INDIA METEOROLOGICAL DEPARTMENT

QUESTION BANK

OF

ADVANCED METEOROLOGICAL TRAINING COURSE (AMTC)

SEMESTER-II EXAMINATION

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PAPER-VII: COMPUTER PROGRAMMING & APPLICATIONS

PART B

India Meteorological Department
Meteorological Training Institute
Advanced Meteorological Training Course,

SEMESTER-II Final Examination

PAPER-VII Computer Programming & Applications

PART-B

Q1. Fill in the gaps by selecting the options given.

1) In Newton Raphson method, if ___________ is zero or very close to zero, method fails.

   a) x_1 b) $f(x_1)$ c) $f'(x_1)$ d) None of the above

2) Newton's forward difference interpolation formula fails to work in case of ________ intervals

   a) equal b) unequal c) missing d) None of the above

3) When n is large, interpolation polynomial of degree n does not provide accurate results at the _____ of range.

   a) ends b) beginning c) middle d) None of the above

4) Suppose we have function, f(x), whose values are known at set of points $x_1, x_2, \ldots, x_n$ then $f(x_{i+1}) - f(x_i) =$ _________.

   a) Δf_i b) δf_i c) Ef_i d) None of the above

5) Numerical integration technique use the concept of _________ to find the area.

   a) Summation b) Multiplication c) Subtraction d)Division

6) ydx $= h/3 \{yo + 4(y_1 + y_2 + y_3 + \ldots + y_{n-1}) + 2(y_2 + y_4 + \ldots + y_{n-2}) + y_n)$ is known as ___________.

   a) Trapezoidal rule b) Weddle's rule c) Simpson's 1/3 rule d) None of the above

7) Analysis of linear equations is significant because ____________

   a) Mathematical models of many real world problems are either linear or can be approximated reasonably well using linear relationships

b) It is easier than that of non-linear relationships

c) Both a) and b)

d) None of the above

8) $y'(x) = f(x, y(x), y(x_o) = y_o$ represents ___________.

a) Intial Value Problem of an ordinary first order differential equation

b) Taylor series

c) Bisection method

d) None of the above

9) $y_{i+1} = y_i + hf(x_i , y_i)$ where $f(x_i , y_i)$ is slope of $y(x)$ at $(x_i , y_i)$and $hf(x_i , y_i)$ is increment value of y. represents ____________________________ .a)formula of Euler's method b) formula of Taylor series method c) formula of Heun's method d) None of the above

10) ___________ are errors caused due to human imperfection. a)Blunders b) Inherent errors c) Modelling errors d) None of the above

11) The degree of differential equation is the power of the __________order derivative.

b) highest b) lowest c) second d) None of the above

12) If b2 – 4ac = 0, then partial differential equation is known as ___________.

b) elliptic b) parabolic c) hyperbolic d) None of the above

13) When n is large, interpolation polynomial of degree n does not provide accurate results at the _____ of range.

b) ends b) beginning c) middle d) None of the above

14) 2sinx –x = 0 is an example of _________ equation.

b) Algebraic b) Polynomial c) Transcendental d) None of the above

15) Numerical integration technique use the concept of _________ to find the area.

b) Summation b) Multiplication c) Subtraction d)Division

16) The number 57.396 is accurate to _________ significant digits.

b) Three b) Five c) Two d) None of the above

17) In basic ___________ method, the element aij when i=j is known as a pivot element.

e) Gauss Elimination
f) Jacobi
g) Gauss- Jordan
h) Gauss-seidel

18) The second phase of the process of numerical computing is ___________.

a) Validation of the solution
b) Implementation of the method to obtain a solution
c) Construction of an appropriate numerical method
d) Formulation of a suitable mathematical model

19) The number 57.396 is accurate to _____ significant digits

a. two
b. three
c. four
d. five

20) ________ errors are those that are present in the data supplied to the model.

a. Numerical errors
b. Truncation errors
c. Inherent errors
d. Blunders

21) The Assumption “Function changes sign in the vicinity of the root” is made in _____.

a. Graphical methods
b. Trial and error methods
c. Iterative methods
d. Bracketing methods

22) In Newton Raphson method, method fails if $f'(x1)$ is ____ or very close to ___.

a. One
b. Zero
c. Two
d. Three

23) $\Delta =$ _______

a. E-1
b. E+1
c. 0
d. d)1-E , where E is a shift operator and Δ is forward difference operator.

24) Numerical integration techniques and graphical methods use concept of _____ to find the area.

a. Summation
b. Multiplication
c. Division
d. Subtraction

25) Fortran 90/95 is a free source form, where each line of Fortran statement may be up to ________ characters long.

26) A$ is an _____ variable name because _____.

27) 111E3 is not a valid real constant because ____________.

28) Correct form of Type declaration statement with a parameter attribute for following is __________.

Real :: Parameter, pi=3.141593

29) The arithmetic operator is _________ used as Exponentiation in Fortran 90/95.

30) Program Test

```
Character(len=10)::a
Character(len=8)::b,c
a= 'ABCDEFGHIJ'
b= '12345678'
c=a(1:3)//b(4:5)//a(6:8)
```

end program Test

Variable c will contain the string _____.

(1) 'ABC45FGH' (2) 'FGH45ABC' (3) 'ABC54FGH' (4) 'FGH54ABC'

31) MOD(A,B) = ________ if A=10, B=3

(1) 3 (2) 1 (3) 10 (d) 0

32) Which of the following is the low level language _________

(1) Machine Language (2) COBOL (3) FORTRAN (4) BASIC

33) The exponent operator in FORTRAN is ________

(1) ** (2) ^ (3) EXP (4) 1.23E04

34) Intrinsic function to evaluate Nearest Integer to x (x is rounded) is ________

(1) INT(X) (2) NINT(X) (c) REAL(I) (4) None

35) In Fortran 90, a too long statement can be continued on the next line by ending the current line (and optionally starting the next line) with an _______ character.

(1) $ (2) @ (3) & (4) &&

36) The correct computer expression for $A.\frac{B}{C}-D$ is _______.

(1) A*B-D/C (2) A*B/C-D (3) (A*B)/(C-D) (4) ((A*B)-D)/C

37) Correct form of Type declaration statement with a parameter attribute for following is __________. Real :: Parameter, pi=3.141593

(1) Real,Parameter:: pi=3.141593 (2) real::Parameter, pi=3.141593 (3) None of the above

38) The flowchart gives the logical flow of the solution in a _______ form, and provides a plan from which a ______ can be written.

a) Formulae, computer program
b)Diagrammatic, computer program
c) Pictorial, computer program
d)None of the above

39) Mixing ratio is given as, r = 0.622x$\frac{e}{p-e}$. The correct Fortran statement for this is given by ________

a) r = 0.622 * e/(p-e)
b) r = 0.622*e/p-e
c) r = 0.622e/p-e
d) None of the above

40) _________ gives a step-by-step description of the solution.

a) Algorithm
b) Flow chart
c) Algorithm and Flow chart
d) None of the above

41) The Fortran statement Fahrenheit=1.8*Celsius+32.0 is correct.

42) If ires = 10.0 / 3 then the value of ires is __________.

a) 3
b) 3.0
c) 3.333333
d) 0

43) A function subprogram is called in the main program by CALL statement.

44) Always use the IMPLICIT NONE statement to catch typographical errors in your program at compilation time.

45) The correct statement in Fortran for the height of the ball at any time after it is thrown given by equation y(t)=y0 + vy0 t + ½ gt2 is

a) y(t)=y0 + vy0 * t + (0.5)*g*t**2
b)y(t)= y0 - vy0 * t - (0.5)*g*t**2
c)y(t)= y0 + vy0 * t + (0.5)/g*t**2
d)None of the above

46) FORTRAN is the acronym for Formula Translation

Q2. State true or false with reason.

1. A polynomial is a common choice for interpolating function.

2. The major pitfall of using Lagrange polynomial is it does not use the polynomial already computed, i.e. if we add one more data point, we have to compute the polynomial from the beginning.
3. $\Delta = E - 1$
4. Numerical approximation of the solution may be considered as a possible approach when the analytical techniques fail in case of models which take into account effect of conditions of real life situations.
5. dy/dx = f(x,y) is second order differential equation
6. Partial differential equation is elliptic in case of u/ x2 + u/ y2 + 2 u/ x y = 0
7. Accuracy and precision of the number 57.396 is five significant digits and 0.001 respectively.
8. Numerical computations play an indispensible role in solving real life mathematical, physical and engineering problems.
9. A polynomial is a common choice for interpolating function.
10. The major pitfall of using Lagrange polynomial is it does not use the polynomial already computed, i.e. if we add one more data point, we have to compute the polynomial from the beginning.
11. One way to find roots of non-linear equation is iterative methods which are grouped as bracketing methods and open-end methods.
12. Gauss-Seidel method is similar in principle to Jacobi method.
13. Simpson method is more accurate than Trapezoidal method.
14. Validation means the verification of results to see that it is within the desired limits of accuracy.
15. Newton Raphson method is an open end method
16. Lagrange interpolation Polynomial is applicable for inequal intervals.
17. One way to find roots of non-linear equation is iterative methods which are grouped as bracketing methods and open-end methods.
18. Accuracy and precision of the number 47.426 is five significant digits and 0.001 respectively.
19. Never raise a negative number to a real power.
20. The relational operator can be used in assignment statement.

