PHY-920 Classical Field Theory

Credit Hours: 3+0

Prerequisite: None

Course Objectives: To introduce students to the methods of classical field theory. This course will be useful for the students who wants to do research in theoretical physics. The techniques which student will learn in this course can applied in different fields, such as theoretical high energy physics, General relativity and cosmology, Theoretical condensed matter physics, Quantum optics and quantum information.

Core Contents: Review of Special relativity, Covariant formalism of electrodynamics, Introduction to gravitational field in relativistic framework, Introduction to curvature tensor.

Detailed Course Contents: Postulates of Special relativity, Lorentz transformation, Four vector notation, Invariant interval, The principle of least action, Energy and momentum using four-vector notation, The electromagnetic field tensor, Lorentz transformation of electromagnetic field, Invariance of electromagnetic fields, The equation of continuity, The second pair of Maxwell's equations, Energy density and energy flux, The energy momentum Tensor, The energy momentum tensor of the electromagnetic field,The energy momentum Tensor, The energy momentum tensor of the electromagnetic field, The retarded potentials, The Lienard-Wiechert potentials, Spectral resolution of the retarded potentials, The Lagrangian to terms of the second-order, Gravitational fields in non-relativistic mechanics, The gravitation field in relativistic mechanics, Curvilinear coordinates

Course Outcomes: On successful completion of this course, students will be able to understand

- Special theory of Relativity
- Variational approach in physics
- Maxwell equation in covariant formalism.

- Relativistic version of gravitation field

Textbook: Landau and E. M. Lifshitz, The Classical Theory of Fields, Butterworth Heinmann 1975. (referred as LL)

Reference Books: John David Jackson, Classical Electrodynamics, John Wiley and Sons 1998.

Weekly Breakdown		
Week	***Section***	***Topics***
1.	Handouts LL 2,3, 8,9	Postulates of Special relativity, Lorentz transformation, four vector notation, Invariant interval, The principle of least action, Energy and momentum using four vector notation.
2.	LL 16,17,18,19	Charges in electromagnetic field: Four potential of field, Equation of motion of charge in a field, Gauge invariance, Constant electromagnetic field.
3.	LL 23-25	The electromagnetic field tensor, Lorentz transformation of electromagnetic field, Invariance of electromagnetic fields.
4.	LL 26-28	The Electromagnetic field Equations: The first pair of Maxwell's equations, The action function of electromagnetic field, The four-dimensional current vector.
5.	LL 29-31	The equation of continuity, The second pair of Maxwell's equations, Energy density and energy flux.
6.	LL 32-33	The energy momentum Tensor, The energy momentum tensor of the electromagnetic field.
7.	LL 34-35	The virial theorem, The Energy momentum tensor for macroscopic bodies.
8.	LL 62-63	The retarded potentials, The Lienard-Wiechert potentials
9.	LL 64-65	Spectral resolution of the retarded potentials, The Lagrangian to terms of the second order.
10.	LL 81-83	Gravitational fields in non-relativistic mechanics, The gravitation field in relativistic mechanics, Curvilinear coordinates.

11.	LL 84-85, Handouts	Distances and time interval, Covariant differentiation, Christoffel symbols
12.	LL 86-87	The relation of Christoffel symbols to metric tensor, Motion of particle in a gravitation field
13.	LL 88-89	The constant gravitational field, Rotation
14.	LL 90-91	The equation of electrodynamics in the presence of a gravitational field, The curvature tensor
15.	LL 92-94	Properties of the curvature tensor, The action function for the gravitation field, The energy momentum tensor.