'समानो मन्त्रः समितिः समानी'

UNIVERSITY OF NORTH BENGAL

B.Sc. Honours 5th Semester Examination, 2023

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: 1×5 = 5

   (a) Define an autonomous dynamical system.

   (b) Check whether the system $\dot{x} = -y,\ \dot{y} = x$ is conservative or not.

   (c) Find the nature of the fixed point $x = 0$ in case of $\dot{x} = \sin x$.

   (d) Define fractals.

   (e) For which $a > 0$, the solutions of the equation $\ddot{x} + \alpha x e^{-at} = 0$, oscillates on $[0, 2\pi]$, α being a non-zero real constant?

   (f) What is the physical significance of Reynold's number?

   (g) Define incompressible fluid flow.

   (h) What is a strange attractor?

GROUP-B

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

2. (a) An oscillator is described by the equation $\ddot{x} - k(1 - x^2)\dot{x} + \omega^2 x = 0$. Convert it to a dynamical system and check whether it is dissipative or not. 2

   (b) Graph the potential for the system $\dot{x} = x - x^3$ and identify all the equilibrium points. 3

3. (a) Consider the map $x_{n+1} = \cos x_n$ which has a fixed point at $x \approx 0.74$. Check analytically that the fixed point is stable and hence show graphically how the stable point is approached if one starts from a nearby point. 3

(b) Draw the phase-space trajectory of a free electron with mass '*m*' in 1-D in absence of any damping. 2

4. Consider the two dimensional dynamical system $\dot{x} = y,\ \dot{y} = x$. 1+2+2

(i) Write down the fixed point and the stability matrix.

(ii) Determine the eigenvalues of the stability matrix and hence comment on the nature of the fixed point.

(iii) Find the eigen directions and draw the flow-lines w. r. t. these directions.

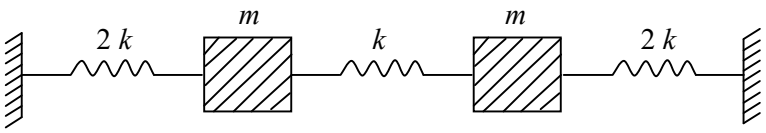
5. (a) The velocity components in a fluid flow are given by 2+1

$$u = x^2 + z^2 \quad , \quad v = y^2 + z^2 \quad , \quad w = -2z(x + y)$$

Show that the flow is possible indeed. Examine whether the flow is rotational or not.

(b) Write down the Navier-Stokes equation and explain the terms involved. 2

6. (a) Two blocks, each of mass '*m*' are fixed with springs as shown in the below fig: 3



The spring constant of the springs are mentioned in the fig. If the blocks, execute small amplitude oscillation on a frictionless surface, find the corresponding normal mode frequencies of the system.

(b) Verify that the system $\dot{x} = y,\ \dot{y} = -x + y + x^2 + y^2$ has no periodic solutions. 2

GROUP-C

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

7. (a) Find a Hamiltonian for the undamped oscillators given by the equation of motion, $\ddot{x} + \sin x = 0$. Hence, calculate the fixed points of the system and sketch the corresponding phase portrait. 2+2+1

(b) Locate the critical point and find its nature for the system $\dot{x} = x + y$, $\dot{y} = x - y + 1$. Also, find the equation for the phase path of the system. 1+2+2

8. (a) For the map $x_{n+1} = 3.3x_n(1 - x_n)$, determine the fixed points and investigate their nature. 2+2

(b) Draw $\dot{x}$ vs x for the one-dimensional dynamical system $\dot{x} = r + x^2$ for $r = 1$, $r = 0$ and $r = -1$. Hence determine the nature of the fixed points for each of the case. 3+3

9. (a) What is Euler's equation of motion for an ideal fluid? Starting from Euler's equation of motion, deduce Bernoulli's equation of motion for an incompressible irrotational fluid flow. 1+4

(b) A tube has diameters of 2 cm at one point and of 1 cm at a level 40 cm below the first. The flow rate of water through the tube is 30 cc/sec. What is the pressure difference (in cm) of water between the two levels? Assume streamline flow of water. 3

(c) Explain whether the velocity of an ascending gas balloon will increase or decrease or remain constant. 2

10.(a) Consider a system of particles executing small oscillations in a conservative force field around an equilibrium point. Find out the expression of potential energy, when expressed in terms of normal co-ordinates. 4

(b) Classify the fixed point at the origin for the system $\dot{x} = -y + ax^3$, $\dot{y} = x + ay^3$, for all real values of the parameter a. 4

(c) If $\dot{x} = rx - x^3$ is cast in the form $\dot{x} = -\frac{1}{\Gamma}\frac{dV}{dx}$, then identify $V(x)$ and plot it for $r > 0$. 2

DSE-2B

ATMOSPHERIC PHYSICS

GROUP-A

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

(a) Write down the radar range equation.

(b) State the principles of radiometry.

(c) What is solar constant?

(d) Why does the coriolis force is called “apparent force”?

(e) What are the ‘stratus’ clouds?

(f) Write down the three dimensional vorticity equation.

(g) Define minimum detectable signal in radar system.

(h) Why is vorticity a vector quantity but circulation a scalar quantity?

GROUP-B

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

2. What is Lapse rate? Is it positive or negative in the troposphere? Find an expression for adiabatic Lapse rate. Plot a graph to show how atmospheric stability is related to adiabatic Lapse rate. $1\frac{1}{2}+2+1\frac{1}{2}$

3. (a) Why is the centrifugal force called apparent force? If an air parcel moves from west to east, in what direction coriolis force will be acting? Explain in each hemisphere. 1+2

(b) What do you understand by surface and body forces? 2

4. (a) What do you understand by potential temperature? If an air parcel is at a pressure level of 900 hPa where the air temperature is 300 K, then what will be the value of potential temperature? 1+2

   (b) Why does the sea breeze flow from ocean to land? Explain with proper diagram. 2

5. What do you mean by general circulations? Describe the causes for general circulations of the atmosphere. How do these circulations effect the oceans? 1+3+1

6. Describe radiative forcing of aerosols in detach. 5

GROUP-C

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

7. (a) What are anemometers and radiosonde in meteorology? Mention 2 applications of each. 4

   (b) Establish the equation of propagation of atmospheric gravity waves in a non-homogeneous medium. 6

8. (a) What are different types of aerosols? How are they produced in the atmosphere? Why are these harmful to human health? What measures can be take to remove aerosols from the atmosphere? 1+2+1 $\frac{1}{2}$ +2

   (b) What do you mean by optical phenomena in the atmosphere? Briefly explain the following phenomena: $3\frac{1}{2}$

   (i) sundog or mock sun (ii) halo.

9. (a) Describe the expression for power received by radar. 5

   (b) Why do we need to add the apparent forces in the second law of motion when dealing with atmospheric motion? 2

   (c) What is the concept of effective temperature? Define green house effect in terms of effective temperature. 3

10. (a) Establish the hydrostatic balance equation. 4

    (b) Write a short note on ionosphere. 3

    (c) A typical lapse rate for the atmosphere is $\gamma = 6.5$ K/km. The troposphere is defined by a temperature profile 3

    $$T(z) = T_0 - \gamma z$$

    with surface temperature $T_0 = 288.2$ K, $z =$ geographical height.

    A dry air parcel at $z = 0$ is made to lift rapidity over a hill of 1000 m high. Estimate the difference in temperature between the parcel and the environment at the top of the hill.

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