**Physics 353- Introduction to Nonlinear Methods (3 credits)**

**Prerequisites**: Methods of Mathematical Physics (PHYS 341)

**Course Contents:**

Linear Differential equations; Wave amplitude dependent phase velocity and Non-Linear effect; Multiple Scale Analysis; Introduction to Chaos - One dimensional model; Discovery of the solitary waves; Introduction to Korteweg deVries equation, solitary limit; Relation between amplitude, speed and width; Sagdeev Potential; Conservation Laws; Wave equation and Dispersion Relation; Dispersive Waves, Phase velocity and group velocity; Reductive Perturbation Method; Solitary waves, Dispersion and Non Linearity; Non Linear Schrodinger equation; Evolution equation for envelope function

**Rationale:**

This course has been designed for undergraduate students. This is an elective course. Thepurpose is to train and familiarize undergraduate students with field of nonlinear physics whichwould further help them to understand the nonlinear phenomena in theoretical and experimental

courses.

**Course Objectives:**

1.To develop in the students the basic understanding about nonlinear physics.

2. To provide them the mathematical background of basic nonlinear physics.

3. To give them knowledge with sample applications of nonlinear physics in fusion; space and astrophysics.

4. To make them familiar of how waves can behave in nonlinear regime.

**Learning Outcomes:**

By the end of this course, it is hoped that students will be able

1. To become familiar about nonlinear physics,

2. To understand and appreciate that most of the phenomena can be explained using nonlinear physics theory,

3. To become familiar with nonlinear physics uses applicable in different fields of physics,

4. To treat mathematical equations and to develop a model for the study of various waves propagation.

**Course Content:**

**I. Nonlinearity and Non Linear Effects**

Introduction; Linear Differential equations; Superposition principle; Types of Linear waves; Harmonic oscillator and introduction to phase space; Carrier wave and wave modulation; Amplitude dependent phase velocity and Non Linear effect; Autonomous equations;

**II. Multiple Scale Analysis**

Introduction to multiple scale analysis; Approximate solutions to nonlinear differential equations; Resonance producing secular terms; Van der Pol oscillator; Duffing oscillator; Driven damped oscillators;

**III. Introduction to Chaos - One dimensional model**

Deterministic Chaos; Difference equations; Logistic Map Population Biology; Fixed Points and Stability of 1-D maps; Time Series, Transients and Attractors; Graphical representation; Period Doubling; Bifurcation Diagram; Fixed points and stability; Lyapunov Exponent for I-D map; Universality, Feigenbum number

**IV. Solitons**

Preliminaries; Discovery of the solitary waves; Introduction to Korteweg deVries equation, solitary limit; Relation between amplitude, speed and width; Sagdeev Potential; Conservation Laws; Wave equation and Dispersion Relation; Dispersive Waves, Phase velocity and group velocity; Reductive Perturbation Method; Solitary waves, Dispersion and Non Linearity; Non Linear Schrodinger equation; Evolution equation for envelope function

**References**

1. