

(8 pages)

Reg. No. :

Code No. : 5436

Sub. Code : WPHE 23

M.Sc. (CBCS) DEGREE EXAMINATION, APRIL 2025.

Second Semester

Physics

Elective – NONLINEAR DYNAMICS

(For those who joined in July 2023 onwards)

Time : Three hours

Maximum : 75 marks

PART A — (15 × 1 = 15 marks)

Answer ALL questions.

Choose the correct answer :

1. Which one of the following is an example of nonlinear dynamical system?
 - (a) damped harmonic oscillator
 - (b) three dimensional isotropic harmonic oscillator
 - (c) anharmonic oscillator
 - (d) both (a) and (b)

2. The presence of independent variable in the differential equation does not affect the _____ nature.

- (a) linearity
- (b) nonlinearity
- (c) linearity/nonlinearity
- (d) none

3. An example of autonomous systems is

- (a) driven pendulum
- (b) driven vander pol oscillator
- (c) driven linear oscillator
- (d) an exponential oscillator

4. The Kdv equation is

- (a) non linear dispersive wave equation
- (b) linear dispersive wave equation
- (c) linear non dispersive wave equation
- (d) all of the above

5. When a radio station broadcasts its signals, the electromagnetic energy from its transmitter radiates outward in an identical fashion is an example of
 - (a) linear dispersive wave
 - (b) linear nondispersive wave
 - (c) autonomous wave
 - (d) both (a) and (b)
6. A solitary wave which preserves its identity even after collision with another solitary wave is called
 - (a) proton
 - (b) electron
 - (c) soliton
 - (d) neutron
7. The tuning fork-like appearance of the bifurcation diagram is called
 - (a) Hopf bifurcation
 - (b) Saddle-node bifurcation
 - (c) Pitchfork bifurcation
 - (d) Transcritical bifurcation
8. In a subcritical Hopf bifurcation, the bifurcated limit cycle will be
 - (a) unstable
 - (b) stable
 - (c) either unstable or stable
 - (d) none

9. Which one is the last step in the quasiperiodic route to chaos?
 - (a) stable limit cycle
 - (b) stable equilibrium point
 - (c) quasiperiodic orbit
 - (d) chaotic orbit
10. In the bifurcation phenomena of the double well Duffing oscillator if the value of f is $0.355 < f < 0.3577$, the nature of solution is
 - (a) period T oscillation
 - (b) period $2T$ oscillation
 - (c) period $4T$ oscillation
 - (d) one band chaos
11. The term fractal was coined by
 - (a) Sierpinski
 - (b) Georg cantor
 - (c) Gaston Julia
 - (d) Mandelbrot
12. The dimension of Koch curve fractal is
 - (a) 1.2618
 - (b) 0.631
 - (c) 2.5
 - (d) 0.012

13. Light amplification in _____ glass fibers allows intercontinental communication at 10 billion bits per second.
- (a) Silica doped (b) Erbium-doped
(c) Germanium doped (d) zinc Doped
14. The ISM band operates at about
- (a) 1 MHz (b) 2.4 GHz
(c) 2.5 MHz (d) 3 Hz
15. A reliable and preferable cryptographic system can be obtained when the secret key k is
- (a) As random as possible
(b) Not smaller than the size of the message
(c) Available to both sender and receiver Simultaneously
(d) All of the above

PART B — ($5 \times 4 = 20$ marks)

Answer ALL questions, choosing either (a) or (b).
Each answer should not exceed 250 words.

16. (a) Discuss the free oscillations and damped oscillations of damped and driven nonlinear oscillators.
- Or
- (b) Write the stable node/star classification of equilibrium points.

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17. (a) Write a note on solitons.

Or

- (b) Show that the behavior of wave as a function of wave number in linear dispersive wave propagation.

18. (a) Write a note on limit cycle motion.

Or

- (b) What are bifurcations? Explain the saddle/node bifurcation.

19. (a) Explain the period doubling route to chaos in the Duffing oscillator.

Or

- (b) Write any four applications of fractals.

20. (a) Write a note on Chaos based communication.

Or

- (b) With the neat schematic diagram explain the soliton based -communication system.

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PART C — ($5 \times 8 = 40$ marks)

Answer ALL questions, choosing either (a) or (b)
Each answer should not exceed 600 words.

21. (a) Explain the various linear oscillators.
- Or
- (b) Explain forced oscillations, primary resonance jump phenomenon with the frequency response curve.
22. (a) Derive the general solution of Kdv equation
Cnoidal and solitary Waves.
- Or
- (b) Explain the backlund transformation with the necessary equations.
23. (a) Explain (i) discrete dynamical systems
(ii) how the logistic map is useful in the development of the theory of chaos.
- Or
- (b) What is strange attractor? Explain self-similar structure.

24. (a) Draw the mechanical model of the Duffing equation and explain the bifurcation scenario in Duffing oscillator.

Or

- (b) What is fractal? Explain the construction and properties of middle third cantor set and Koch curve.
25. (a) What is stochastic resonance? Explain with necessary equations and diagram.
- Or
- (b) Explain the elementary chaotic cryptographic system.
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