B. P. Poddar Institute of Management & Technology
Department of Electronics & Communication Engineering
Academic Year: 2020-21 Semester: Even
Laboratory Name: Ramanujan Laboratory Room No.: B604
ECE 2nd Semester
Course Name: Programming for Problem Solving (ES-CS 291)

INTERNAL LABORATORY EXAMINATION

Question Booklet

[Discussion NOT required to be written in Answer Sheet. They are given for further exploration.]

Q1. WACP to compute the roots of a quadratic/cubic equation: (a, b, c, d are user inputs)

$$Quadratic: \quad ax^2 + bx + c = 0 \;\; ; \;\; a \neq 0, a, b, c, \in R$$

$$Cubic: \quad ax^3 + bx^2 + cx + d = 0 \;\; ; \;\; a \neq 0, a, b, c, d \in R$$

Input (List is minimum, more inputs can be taken if necessary)
a ($a \neq 0$), b, c, d as any real coefficients
Desired Output
All real roots (no complex roots required to be computed) for a given set of a, b, c, d.
Discussion
Tabulate (real roots) vs. (coefficient vector: [a, b, c, d]) with at-least 3 experiments (or testcases).

Q2. Consider the following series:

$$S_n = \frac{1}{4!} - \frac{1}{6!} + \frac{1}{8!} - \cdots \frac{1}{n!}$$

Write a C program to compute the series sum S_n for a given input n. Use a recursive C function to calculate factorial of an integer.

Also determine if the series sum S_n is convergent. Hence obtain the minimum value of n for which S_n becomes convergent.

Input (List is minimum, more inputs can be taken if necessary)
n as any positive integer
Desired Output
(1) S_n (2) Convergence of S_n
Discussion
Minimum value of n for convergence of S_n

Q3. WACP to display the following pattern on console output screen using binomial expansion technique:

1 6 15 20 15 6 1
1 5 10 10 5 1
1 4 6 4 1
1 3 3 1
1 2 1
1 1
1

Fig.1

Input (List is minimum, more inputs can be taken if necessary)
n: no of rows of the pattern; n > 3 is any natural number
Desired Output
Fig.1
Discussion
Mathematical formulation of (1) no. of space, $sp \rightarrow sp(n,r)$ (2) no. of data, $data\_count \rightarrow data\_count(n,r)$ where r is the index variable of a row.

Q4. Write a C program to calculate the weighted average of a list of 'n' real numbers, using the formula:

$$x_{avg} = f_1x_1 + f_2x_2 + \cdots + f_nx_n \ldots (1)$$

where the f's are fractional weights such that,

$$0 \leq f_i \leq 1 \ldots (a) \quad and \quad f_1 + f_2 + \cdots + f_n = 1 \ldots (b)$$

Input (List is minimum, more inputs can be taken if necessary)
(1) n ; $x_i, f_i \ for\ all\ 1 \leq i \leq n$ (2) f_i is any real number input given by user. It must not be restricted to condition (a) and (b) to the user. The program must be written in such a way to satisfy the conditions (a) and (b)
Desired Output
x_{avg}
Discussion
Proof of the following corollary result: " If conditions (a) and (b) are satisfied then, $x_{avg}\ given\ in\ eq(1)$ is equivalent to weighted average on n real numbers"

Q5. Consider a 2D matrix shown below:

$$A_{m\times n} = \begin{bmatrix} a_{11} & \dots & a_{1n} \\ a_{21} & \dots & a_{2n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \dots & a_{mn} \end{bmatrix}_{m\times n}$$

Compute f(A) where $f: R^2 \rightarrow R$ is a real valued function defined as follows:

$$f(A) = \max_{\forall i=1,2,3,\dots m} \left\{ \min_{\forall j=1,2,\dots n} a_{ij} \right\}$$

$$where\ a_{ij}: element\ of\ A\ in\ row\ i\ and\ column\ j$$

Input (List is minimum, more inputs can be taken if necessary)
m, n ; $a_{ij},\ for\ all\ 1 \le i \le m, 1 \le j \le$ n in A.
Desired Output
$f(A)$
Discussion
Prove that, $\max_i\{\min_j a_{ij}\} \ge \min_i\{\max_j a_{ij}\}$

Q6. Consider a user given string consisting of n alphabets only. The string is encoded into a binary stream as given below:

$$string:\ c_1c_2c_3 \dots c_n$$
$$bStream = C_1C_2C_3 \dots C_n$$

$$where\ each\ C_i is\ a\ 7-bit\ binary\ equivalent\ of\ ASCII\ value\ of\ the\ character\ c_i; 1 \le i \le n$$

Write a C function to generate binary output stream as follows:

$$encodedStream = C_1\boxed{p}C_2\boxed{p}C_3\boxed{p}\dots\boxed{p}C_n$$
$$where\ p\ is\ defined\ as:$$
$$p = \begin{cases} 1; & if\ string\ is\ palindrome \\ 0; & if\ string\ is\ not\ palindrome \end{cases}$$

Input (List is minimum, more inputs can be taken if necessary)
any $string:\ c_1c_2c_3 \dots c_n$
Desired Output
$encodedStream = C_1\boxed{p}C_2\boxed{p}C_3\boxed{p}\dots\boxed{p}C_n$
Discussion

Q7. Write a C function to multiply two matrices using the following features:
(1) dynamic memory allocation for matrix storage
(2) check for possibility of the matrix multiplication

Hence, check to determine if the resultant matrix is "idempotent matrix".

