UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 5th Semester Examination, 2022

DSE-P2-PHYSICS

Time Allotted: 2 Hours　　　　　　　　　　　　　　　　　　　　　Full Marks: 40

The figures in the margin indicate full marks.

The question paper contains paper DSE-2A and DSE-2B.
The candidates are required to answer any *one* from *two* sections.
Candidates should mention it clearly on the Answer Book.

DSE-2A

APPLIED DYNAMICS

GROUP-A

1.　Answer any *five* questions from the following:　　　　　　　　$1 \times 5 = 5$

(a) Give an example of an autonomous system.

(b) Find the stable equilibrium point of a particle of mass *m* moving in a potential $V(x) = \frac{1}{2} ax^2 + \frac{1}{4} bx^4$, [*a*, *b* are +ve constants].

(c) For the differential equation $\dot{x} = \frac{1}{2r} x^2 - \frac{x}{r} - 1$, [*r* is a non-zero +ve constant], find the fixed points.

(d) Write down the Navier-Stokes equations explaining the terms involved.

(e) What do you mean by normal modes of oscillations?

(f) What is Reynold's number?

(g) State Lyapunov stability theorem.

GROUP-B

Answer any *three* questions from the following　　　　　$5 \times 3 = 15$

2.　Consider the differential equation $\dot{x} = -x^2 + x(1-r) + r$, $r > 0$ for this equation.

(a) Find the fixed points and their stability.　　　　　　　　　3

(b) Determine the potential function $V(x, r)$.　　　　　　　　　2

3.　For the system of differential equations $\dot{x} = -x^3 + y$, $\dot{y} = -ax - by$ (*a*, *b* > 0),　$1\frac{1}{2} + 2 + 1\frac{1}{2}$ show that (0, 0) is a fixed point. Also find the Jacobian and calculate eigenvalues of the fixed point (0, 0) as a function of *a* and *b*.

4. Use Euler's equation to show that the equation of the free surface of the liquid rotating with constant angular velocity, is a paraboloid of revolution. 5

5. Solve the system $\dot{x} = -x - 3y$, $\dot{y} = 2x$ and sketch the phase portrait. 3+2

6. What do you mean by a logistic map? Characterize the logistic map $x_{n+1} = rx_n(1 - x_n)$ for $0 \le x_n \le 1$ and $0 \le r \le 4$. 1+4

GROUP-C

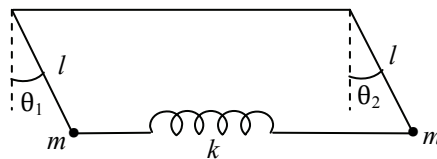**Answer any *two* questions from the following** $10 \times 2 = 20$

7. (a) What do you mean by critical points of a dynamical system? Obtain all critical points of the system $\dot{x} = \sin y$, $\dot{y} = \cos x$. 1+2

    (b) What is the meaning of linearization of a non-linear system? Linearize the system given in 7(a) about any suitable critical point obtained and hence find the equation of the phase path. $2+2\frac{1}{2}+2\frac{1}{2}$

8. (a) Consider the predator-prey system $\dot{x} = x\{x(1-x) - y\}$, $\dot{y} = y(x - a)$, $0 < a < 1$. Find the fixed points and hence justify the statement that a state exists where the predator goes extinct and the prey is still alive. 2+3

    (b) Consider the following set of differential equations: 2+3

    $$\dot{x} = -x + y + xy, \quad \dot{y} = x - y - x^2 - y^3.$$

    Show that the system has one fixed point. Hence prove that this fixed point is stable by applying a Lyapunov functional of the form $V(x, y) = ax^2 + 2y^2$, $a > 0$.
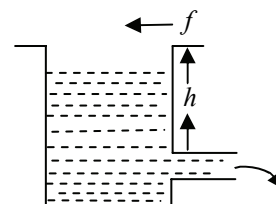
9. (a) Deduce the eigenvalue equation for small oscillation. 3

    (b) Find the frequencies of small oscillations of a parallel pendulum as shown: 5

    (c) Distinguish between rotational and irrotational motions of fluid. 2

10. (a) Derive an expression for the equation of continuity of a fluid. 4

    (b) A vessel of rectangular cross-section containing water is moving with a constant acceleration f and water is coming out from the hole. Find the velocity of efflux of water when the height of the water column is h above the hole. 4

    (c) What do you mean by a Hamiltonian system in two dimensions? 2

DSE-2B
ATMOSPHERIC PHYSICS
GROUP-A

1. Answer any *five* questions from the following: 1×5 = 5

   (a) What are Rossby waves?

   (b) What are atmospheric gravity waves (AGW)?

   (c) Write down two applications of the basic equations of atmospheric flow.

   (d) What do you mean by effective temperature of the earth?

   (e) Mention one difference between the general circulation and the mesoscale circulation.

   (f) What is the difference between cyclones and anticyclones?

   (g) What do you mean by Rayleigh scattering?

   (h) What is 'return signal'?

GROUP-B

Answer any *three* questions from the following   5×3 = 15

2. What is a LIDAR? Describe how it is used to study atmospheric phenomenon.   5

3. Write a short note on land breeze and sea breeze.   5

4. What are aerosols? Classify them and write down their properties. How do the aerosols effect our health?   1+3+1

5. (a) What do you mean by scale analysis in atmospheric dynamics?   1

   (b) What are the conservation laws that are useful to atmospheric dynamics?   2

   (c) Explain different types of clouds.   2

6. Derive radar range equation.   5

GROUP-C

Answer any *two* questions from the following   10×2 = 20

7. (a) Describe the vectorial form of the momentum equation in rotating co-ordinate system.   7

   (b) Write a short note on green-house effect.   3

8. (a) What do you mean by the term 'meteorology'? Describe various types of meteorological instruments.   4

   (b) Describe various types of fronts.   6

9. (a) Describe various types of atmospheric radars in brief.　　　　　　　　3

　(b) Write down the applications of radars and describe how they are used to study atmospheric phenomenon.　　　　　　　　7

10.(a) Describe spectral distribution of solar radiation.　　　　　　　　2

　(b) What is the effect of aerosols on solar radiation?　　　　　　　　2

　(c) Explain the process of absorption and scattering of solar radiation in the atmosphere.　　　　　　　　6

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