Syllabus

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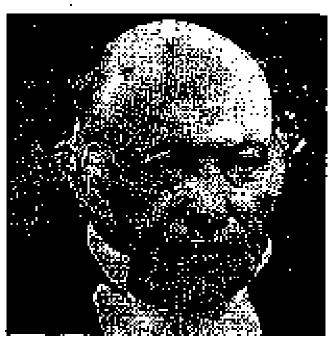
PHYSICS 711, CLASSICAL THEORETICAL PHYSICS - DYNAMICS

The course is divided into three units with different themes and emphases: Unit 1, LAGRANGIAN MECHANICS; Unit 2, SYMMETRY TRANSFORMATIONS, ROTATIONS, AND RELATIVITY; and Unit 3, HAMILTONIAN MECHANICS.

Joseph-Louis Lagrange
1764



William Rowan Hamilton
1834

Amalie Emmy Noether

UNIT 1: LAGRANGIAN MECHANICS

Week	Lec.	Date	Subjects
1	1	Sept. 3	**Chap. 1.** D'Alembert's principle, constraints on motion, Lagrange's equations.
	2	5	Lagrange's equations, the Lagrangian function, examples.
2	3	Sept. 8	Change of variables in the Lagrangian, examples; integrability of Lagrange's equations.
	4	10	Velocity-dependent forces. **Chap. 2.** Variational principles, Euler's equations, the brachistochrone problem.
Hw. 1	5	12	Geodesics, examples; Hamilton's principle, the Euler-Lagrange equations.

3	6	Sept. 15	Integral constraints, Lagrange multipliers; nonholonomic constraints, elimination of differential constraints using multipliers.
	7	17	Integrability conditions for differential constraints; examples of constrained systems, Lagrangian constraints.
Hw. 2	8	19	Constants of the motion, symmetries, and Noether's theorem.
4	9	Sept. 22	Examples of symmetries; time translations and the Hamiltonian.
	10	24	**Chap. 3.** Two-body problems: symmetries, orbit and time equations; *n* bodies.
Hw. 3	11	26	Qualitative description of two-body motion, Kepler problem, scattering.
5	12	Sept. 29	Extra symmetries for the Kepler problem (the Laplace vector) and the *n*-dimensional isotropic oscillator; the virial theorem.
	13	Oct. 1	**Chap. 6.** Small oscillation problems, motions near equilibrium, quadratic Lagrangians, characteristic frequencies of oscillation.
Hw. 4	14	3	Transformation to normal coordinates, examples; symmetries, uniform motions and "zero modes".
6	15	Oct. 6	Examples of oscillation problems; motions near a steady motion; stability of motion, Lyapunov indices.
			END OF UNIT 1, START UNIT 2
	16	8	**Chap. 4.** Rotations, direction cosines, representation of rotations by orthogonal matrices, properties.
Hw. 5	17	Oct. 10	Matrix algebra, transformations of matrices, diagonalization; reflections; examples for rotations.

Leonhard Euler
1736

Albert Einstein

UNIT 2: SYMMETRY TRANSFORMATIONS, ROTATIONS AND RELATIVITY

Week	Lec.	Date	Subjects
7	18	Oct. 13	**HOUR EXAM IN CLASS ON THE MATERIAL IN UNIT 1, CHAPS. 1-3, 6**
	19	15	Euler angles, fixed and moving axes, matrix representations of Euler rotations.
	20	17	SU(2) representation of rotations, spinors; the groups SU(2) and SO(3), group generators, exponential representations.
8	21	Oct. 20	Infinitesimal rotations and angular velocity; angular velocities for Euler rotations, body and space axes.
	22	22	Rotating coordinates, Coriolis forces; applications.
Hw. 6	23	24	**Chap. 5.** Rotating rigid bodies, **I**, **L**, T; calculation of the moment tensor, Euler's equations of motion.
9	24	Oct. 27	Free rotation, partially rotating coordinates, examples and applications.
	25	29	Poinsot construction, symmetrical rotator, qualitative description of the motion.
Hw. 7	26	31	Symmetrical top, equations of motion, precession, nutation, examples.
10	27	Nov. 3	**Chap. 7. Relativity**, Lorentz transformations, invariants, metric tensor, matrix representation, matrix generators of the Lorentz group.
	28	5	Hyperbolic geometry: boosts, rapidities, and addition of velocities; SL(2,C) representation of Lorentz transformations.
Hw. 8	29	7	Differential operators and the wave equation; the light cone and geometry; particle motion, world lines, four velocities, kinematics, and Wigner rotations.
11	30	Nov. 10	Relativistic particle Lagrangian, conservation laws; electromagnetic interactions, other examples, the no-interaction theorem.
			END OF UNIT 2, START UNIT 3
	31	12	**Chap. 8.** Legendre transformations and Hamilton's equations of motion, interpretation of Hamilton's equations, examples.
Hw. 9	32	Nov. 14	Variational principle for Hamilton's equations; motion near a steady motion, examples.

Simeon Denis Poisson
1808

Karl Gustav Jakob Jacobi
1843

Henri Poincaré
1880

UNIT 3: HAMILTONIAN MECHANICS

Week	Lec.	Date	Subjects
12	33	Nov. 17	**HOUR EXAM IN CLASS ON THE MATERIAL IN UNIT 2, CHAPS. 5, 7**
	34	19	**Chap. 9.** Canonical transformations, invariance of Hamilton's equations, examples using canonical transformations.
	35	21	Symplectic transformations, structure of Hamiltonian mechanics; the variational principal and generating functions for canonical transformations.
13	36	Nov. 24	Examples; symplectic invariants, Poisson and Lagrange brackets, tests for canonical transformations.
Hw. 10	37	26	Infinitesimal canonical transformations; time development as a canonical transformation; canonical transformations and symmetries, generators of continuous transformations.
			THANKSGIVING RECESS, Nov.27-30
14	38	Dec. 1	Noether's theorem, symmetry algebras and constants of the motion, examples.
	39	3	**Chap. 10.** Hamilton-Jacobi theory, separation of variables in the Hamilton-Jacobi equations, applications.
Hw.11	40	5	Action and angle variables, phase plots, applications.
15	41	Dec. 8	**Chap. 12.** Linear chain, continuum limit and the classical scalar field, the Lagrangian density $\mathcal{L}$ and Hamilton's principle for fields.
	42	10	Euler's equations for fields, boundary conditions; examples of classical fields; vibrating membranes.
Hw. 12	43	12	Relativistic fields, Lorentz invariance of $\mathcal{L}$, symmetries; **A** and **F**, electromagnetic Lagrangian, Maxwell's equations
			END OF UNIT 3
Final		Dec. 17	**FINAL EXAM TUESDAY, DECEMBER 16, 12:25 pm, EMPHASIS ON UNIT 3**

WINTER RECESS DECEMBER 22-JANUARY 11.

SECOND SEMESTER: FIRST CLASS ON TUESDAY, JANUARY 20
PHYSICS 722 STARTS WEDNESDAY, JANUARY 21