21. 3/10 is 0 in Fortran 90/95
22. Always use Implicit none statements in the program
23. Never raise a negative number to a real power.
24. The relational operator can be used in assignment statement.
25. 3/10 is 0 in Fortran 90/95
26. Always use Implicit none statements in the program
27. The output of the program given below is 1 2 1 2 1 2…..

```
Program Test_Cycle
    Integer :: i
    Do i=1,5
    If(i==3)cycle
    Write(*,*)i
    Enddo
    Write(*,*) 'End of the loop'
    End Program Test_Cycle
```

28. 'MPI_Isend' and 'MPI_Irecv' are blocking MPI communication calls.
29. The 'barrier' directive in OpenMP synchronises the threads.
30. Within a parallel region in OpenMP, all declared variables are by default 'shared'.
31. The 'copyin' clause in OpenMP provides a mechanism to assign the same value to 'threadprivate' variables for each thread in the team executing the parallel region.
32. There are nine sections in a message in grib2 data format.
33. If A and B are two n-dimensional vectors of real numbers, then the result of the statement C = A .* B (i.e., dot-star operation) executed in MATLAB would be a dot product of A and B (scalar or a single real number).
34. The maximum speed-up of a parallel computation given that 90% of the computation can be executed in parallel is 10.

35. In ‘MPI_Isend(&someint, 1, MPI_INT, destid, tag, MPI_COMM_WORLD, &reqs)’ variable ‘someint’ can be altered anytime without affecting the message being transferred.
36. GRIB data format is most suited for data transmission.
37. BUFR format is WMO standard format to store model simulation data.
38. There are only 5 sections in a message in grib2 data format.
39. Raster images can be stored in HDF5 data format.
40. Vector computers use vector pipelines to handle arithmetic operations efficiently.
41. Crossbar networks connecting n processors with n memory modules require n4 switches.
42. The total execution time of a program consists of a part that can be parallelized and a part that is serial. If the serial fraction of the total time is k, the maximum speedup (for a fixed-problem size) that can be obtained is 1 / [k + (1 - k) / p], where p is the number of processors used in parallelisation.
43. The purpose of tag in MPI communications is to assign a message ID to the message.
44. All blocking message passing communication calls are synchronous.
45. They primary R system is available from

    a) CRAN
    b) CRWO
    c) GNU
    d) LIBRARY

46. Which of the following is used for Statistical analysis in R language?

    a) Studio
    b) RStudio
    c) Heck
    d) Console

47. What would be the result of following code?

> x <-vector(“numeric”, length=10)

>x

a) 10

b) 1 1 1 1 1 1 1 1 1 1

c) 01

d) 0 0 0 0 0 0 0 0 0 0

48. Which of the following statement read a tab or space delimited file?

a) read.table(filename,header=TRUE)

b) read.CSV(filename,header=TRUE)

c) read.table(filename,header=FALSE)

d) read.tableall(filename,header=TRUE)

49. Crossbars and Multistage interconnection networks can also be used to interconnect computers.

50. Strategies for parallelization include

a) Use of automatic parallelisation
b) Use of parallel libraries
c) Develop parallel code, ab initio
d) All the above

51. Parallel program scalability refers to

a) Addition of extra processors to the machine
b) Proportionate increase in speed-up with increase in processors used in parallel program
c) Decrease in efficiency
d) Parallel overhead

52. In Trivial decomposition n copies of the same sequential code are executed as n independent tasks.

53. In Block data decomposition the data is divided into p contiguous blocks of equal size.

54. MPI stands for
    a) Specification for a library of message passing functions
    b) A specific implementation/product for message passing
    c) A compiler specification
    d) A HPC organisation
55. The statement real, parameter :: g = 9.8 defines g to be a constant equal to the value 9.8.
56. The highest precedence of combination of operators is Function evaluation.
57. The '* *' is the operator meaning "raise to the power of" in Fortran 90/95.
58. Fortran built-in function for loge(x) is LOG10(X)
59. String A= 'true12345' and String A(1:4)= 'true' A//A(1:4) gives the result 'true12345true'
60. The result of the operation 4==4 is
61. An example of integer constant is 9,20

Q3. Attempt the following.

