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Total Printed Pages -11

**F - 1499**

**C.B.S. (Tenth Semester)  
EXAMINATION, May - June, 2022  
(Mathematics Stream)  
Dynamical System Using Matlab  
(ME1001)**

*Time : Three Hours]*

*[Maximum Marks:40*

**Note: Attempt all sections as directed.  
(Section-A)**

**(0.5 marks each)**

**Note: Attempt all questions.**

**Choose the correct/most appropriate answer and write  
in your answer Book:**

1. Array operations are executed element by element  
\_\_\_\_\_
- (A) One Dimensional Array only
  - (B) Multi Dimensional Array only
  - (C) Both on One Dimensional and Multi-Dimensional Array
  - (D) Neither One Dimensional Nor Multi-Dimensional Array

**P.T.O.**

[2]

2. \_\_\_\_\_ is a file that contains multiple sequential lines of matlab commands and function calls.
- (A) A function file
  - (B) A Script file
  - (C) Worksheet
  - (D) Presentation file
3. \_\_\_\_\_ function is used as matlab command in interpolation.
- (A) Interp1 ( )
  - (B) Inter ( )
  - (C) Interpolation ( )
  - (D) Interpolation [ ]
4. \_\_\_\_\_ examines the relationship between one or more predictors(independent variables) and a response variable (dependent variable) with the goal of defining a 'best fit' model of the relationship.
- (A) Scalar Variables
  - (B) Mathematical Operations
  - (C) Interpolation
  - (D) Curve fitting

**F - 1499**

[3]

5. The equation of logistic map is given by
- (A)  $x_{k+1} = \beta(1 - x_k)$
  - (B)  $x_{k+1} = \beta x_k(1 - x_k)$
  - (C)  $x_{k+1} = \beta x_k$
  - (D)  $x_{k+1} = \beta(1 + x_k)$
6. If the slope of the linear map \_\_\_\_\_ absolute value than the slope of  $y = x$ , then the fixed point is attracting.
- (A) is greater in
  - (B) is less in
  - (C) is equal in
  - (D) is less than equal in
7. The number  $\delta$  known as the Feigenbaum constant is equal to \_\_\_\_\_
- (A) 3.0109
  - (B) 4.669202
  - (C) 2.0609
  - (D) 1.0609
8. For  $x_{n+1} = x_n^2$ , the fixed point  $x^*$  are given by 0 and 1, then \_\_\_\_\_
- (A)  $x = 0$  is stable and  $x = 1$  is unstable
  - (B)  $x = 0$  is unstable and  $x = 1$  is stable
  - (C)  $x = 0$  and  $x = 1$  is stable
  - (D)  $x = 0$  and  $x = 1$  is unstable

F - 1499

P.T.O.

[4]

9. The Gaussian map is defined by \_\_\_\_\_
- (A)  $G(x) = e^{-\alpha x} + \beta$ ,  $\alpha$  and  $\beta$  are constants
  - (B)  $G(x) = e^{-\alpha x^2}$ ,  $\alpha$  is constants
  - (C)  $G(x) = e^{-\alpha x^2} + \beta$ ,  $\alpha$  and  $\beta$  are constants
  - (D)  $G(x) = \beta x$ ,  $\beta$  is constants
10. The Julia set J is \_\_\_\_\_
- (A) A attractor
  - (B) A repellor
  - (C) Variant
  - (D) Always connected
11. The parabola has equation \_\_\_\_\_ where  $D = \det(A)$  and  $T = \text{trace}(A)$
- (A)  $T^2 - 4D < 0$
  - (B)  $T^2 - 4D = 0$
  - (C)  $T^2 - 4D > 0$
  - (D)  $T^2 - D = 0$
12. The fixed point which we call \_\_\_\_\_ has atleast one attracting direction and atleast one repelling direction.
- (A) Sink
  - (B) A Saddle
  - (C) Source
  - (D) Saddle point

F - 1499

[5]

13. A flow on  $R^2$  is a mapping  $\pi : R^2 \rightarrow R^2$  such that \_\_\_\_\_

- (A)  $\pi$  is continuous
- (B)  $\pi$  is discontinuous
- (C)  $\pi(x,0) \neq 0$
- (D)  $\pi(x,0) \neq 1$

14. RelTol and AbsTol are used to \_\_\_\_\_ the accuracy in plotting phase portrait.

- (A) Decrease
- (B) Increase
- (C) Measure
- (D) None of the above

15. The system of equations are given by  $\dot{r} = \alpha r, \dot{\theta} = -\beta$ .

If  $\alpha = 0$  then the critical point is called a \_\_\_\_\_.

- (A) Unstable Focus
- (B) Center
- (C) Stable Focus
- (D) Trajectories spiral clockwise around the origin.

