for the input of n=4. The value of n is input by the user.

```
                                              1
                                             1 1
                                            1 2 1
1              1            1              1 2 2 1        4 3 2 1 0
1 2            1 2          1 2 1          1 2 3 2 1      3 2 1
1 2 3          1 2 3        1 2 3 2 1      1 2 3 3 2 1    2
1 2 3 4        1 2 3 4      1 2 3 4 3 2 1  1 2 3 4 3 2 1
```

```
      +                1              +++++++++              +
     +++              121             ++++ ++++            +   +
    +++++            12321            +++     +++         +     +
   +++++++          1234321           ++       ++       +       +
    +++++            12321            +         +       +       +
     +++              121             ++       ++        +     +
      +                1              +++     +++         +   +
                                      ++++ ++++              +
                                      +++++++++
```

[OPTIONAL]

25. Write a program to add first seven terms of the following series using a for loop:

$1/1! + 2/2! + 3/3! + \cdots$ **[OPTIONAL]**

Array

(Any five assignments)

1. Write a program in C to reverse the contents of the elements of an integer array.

2. Write a program in C to read n number of values in an array. After that, count the total number of duplicate elements in that array. Then copy the elements except the duplicate elements of that array into another array and display this array in reverse order.

3. Write a menu-driven program for accepting values in two square matrix of 3x3 dimension and generate their sum, difference and product.

4. Write a program to find the range of a set of integers entered by the user. Range is the difference between the smallest and biggest number in the list.

5. Write a C program which accepts ten integers from user and prints them in ascending order. Use array to store the integers.

6. Write a C program which accepts number obtained by five students in five subjects. Print the total marks obtained by all the students. Also determine the highest total marks.

7. Write a C program which accepts roll numbers of ten students and marks obtained by them in five subjects and prints the names of the students who have obtained highest and second highest marks subject wise. **[OPTIONAL]**

8. Write a C program which accepts a matrix and prints its transpose.

9. Write a C program to replace a square matrix by its transpose without using a second matrix. **[OPTIONAL]**

10. Consider the following procedure:

    i.   Take as input any four-digit number, using at least two different digits. (Leading zeros are allowed.)

    ii.   Arrange the digits in descending and then in ascending order to get two four-digit numbers, adding leading zeros if necessary.

    iii. Subtract the smaller number from the bigger number. Let the difference be the new four digit number.

    iv.   Go back to step ii.

The above process, known as Kaprekar's routine, will always reach a fixed point (Known as Kaprekar Constant). Write a C-Code to implement the algorithm given above and find out the constant number. Also create an output file 'output.dat' in the working folder and write the following with appropriate format for each step of iteration: The 4-digit number, the larger number, the smaller number and the difference of the larger and the smaller number.

Note:

    A. The fixed point is achieved when in two consecutive steps the same number is obtained

    B. In C the binary arithmetic operation m%n gives the remainder when m is divided by n

           [OPTIONAL]

11. Write a program which takes some numbers and computes the standard deviation of them.

Formulas: For a set of n values, $x_1, x_2, \ldots x_n$, the average or mean is given by

$$\bar{x} = \frac{\sum x_i}{n}$$

The standard deviation is given by: $s = \sqrt{\dfrac{\sum (x_i - \bar{x})^2}{(n-1)}}$

[OPTIONAL]

Function and Pointers

(Any ten assignments)

1. Write a function to compute the distance between two points and use it to develop another function that will compute the area of the triangle whose vertices are A(x1, y1), B(x2, y2), and C(x3, y3). Use these functions to develop a function which returns a value 1 if the point (x, y) lies inside the triangle ABC, otherwise a value 0.

2. A positive integer is entered through the keyboard, write a C function to find the binary equivalent of this number using recursion.

3. Write a recursive function which returns the sum of individual digits of a number passed as argument.

4. Amicable numbers are a pair of numbers with the following property: the sum of all of the proper divisors of the first number (not including itself) exactly equals the second number while the sum of all of the proper divisors of the second number (not including itself) likewise equals the first number. Write a function which takes as argument two numbers and returns 1 if they are amicable numbers else 0. **[OPTIONAL]**

5. Write a C program which accepts a string from user and counts the number of characters in the string without using string library functions.

6. Write a C program which accepts a string from user and prints the reverse of the string without using string library functions.

