

Classical Mechanics Syllabus:

Day 1: Introduction to classical mechanics – short history. Basic concepts of force, motion, mass and units of physical quantities used in laws of motion. Quick survey of laws of motion.

Day 2. Set up of all three laws of motion and introduction to Newton's Laws. Implications of Newton's laws, idea of inertial frame of reference and motion as momentum. Examination of $F=p'$ (derivative of momentum) and third law: $F_{(ij)}=-F_{(ji)}$. Full analysis of all three laws of motion and some problems related to them including motion down an inclined plane and some Tension/String/Pulley type problems

Day 3: Introduction of conservation of energy. $F=ma$ continued, Concept of work as an integral quantity. $F.dr=dW$ and integrating around integrals with one example using vector calculus and study of line integrals/paths of integration.

Day 4: Trip to Millipark

Day 5: Continue with definition of work as line integral and conservative fields – meaning of conservative and non-conservative force fields. How the definition of work arises out of integrating $T=1/2 mv^2$. Also, around a closed curve the line integral gives 'zero' signifying a conservative field. Examples and several line integral problems worked out showing path independence.

Day 6 Curl of a conservative force field is zero. Why? Proof. Idea of potential, and potential energy of a force field and their difference. Motion in a general one dimensional potential including calculations of stability and equilibrium.

Day 7 More on momentum. Conservation of momentum. Angular momentum revisited. Some examples using vector calculus. Single and multi component systems

Day 8 Circular motion, Uniform circular motion, Centripetal acceleration, Simple Harmonic motion, conical pendulum damped oscillatory motion

Day 9 More examples from Day 8 on this topic leading to planetary motion

Day 10 Calculus of variations – introduction to famous problems like the ‘Brachistochrone’. Fermat’s principle and use of it for proofs of Snell’s law and problems arising out of them. Motivation: idea behind ‘extremalising’

Day 11 Holiday – Milli Park

Day 12 Lagrange’s formulation introduction: Principle of least action. Changing coordinate systems – generalized coordinates

Day 13. Setting up for Hamiltonian dynamics. Suggestions and more equations. Generalised momenta, Conditional variation including the lagrange multiplier method – catenary. What is the meaning of constraint. How does Hamiltonian formulation help us?

Day 14 Constrained Lagrangian using Hamilton’s formulations – deeper into Hamiltonian physics – Spring coupled masses: using matrix notation.

Day 15 Derivation of Hamilton’s equations using Symplectic Geometry – (Ferit’s guest lecture on Symplectic geometry and how it links up with the physics laws). Hamilton’s equations and the link to classical and quantum formalisms.

Day 16 How Symplectic geometry fits into all the previous derivations through physics – exploitation of the idea of phase space. Treating the Hamiltonian flow in phase space and illuminating its symplectic nature. Introduction to Poisson brackets and a full illustration of what that means in physics and in the context of other topics. Principle of least action for Hamiltonian methods. Introduction to a problem set.

Day 17 Canonical transformations in Hamiltonian method. Hamiltonian Jacobi equation and its implications – links to Noether’s theorem brief comment.

Day 18 Further discussion of symplectic geometry in the language of classical mechanics; thereby firmly establishing the link between classical and quantum mechanics smoothly. Brief discussion of how ‘everything’ covered in the syllabus fits in together. Liouville’s theorem in classical mechanics. ‘Continuity equation in classical mechanics’. Test of time independence for the Hamiltonian in the notation of Poisson

Brackets.

Day 18 Holiday

Day 19 How everything connects together – problem sets and inspecting them. Introduction to quantum mechanical notation in the light of classical mechanics. Where and how classical mechanics, through the language of symplectic geometry creates a bridge between quantum and classical mechanics.

Day 20 Last day of classes: Continue with problem sets and wrap up – guest lecture with Prof. Omur Akyuz in the beginnings of quantum mechanics at 10am.

- Problems set everyday – to be discussed in class the following day
- References: Lecture notes on Classical Mechanics by David Tong (Cambridge)
- Further Reference: Lecture notes by James Binney on Classical Mechanics
- Books: Mechanics by Landau and Lifshitz; Symplectic Geometry and Quantum Mechanics by Maurice de Gosson

Thank you for your invitation and hospitality at mathematics summerschool, Sirince.

Dr. Ashna Sen
Department of Mathematics
Brockwood Park
Hampshire, SO24 0LQ,
United Kingdom

ashnasen@yahoo.co.uk