

TOPICS

A.) Hamiltonian Mechanics

- a.) Formulation of Hamiltonian Mechanics, Derivation of Eikonal Theory, Liouville's Theorem
- b.) Hamilton-Jacobi Theory, Integrability, Semi-Classical Limit of Quantum Mechanics
- c.) Adiabatic Invariants
- d.) Poisson Brackets
- e.) Canonical Transformations, Transition to Quantum Mechanics
- f.) Formal structure of Hamiltonian Mechanics of fields

B.) Basic Continuum Mechanics

i.) Strings and Membranes

- a.) String Lagrangian, Hamiltonian, EOMs
- b.) D'Alembert's Solution
- c.) Energy Flux, Energy and Momentum Density, Balance Theorems
- d.) Eigenfunctions, Variational Principles, Green's Function, Perturbation Theory
- e.) Membranes-Formulation and examples

ii.) Basics of Fluid Dynamics

- a.) Conservation Laws and Ideal Fluid Equations, Viscous Fluids
- b.) Vorticity, Induction Equation, Kelvin's Theorem
- c.) Potential Flow, Induced Mass
- d.) Surface Waves – Basic model, dispersion relation
- e.) Wave Patterns, Stationary Phase, etc.

iii.) Hydrodynamic Stability – An Introduction

- a.) Basic Ideas on Stability
- b.) Ideal Examples: Rayleigh-Taylor Instability, Kelvin-Helmholtz Instability
- c.) Convection-Schwarzschild Criterion

iv.) Acoustics

- a.) Sound Waves
- b.) Eikonal Theory, Ray Equations
- c.) Green's Function, Helmholtz Integral
- d.) Acoustic Radiation – Oscillating Sphere
 - Piston
- e.) Diffraction, Scattering – Kirchoff Approximation
 - Scattering by Cylinder
- f.) Shocks – Traffic Flow
 - Gas Dynamics (introduction)

v.) Non-Ideal Fluids – the Role of Dissipation

- a.) Heat Conduction
- b.) Viscous Fluids

C.) Selected Topics in Statistical Dynamics

i.) Brownian Motion, Langevin Equation

- a.) Langevin Equation, concept of Random force
- b.) Diffusion, Drag, Einstein Relations, Fluctuation-Dissipation Theorem
- c.) Fokker-Planck Equation, Smoluchowski Equation, applications

ii.) Boltzmann Equation, Kinetic Theory

- a.) Boltzmann Collision Operator
- b.) Boltzmann Equation, H-theorem
- c.) Transport coefficients-Simple Examples
- d.) From Boltzmann to Fokker-Planck

D.) Selected Topics in Nonlinear Dynamics (Time Permitting)

i.) Simple Nonlinear Oscillators

- a.) Duffing Oscillator
- b.) Forced Duffing Oscillator, Mode Jumping Bifurcations
- c.) Equation and Limit Cycles Van-der-Pol

ii.) Lorenz system

- a.) Formal Theory of Rayleigh-Benard Instability
- b.) Lorenz Model: Derivation
- c.) Lorenz Model: Analysis

iii.) Logistics, Logistic Fronts

- a.) Simple Ideas on Lotka-Volterra Systems
- b.) Logistic System, Logistic Map, Period Doubling
- c.) Fisher Equation, Fisher Fronts