1. Solve the following system of equations using Gauss Elimination **with partial pivoting**
   a. $2x_1 + 3x_2 + 4x_3 = 5$
   b. $3x_1 + 4x_2 + 5x_3 = 6$
   c. $4x_1 + 5x_2 + 6x_3 = 7$
2. Solve 1/(1+x2) dx by Simpson's 1/3 rule and Trapezoidal rule and compare the results and comment on it.
3. Classify following second order differential equations into elliptic, parabolic and hyperbolic. 1. $U_{yy} - a^2U_{xx} = 0$, 2. $KU_{xx} = U_y$

4. Describe two basic approaches that are employed for solving a system of linear equations.
5. State four phases of numerical computing. Derive the Newton-Raphson iterative formula for solving f(x) = 0.
6. What is numerical integration? When do we need to use a numerical method instead of analytical method for integration?
7. Give basic difference between bracketing methods and open end methods.
8. Illustrate with a figure, a taxonomy of errors encountered in a numerical process.
9. Flowcharts in Fortran 90/95
10. Advantages of Fortran 90/95
11. Taxonomy of Errors encountered in a numerical process
12. Iterative method for finding roots of non-linear equations
13. CYCLE and EXIT Statements with examples
14. Define vector processing.
15. Explain shared memory parallel computer architecture.
16. What is distributed memory message-passing architecture?
17. Explain the terms UMA and NUMA in the context of parallel computer architectures.
18. What is a communicator in MPI?
19. What is Cannon's algorithm about?
20. Define virtual topology in MPI.
21. Give expressions for speedup and efficiency of a parallel program.
22. What is functional decomposition?
23. What is parallel overhead?
24. What is Matlab?
25. Enlist two matrix manipulation operations supported by Matlab.
26. Flowcharts in Fortran 90/95
27. Advantages of Fortran 90/95
28. Subprograms used in FORTRAN 90/95
29. Do loops
30. Structure of a Fortran program in Fortran 90
31. Allocatable arrays

32. Write a Fortran program to compute potential temperature of a given sample of air of 500 hpa Level and temperature -10.0 deg. C which is compressed adiabatically to a Pressure of 1000 hPa Level.
33. Design a FORTRAN program that reads an input temperature in degrees Fahrenheit, converts it to an absolute temperature in Kelvins, and writes out the results. Use IMPLICIT NONE statement and TYPE declaration statement in your program.
34. What are the 5 intrinsic data types available in FORTRAN 90?
35. Work out the answers in each of the following :
    a. 10.0/2.0*5.0
    b. 5.0*2.0**3
    c. 2**2**4
36. What are the main forms of loop structures in FORTRAN 90?
37. Explain differences between subroutines and functions.
38. Write algorithm for a program to fit a straight line to a set of points (xi,yi), i=1,N
39. Write fortran program to calculate potential temperature of an air parcel.
40. Explain open statement used in Fortran 90.
41. Explain with examples: MPI_Scatter and MPI_Gather.
42. Describe in brief Flynn's method of classification of parallel computers.
43. What are SAS and SPSS?
44. Explain the difference between interpreted and compiler language. Is FORTRAN a compiler or an interpreted language?
45. Distinguish between UMA and NUMA parallel computer architectures. Draw block diagrams of each architecture.
46. Explain in brief any *two* of the following:
    (a) MPI_Comm_rank and MPI_Comm_size
    (b) MPI_Test and MPI_Wait
    (c) MPI_Init and MPI_Finalize
47. Explain M-Files and method to write user-defined functions in MATLAB.
48. The initial state of an air parcel is p=997 hPa, T=26.5°C, q=15.4 gKg-1. Write a Fortran program to compute the mixing ratio, relative Humidity RH, virtual temperature Tv and the potential temperature.

49. Write short note on Use of FORTRAN in meteorology
50. What are subprograms? Explain two subprograms used in Fortran.
51. In the Artic, the mean virtual temperature of the 1,000 to 500hPa layer is -40℃.
52. Write a Fortran Program to determine thickness of the layer between these levels.