16. The sum of the indices of the critical points contained entirely within a limit cycle is \_\_\_\_\_.

- (A) -1
- (B) 1
- (C) 0
- (D) 0.5

F - 1499

P.T.O.

[6]

17. Lotka-Volterra Model is \_\_\_\_\_

- (A) Structurally Stable
- (B) Structurally Unstable
- (C) Stable Focus
- (D) Unstable Focus

18. For the Lorenz equations,

$$\dot{x} = \sigma(y - x), \dot{y} = rx - y - xz, \dot{z} = xy - bz, \text{ at } r \approx 24.06$$

- (A) The origin is unstable
- (B) The origin is the only critical point.
- (C) A strange attractor is formed
- (D) The origin is stable

19. \_\_\_\_\_ is an attractor that exhibits sensitivity to initial conditions.

- (A) Double Scroll Attractor
- (B) An attractor
- (C) A strange attractor
- (D) Basin of attractor

20. A limit cycle is of period \_\_\_\_ if  $x(t) = x(t+T)$  for some minimum constant T called the period.

- (A) Two
- (B) Zero
- (C) One
- (D) Half

F - 1499

[7]

**(Section-B)****(Very Short Answer Type Questions)****(0.75 marks each)**

**Note- Answer the following very short type questions in 2-3 sentences each.**

1. Write about three dimensional plots?
2. Write a matlab Programming for plotting  $f(x) = e^{-x/10} \cos(x)$  for x between 0 and 20.
3. Write about Periodic Window.
4. Write about Sensitive Dependence On Initial Condions?
5. Write about Jacobian Matrix for higher dimensional map?
6. Determine the stable and unstable mainfolds for the linear

system  $\dot{X} = \begin{pmatrix} -3 & 4 \\ -2 & 3 \end{pmatrix} X$

7. State Existence and Uniqueness theorem for dynamical sysem?
8. Use a linear stability analysis to determine the stability of the critical points for the following differential equations :

$$\dot{x} = e^{-2x} - 1$$

F - 1499

P.T.O.

[8]

9. State Peixoto's Theorem in the plane.
10. Write about Rossler System.

**(Section-C)****(Short Answer Type Questions)****1.25 marks each**

**Note- Answer the following questions in  $\leq 75$  words .**

1. Construct a script file to the solve the following system of liner equations :

$$\begin{bmatrix} 5 & 2r & r \\ 1 & 6 & 2r-1 \\ 2 & r-1 & 2r \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 2 \\ 3 \\ 5 \end{bmatrix}$$

2. Write matlab programming for plotting

$$r^2 = 2 \cos 5t, 0 \leq t \leq 2\pi \text{ for } x = r \cos t, y = r \sin t$$

3. Prove that let f be (smooth) map on  $\square$ , and assume that p is a fixed point of f.

(a) if ,  $|f'(p)| < 1$ , then p is a sink

(b) if ,  $|f'(p)| > 1$ , then p is a source

F - 1499

[9]

4. Write about COBWEB PLOT.
5. Show that the map  $f(x) = 3x \pmod{1}$  on the real line exhibits positive Lyapunov exponents and chaotic orbits.
6. Write a matlab programming for Bifurcation diagram of the Gaussian map for  $\alpha = 20, -1 \leq \beta \leq 1$ .
7. State and prove Dulac's Criteria.
8. Investigate the stability of the critical points at the origin for the following systems:

$$\dot{x} = -y - x^3, \dot{y} = x - y^3 \text{ using the Lyapunov function } V(x, y) = x^2 + y^2.$$

9. Write about Multistability and Bistability?
10. Plot a bifurcation diagram for the planar system  $\dot{r} = r(\mu - 0.2r + r^4 - r^2), \dot{\theta} = -1$  and indicate the regions where the system is multistable and/or possible bistable using matlab.

[10]

**Section-D**

**(Long Answer Type Questions)**

**(2 marks each)**

**Answer the following questions in 175 words .**

1. Write a matlab programming for a straight-line (linear) fit.

**OR**

Write a matlab programming for least squares curve fitting.

2. Write about chaos in logistic map.

**OR**

Write about stability of fixed points.

3. Write a matlab programming for the iteration of the Henon map.

**OR**

Write about a Higher Dimensional Maps.

[11]

4. Sketch a phase portrait for the linear system

$$\dot{x} = -x - y, \dot{y} = x - y$$

**OR**

Write a matlab programming for plotting the phase portrait

of a non-linear system  $\dot{x} = y, \dot{y} = x(1 - x^2) + y$

5. Write a matlab program for Chua's Chaotic Attractor.

**OR**

Write about the Belousov-Zhabotinski Reaction.