Input (List is minimum, more inputs can be taken if necessary)
Matrix A and B
Desired Output
$C = AB$ C is "idempotent matrix" or "not idempotent matrix"
Discussion
Mathematical formulation of matrix multiplication: $c_{ij} \in C \quad \forall i, j$

Q8. Write a recursive C function to implement the Ackerman function, A(m, n).
Hence, develop a function find the no. of digits (dig_count) in A(m, n).

Input (List is minimum, more inputs can be taken if necessary)
$0 \leq m \leq 3, \quad 0 \leq n \leq 4$
Desired Output
$A(m, n)$
Discussion
Tabulate m , n, dig_count, A(m, n) for $0 \leq m \leq 3,\ 0 \leq n \leq 4$

Q9. Consider the following series:

$$S_n = \frac{1}{1+2} + \frac{1}{3+4} + \frac{1}{5+6} + \cdots n\ terms$$

Write a C function to compute the series sum S_n for a given input n. Use a recursive C function to calculate factorial of an integer.
Also determine if the series sum S_n is convergent. Hence obtain the minimum value of n for which S_n becomes convergent.

Input (List is minimum, more inputs can be taken if necessary)
n as any positive integer
Desired Output
(1) S_n (2) Convergence of S_n
Discussion
Minimum value of n for convergence of S_n

Q10. WACP to display the following pattern on console output:

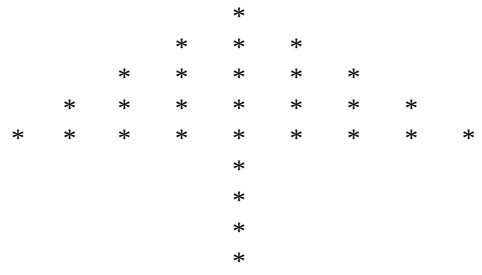

Fig.2

Input (List is minimum, more inputs can be taken if necessary)
n: no of rows of the pattern; n > 3 is any odd natural number
Desired Output
Fig.2
Discussion
Mathematical formulation of (1) no. of space, $sp \rightarrow sp(n,r)$ (2) no. of data, $data\_count \rightarrow data\_count(n,r)$ where r is the index variable of a row.

Q11. Consider the mean of a list of 'n' real numbers, using the formula:

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} \quad \ldots (1)$$

WACP to find the position of the real number x_i $(1 \leq i \leq n)$ to which the mean $\bar{x}$ is closest.

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Input (List is minimum, more inputs can be taken if necessary)
n ; $x_i \ for\ all\ 1 \leq i \leq n$
Desired Output
$i\ such\ that\ x_i\ is\ closest\ to\ \bar{x}$
Discussion
Show that, for uniform distribution, $\bar{x} = median\ of\ the\ list$

Q12. Consider a 2D matrix shown below:

$$A_{m\times n} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ a_{21} & \cdots & a_{2n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix}_{m\times n}$$

Compute f(A) where $f: R^2 \rightarrow R$ is a real valued function defined as follows:

$$f(A) = \min_{\forall j=1,2,3,\ldots m} \left\{ \max_{\forall i=1,2,\ldots n} a_{ij} \right\}$$

$$where\ a_{ij}: element\ of\ A\ in\ row\ i\ and\ column\ j$$

Input (List is minimum, more inputs can be taken if necessary)
m, n ; $a_{ij},\ for\ all\ 1 \leq i \leq m, 1 \leq j \leq$ n in A.
Desired Output
$f(A)$
Discussion
Prove that, $\max_i\{\min_j a_{ij}\} \geq \min_i\{\max_j a_{ij}\}$

Q13. Write a C function to compute the rank of a matrix A of order 2 or 3 with following features:

(1) dynamic memory allocation for matrix storage

(2) integer pointer

Input (List is minimum, more inputs can be taken if necessary)
A
Desired Output
$rank\ of\ A$
Discussion
Hand sketch to find rank of the matrix example taken in execution

Q14. Write a C function to add two matrices and transpose the resultant matrix with the following features:

(1) dynamic memory allocation for matrix storage
(2) integer pointer
(3) separate functions for matrix addition and matrix transposition

Input (List is minimum, more inputs can be taken if necessary)
Matrix A and B
Desired Output
$C = A + B$ $D = C'$
Discussion
Mathematical formulation of matrix addition and matrix transposition: $c_{ij} \in C \quad \forall i,j$ and $d_{ij} \in D \quad \forall i,j$

Q15. WACP to determine if a sentence/paragraph contains some pre-defined violent words: "riot", "kill", "bomb", "attack", "shoot" etc.

Input (List is minimum, more inputs can be taken if necessary)
sentence/paragraph/essay
Desired Output
"violence detected" or "no violence detected"
Discussion
Stopping criteria to take input characters from user into the data structure.

------End of Paper------