7. Write a C program which accepts a full name from user prints the initials. Eg. SRT for Sachin Ramesh Tendulkar.

8. Write a C program which accepts any string of the form "Ustad Bade Ghulam Ali Khan was the Tansen of the 20th century" and prints it as "Ustad|Bade|Ghulam|Ali| Khan|was|the|Tansen|of|the|20th|century". **[OPTIONAL]**

9. Write a program that reads a line and converts it into all capitals without using any string library function. (input string may also contain capital letters)

10. Write a program to count the number of occurrences of any two vowels in succession in a line of text.

11. Write a program that reads a line and delete from it all occurrences of the word "the". Do not use any string library function. **[OPTIONAL]**

12. Write a program that converts a string like "123" to integer 123. Do not use any string library function.

13. Write a C program which accepts a string from user and checks whether it is palindrome or not. Do not use any string library function. [Example of a palindrome string: "abcba", "abba"]

14. Write a C program which accepts a string from user and counts the number of words in it. Do not use any string library function.

15. Write a C program which accepts a multi-word string in which successive words may be separated by multiple blanks and reformats the string such that successive words are separated by single blank only. Do not use any string library function. **[OPTIONAL]**

16. Write a C program which accepts an integer and creates a string representation of the integer value. Do not use any string library function. [Example: If the argument is integer 1234 the program should form the string "1234"]

17. Write a C program which accepts name of five students and marks obtained by them in five subjects and prints the name of the students and the total marks obtained by them in order of merit. **[OPTIONAL]**

18. Write a recursive C function which returns the length of a string passed as an argument. **[OPTIONAL]**

19. Write a C function which takes as argument two dates in dd/mm/yyyy format as strings, compares them and returns 0 if the two dates are same, 1 if the first date is later than the second one and -1 if the first date is earlier than the second date. **[OPTIONAL]**

20. Write a C program that accepts a date as a string in "dd/mm/yyyy" format from the user, and prints the date in "date-month-year" format. [Example: If the input date is "19/04/2010", the program should print 19-April-2010]. **[OPTIONAL]**

21. Write a program in C that will implement the following functions

    a. Count the total number of words in a string.

    b. Find number of occurrences of a given word

    c. Print individual characters of string in reverse order.

    d. Count total number of vowels and consonants in a string.

    e. Find the most frequent character in a string.

    f. Check whether a given substring is present in the given string. **[OPTIONAL]**

22. Write a program in C to read some strings through keyboard and sort it using bubble sort. **[OPTIONAL]**

23. Write a program in C to store n numbers in an array and print the elements using pointers. Also compute the sum of all elements of that array using pointers.

24. Write a C function which accepts a string str1 and returns a new string str2 which is str1 with each word reversed. Do not use any string library function.

25. Write a C function which takes as argument two strings str1 and str2. It creates a third string str3 which is formed by taking alternating characters from each string and returns it. Example: If the two string arguments are "abcd" and "efgh" the function should return the string "aebfcgdh", If the two string arguments are "abcd" and "efghijkl" the function should return the string "aebfcgdhijkl". Do not use any string library function. **[OPTIONAL]**

26. Write a C function which takes as argument two strings str1 and str2 and an integer i. It returns a new string which is obtained by appending str2 from the ith character in str1. Example: If the two string arguments are "abcd" and "pqrs" and i is 2, then the function should return the string "abpqrs". Do not use any string library function. **[OPTIONAL]**

27. Write a function squeeze(s,c) which removes all occurrences of the character c from the string s.

28. Write the function strend(s,t), which returns 1 if the string t occurs at the end of the string s, and zero otherwise.

29. Write a C function convert(int n, char *s, int w) that accepts three arguments. The function stores the string representation of n in s. The third argument w is a minimum field width; the converted number must be padded with blanks on the left if necessary to make it wide enough. **[OPTIONAL]**

30. Write a C program which dynamically allocates memory for two matrices, orders of which is given by the user, and reads the values of elements of the matrices from the user. The program creates a third matrix which is obtained by multiplying the two input matrices. Your program should check for conformity of multiplication of the two matrices given by the user.

31. Write a program named SUM2L to find out the sum of the last two numbers provided as command line arguments.

Structure and File

(Any five assignments)

1. Create a structure to specify data on students given below:

   Roll number, Name, Department, Course, Year of joining

   Assume that there are not more than 100 students in the college.

   a. Write a function to print the names of all students who joined in a particular year.

   b. Write a function to print the data of a student whose roll number is given.

