（VI） Syllabus on Mathematical Physics

1. Classical mechanics

Lagrangian formalism: inciple of least action, Euler-Lagrangian equation, Noether theorem, Kepler problem, rigid body

Hamiltonian formalism: Hamilton's equation, Poisson bracket, Liouville's theorem, canonical transformation, Hamilton-Jacobi theory

Reference: Landau and Lifshitz, Mechanics
Goldestine, Classical Mechanics

2. Electrodynamics

Electrostatics and magnetostatics: fields, potentials, charges, electric and magnetic fields in matter,

Electrodynamics: Coulomb's law, Lorentz force law, Ohm's law, Faraday's law, Gauss's law, Maxwell's equation, conservation laws, electromagnetic waves, radiation

Basic methods: the method of images, separation of variables, multipole expansion

Reference: Grifiths, Introduction to electrodynamics

3. Thermodynamics and statistical physics

Fundamental principles of thermodynamics, thermodynamic potentials and processes, phase equilibrium and phase transitions, partition function, entropy

Probability theory, the microcanonical, canonical and grand-canonical ensembles, The Boltzmann, Bose and Fermi statistical distributions

Examples: ideal gas model, paramagnet, ideal quantum gases, degenerate Fermi systems; photons and phonons; Bose–Einstein condensation.

Reference: Mehran Kardar, Statistical physics of particles

4.Quantum mechanics:

Fundamental concepts: Hilbert space, states, observables, wave functions, Schrodinger equation, Schrodinger and Heisenberg pictures, canonical quantization, density matrix.

Examples: harmonic oscillator, hydrogen atom model, potential well problems

Symmetry in quantum mechanics， angular momentum, spin, identical particles, and atomic structure.

Perturbation theory, scattering, approximation method

Reference: JJ.Sakurai Mordern quantum mechanics

5. General relativity:

Differential geometry: metric, vector, tensor, differential forms, manifold, connections, curvature, geodesic, tetrads, Lie derivatives, isometries and Killing vectors.

Gravitation: the principle of equivalence, Einstein's equation, Hilbert-Einstein action.

Exact solutions: Minkowski, de Sitter, anti-de Sitter spacetimes, and black hole solutions

Causal structure

References:

Sean Carroll: Spacetime and Geometry: An Introduction to General Relativity

Robert M. Wald: General relativity

6. Quantum field theory:

Classical field theory: Lagrangian and Hamiltonian formalism, Noether's theorem

Quantization: canonical quantization and path integrals

Fermions: representations of Poincare group, Dirac equation

S-matrix: LSZ reduction, Feymann propagator, Feymann rules, normal ordering, Wick’s theorem, the optical theorem, locality

Renormalization: regularization and cutoff, counter terms, renormalization group

References:

Michael E. Peskin and Daniel V.Schroeder: An Introduction To Quantum Field Theory

S. Weinberg: The quantum theory of fields, Vol 1,2