RAMANASRI
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Mechanics & Fluid Dynamics

IFoS (IFS) Previous Year Questions (PYQ) from 2025 to 2009

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IAS, UPSC, IFS, IFoS, CIVIL SERVICE MAINS EXAMS MATHS OPTIONAL STUDY MATERIALS

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2025

1. Derive Lagrange's equation for a particle of mass m sliding on a frictionless wire hanging as a cycloid $x = a(\xi - \sin\xi)$, $y = a(1 + \cos\xi)$. If $\cos\xi = f$, transform the equation to the stated form. **[8 Marks]**

2. Prove the equation of motion of a homogeneous inviscid liquid under forces from a potential V in vector form. For the given cylindrical velocity field, prove the stated vorticity. **[8 Marks]**

3. A uniform rod of length $2a$ and mass m rotates freely about a fixed end. Find the least angular velocity from the lowest position to reach the top and complete a revolution, and find the time consumed. **[15 Marks]**

4. A long infinite cylinder of radius a is placed in a uniform stream with circulation 2κ. Find the complex velocity potential and show using Blasius theorem that the cylinder experiences uplift. **[15 Marks]**

5. A simple source of strength m is fixed at the origin in a uniform incompressible stream of velocity $U\mathbf{i}$. Find the velocity potential, streamlines, and show they lie on $Ur^2\sin^2\theta - 2m\cos\theta =$ constant. **[10 Marks]**

2024

6. For an unsteady three-dimensional flow with velocity components $u = \frac{x}{1+t}$, $v = \frac{y}{1+t}$, $w = \frac{z}{1+t}$, describe the streamlines and pathlines. **[8 Marks]**

7. Is a system of two particles connected by a rod of constant length holonomic? Justify your answer. **[8 Marks]**

8. Derive Hamilton equations for holonomic systems and use them to discuss the motion of a simple pendulum. **[15 Marks]**

9. For inviscid incompressible flow with velocity $\mathbf{q} = \left(x, \frac{y}{1+t}, \frac{z}{2+t}\right)$ under body force $\mathbf{F} = -gz\mathbf{k}$, find the pressure at (x, y, z) if $p(0, 0, 0) = p_0$. **[15 Marks]**

10. Consider a source and a sink of equal strength at points $(\pm a, 0)$ within a fixed circular boundary $x^2 + y^2 = a^2$. Determine the streamlines. **[10 Marks]**

2023

11. For a particle of mass m moving in a plane under attractive force directed to the origin, using polar coordinates write the Lagrangian, derive equations of motion and show angular momentum is conserved. **[8 Marks]**

12. In a two-dimensional flow with equal sources at $(a, 0)$, $(-a, 0)$ and equal sinks at $(0, a)$, $(0, -a)$, determine the stream function and show that the circle through the four points is a streamline. **[8 Marks]**

13. For a dynamical system with two degrees of freedom and given Lagrangian, find the Hamiltonian, derive Hamilton equations, show one generalized momentum is constant and the system is SHM in q_2. **[15 Marks]**

14. For steady two-dimensional Navier–Stokes equations, show that there exists a stream function $\psi(x, y)$ and find the equation satisfied by ψ. **[15 Marks]**

15. There is a doublet at $(c, 0)$ in a two-dimensional flow. A cylinder of radius a $(a < c)$ with z-axis as axis is introduced. Find the complex potential and image system. **[10 Marks]**

2022

16. A rod of length $2a$ revolves with uniform angular velocity ω about a vertical axis through a smooth joint at one end, describing a cone of semi-vertical angle α. Prove the stated angle made by the reaction at the hinge. **[8 Marks]**

17. If velocity of an incompressible fluid at (x, y, z) is $(-Ay, Ax, 0)$, prove that surfaces orthogonal to streamlines exist and are planes through the z-axis, although velocity potential does not exist. Discuss the flow. **[15 Marks]**

18. Verify that $w = ik \log\left(\frac{z-a}{z+a}\right)$ is the complex potential of a steady fluid flow about a circular cylinder with $y = 0$ as a rigid boundary, and find the downward force per unit length. **[15 Marks]**

19. A particle of unit mass is projected with total energy h in a force field of potential $\phi(r)$. Using energy and least action, derive the differential equation of its path as given in the paper. **[15 Marks]**

2021

20. Examine the motion of a particle sliding on a parabolic wire $x^2 = ay$. **[8 Marks]**

21. Verify whether the motion given by $\mathbf{q} = (3x\mathbf{i} - 2y\mathbf{j})xy^2$ is a possible fluid motion. If so, decide whether it is potential and find streamlines and potential or angular velocity. **[15 Marks]**

22. Discuss the flow given by the complex potential $w = \log\left(z - \frac{a^2}{z}\right)$. Draw sketches of streamlines and explain the flow directions. **[15 Marks]**

23. Derive Lagrange's equations for a spherical problem. **[15 Marks]**