2. Write a program in C to create and store information in a text file.

3. Write a program in C whose output is the program itself.

4. Write a program which accepts names, rolls and marks of 10 students in 6 subjects stores it in an array of structures. Write a separate function which prints in ascending order the rank list (roll, name, average) based on the average of 6 subjects.

5. Write a program to build a linked list of integers. Write functions to add a new node at the beginning, at the end, or in the middle. Also write functions to delete a node and to traverse the list. **[OPTIONAL]**

6. Write a program to implement a stack using linked list. Write functions to push and pop elements. **[OPTIONAL]**

7. Write a program which allows you to do addition and subtraction of two integers which can be upto 40 decimal digits long (call it as huge integers). Create your own representation of huge integers and it should use as minimum space as possible. **[OPTIONAL]**

8. Write a program to create a Telephone Directory application, which will have options for

   a. Add Contact (Name and Telephone No.)

   b. Delete Contact

   c. Search (By Name)

   d. Browse

   Contact Information should be stored in a text file in a readable format. Allow multiple telephone numbers against a single contact name. **[OPTIONAL]**

9. Write a program to copy one file to another where files names are passed as command line arguments.

10. Write a program which reads a list of words from a file and sorts them in alphabetical order and displays them one word per line. **[OPTIONAL]**

11. Write a program which read a C source file having comments (between /* and */) and copies it another file leaving the comments.

12. Write a C program which reverses a given link list (pointer to head node is given). Assume suitable definition of link list nodes. **[OPTIONAL]**

13. Write a C program which reads a C source file and determines percentage of characters which are part of comments.

14. Write a C program which reads a C source file and determines no of variables defined of each built in data types. **[OPTIONAL]**

15. Write a program to sort some numbers in ascending order. The numbers are to be input from a file named 'input.txt'. The output should be written in a file named 'output.txt'. Use bubble sort algorithm and dynamic memory allocation for implementation.

16. The Euler–Mascheroni constant (also called Euler's constant) is a mathematical constant occurring in analysis and number theory. It is defined as the limiting difference between the harmonic series and the natural logarithm:

$$\gamma = \lim_{n \to \infty} \left(\sum_{k=1}^{n} \frac{1}{k} - \ln n \right)$$
$$\gamma = \left(1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \cdots + \frac{1}{n} \right) - \ln n$$

Write a C-Code to evaluate an approximate value for the above mentioned constant for progressively increasing number of terms (n). Consider double precision variables. Termination criterion:

Difference between two successive evaluations is very small ($\varepsilon = 10^{-6}$)

Create an output file 'output.txt' in the working folder and write the generated results of each iteration to the output file in appropriate format. The file should contain the following information: number of terms, evaluated constant value and relative error. **[OPTIONAL]**

Bit-Wise Operators [OPTIONAL]

1. An 8 bit unsigned character is used to store the gender (bit no. 7), year of study (bit nos. 6 and 5) and age of a student (bit nos. 4 to 0), where bit no. 7 is the MSB. Write a C function which accepts an 8 bit unsigned character value and prints the gender, year of study and age of a student.

2. Write a function that moves to the right by n bit positions the bits of an unsigned char x, with the following constraint. If the bit just shifted out of the LSB position is a '0' then a '1' is inserted in the MSB position and vice versa. Both x and n are passed as arguments to the function. The function should print out the result in binary form although input can be in decimal form. Example: if the input is 166 [binary equivalent 10100110], when moved right by 3 bits the output should be 00110100.

3. In Binary Coded Decimal (BCD) encoding, each decimal digit is stored in a 4-bit nibble. Suppose, 8 bit unsigned characters are used to store positive two digit decimal numbers. For example, decimal 39 is stored as 00111001. Write a C function which accepts such a positive two digit decimal number as an 8 bit unsigned character and returns the decimal number as an integer.

4. Write a C function which accepts two unsigned integers x and y and returns an unsigned integer z obtained from x and y. Even bits of z are taken from even bit positions of x and odd bits of z are taken from odd bit positions of y.

5. Write a program which accepts a floating point number (can be single or double precision) and prints the different parts of its storage representation (sign of number, mantissa, exponent, and sign of exponent) in binary.

Numerical Methods

1. Write a menu-driven program for finding roots of a nonlinear equation using Bisection, Regula Falsi and Newton-Raphson method.

2. Use the above program to find 3 roots of the equation xtan(x)=c where c is a user-input constant. Use both bisection method and Newton-Raphson method.

