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Classical Mechanics (Phys 508)

Course Plan

Classical mechanics is an essential, and perhaps the most fundamental discipline in modern advanced physics. This course contain almost all the major ideas and techniques that are used in advanced theoretical physics. This course is **three hours per week** and taught for fifteen weeks. The subjects that wil be taught and the assignments are enlisted the following table

Week	Subject(s)	Assignments	Discover
1	Introduction to classical mechanics, Motion in space and the mathematics of curves in space, Introduction to differential geometry and tensors, the metric. Basic notions in differential geometry	Study different types of tensors used in physics	Further reading: Manifolds and curvilinear coordinates. Covariant calculus.
2	Coordinates transformation, vector calculus, dealing with indicies	Solve problem set 1	Using Mathematica with vector calculus
3	Curvilinear coordinate systems, more on differential geometry	Cont. Problem set 1	Lagrangian formalism of quantum mechanics and path integrals.
4	Elements of differential geometry, curvature	Problem set 2	The curvature of spacetime.
5	Constructing equations of motion, the Lagrangian and stationary action principle(s).	Problem set 3	Hamilton Jacobi equation
6	Application to Lagrangian mechanics, Neother's theorem	Cont. Problem set 3	Symmetric in modern physics Wigner's theorem in quantum mechanics.
7	Symmetries and conservation laws, Neother's theorem (Translational symmetry, rotational symmetry, boost symmetry)	Revision on special relativity	Minkowski space, Poincaré group of transformations.

Week	Subject(s)	Assignments	Discover
8	Relativistic dynamics, constructing a Lagrangian who has Lorentz or Poincaré symmetry.	Problem set 4	Polyakov (string) action.
9	Hamiltonian mechanics, canonical transformations	Problem set 5	Relativistic Hamiltonian mechanics
10	Applications to Hamiltonian mechanics, Phase space and Poisson algebra	Cont. Problem set 5	Phase space and differential geometry
11	Classical Field theory	Problem set 6	More on strings as 1D field theory.
12	Symmetries in Field theory and relativistic field theory.	Index gymnastics, dealing with indices.	Conformal symmetry in field theory
13	Examples of classical fields Maxwell field and General Relativity.	Problem set 7	Curved space-time and gravity.
14	Gauge invariance in fields	Cont Problem set 7	Non-Abelian gauge fields.
15	Revision and presentations	NA	NA.

These are the main topic covering almost all branches of theoretical physics. This is only an introductory course to these concepts. All students are encouraged to discover this topic further. This can be done by following the discover section. And then present one selected topic from there in an open discussion session in the week 14 and 15 . This will be a part of grading. Another part of grading will go to solving problem sets. There are 7 problem sets. And three reports to be written on some selected topics. Making a total of 10 assignments. There is also two mid terms done during the studying weeks. Moreover a final examination held after week 15. This course is based on research and thorough interaction between the instructor and students. Discussion and thought experiments are key aspect in achieving the goal of this course.

The following books are recommended references.

- Finn, J. Michael. Classical mechanics. Jones & Bartlett Publishers, 2009.
- Bagchi, Bijan. Advanced Classical Mechanics. CRC Press, 2017.
- Goldstein, Herbert. Classical mechanics. Pearson Education India, 2011.

Other references are recommended for the ' discover' section

- Tu, Loring W. An introduction to manifolds. Springer Science & Business Media, 2010.
- Nakahara, Mikio. Geometry, topology and physics. CRC Press, 2003.
- Arnol'd, Vladimir Igorevich. Mathematical methods of classical mechanics. Vol. 60. Springer Science & Business Media, 2013.
- Dittrich, W., M. Reuter, and M. Mobius. "Classical and Quantum Dynamics from Classical Paths to Path Integrals." (1996) 594.

Please ask me if you could not find any of the above references, or you feel you need more reference.

Dr Salwa Alsaleh