3. There are three real roots of the equation $x^3 - 2.5x^2 - 2.46x + 3.96 = 0$ in the domain [-4, +4]. Write a program to first find out the disjoint subintervals in the given domain those cover the roots. Hence find the roots by Newton-Raphson method. **[OPTIONAL]**

4. Write a menu-driven program for solving a system of linear equations using Gauss-Elimination method, Jacobi's method and Gauss Elimination with pivoting method

5. Using the above program solve the following system of equations :

    i. $x + y + z = 6$ ii. $x_1 + x_2 + x_3 = \quad 3$ iii. $2x_1 + 4x_2 + 2x_3 = 15$

    $x + y - z = 0$ $2x_1 + 3x_2 + x_3 = 6$ $2x_1 + x_2 + 2x_3 = \ -5$
    $x - y + z = 2$ $x_1 - x_2 - x_3 = \ -3$ $4x_1 + x_2 - 2x_3 = \quad 0$

6. Write a menu-driven program for implementing Interpolation using Lagrange's formula, Newton's forward difference formula, and Newton's backward difference formula.

7. For the following table of values:

x	1	2	3	4
f(x)	1	8	27	64

    Find f(2.5) using all three methods and comment on your answer

8. An experiment gave the following table of values for the dependent variable y for a set of known values of x. Obtain an appropriate least squares fit for the data.

x	1	2	3	4	5	6	7	8	9
y	5.5	7.0	9.6	11.5	12.6	14.4	17.6	19.5	20.5

9. For the data of the following table, obtain the regression line of x on y and of y on x. Compare the two lines. Show that both lines pass through $(\bar{x}, \bar{y})$ where $\bar{x}$ and $\bar{y}$ are means of x and y respectively. **[OPTIONAL]**

x	1.2	2.1	2.8	4.1	4.9	6.2	7.1	7.9	8.9
y	4.2	6.8	9.8	13.4	15.5	19.6	21.6	25.4	28.6

Show that in general the linear regression lines pass through the means $\left(\frac{\sum x_i}{n}, \frac{\sum y_i}{n}\right)$.

10. Find $\frac{dy}{dx}$ using forward, backward and central differencing schemes for $y = Sin\ x$ using (i) $\Delta x = 0.1$ (ii) $\Delta x = 0.01$ for $0 \le x \le \pi$ and determine the relative percentage error, defined as

$$\left|\frac{\left|\frac{dy}{dx}\right|_{numerical} - \left|\frac{dy}{dx}\right|_{exact}}{\left|\frac{dy}{dx}\right|_{exact}}\right| \times 100$$ in each case with the exact derivative given by $\frac{dy}{dx}\Big|_{exact} = \cos(x)$.

Comment on the result.

11. Consider a circle described by the equation $x^2 + y^2 = a^2$ where a is a user input constant. Determine the curvature of a point on the circle given by $(aCos\ \theta, aSin\theta)$ for $0 \le \theta \le \frac{\pi}{2}$. The curvature of a curve $y = f(x)$ is given by

$$\kappa = \frac{\frac{d^2y}{dx^2}}{\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2}}$$

Determine the derivatives using central differencing scheme. Explore the sensitivity of the result to choice of Δx and compare your result at each point with $1/a$. **[OPTIONAL]**

Repeat the problem for $y = \sin(kx)$ where $1 \le k \le 5$ is a user-defined constant. Comment on the appropriate choice of Δx for different values of k.

12. Write a function `integrate` to find the integration of a function f within the limits a and b by Trapezoidal and Simpson's 1/3rd integration method. f, a and b should be provided as arguments of the function `integrate`. Write the main function to take the name of the integrand function and the limits of integration as command line arguments.

13. Write a program to solve the following differential equations by (i) Euler method, (ii) Runge-Kutta second order method. Compare your solutions. In each method estimate the truncation error and choose an appropriate step size.

$$\frac{dy}{dx} = 2xy, y(0) = 0.5, \text{solution for } 1 \ge x \ge 0$$

$$\frac{dy}{dx} = x^2 + y^2, y(0) = 1, \text{solution for } 1 \ge x \ge 0$$

14. Write a program to solve the following second order differential equation by second order and fourth order Runge-Kutta method:

$$\frac{d^2y}{dx^2} + 0.5\frac{dy}{dx} + 4y = 5, y(0) = y'(0) = 0.$$

Find the solution in the range $2 \ge x \ge 0$.   **[OPTIONAL]**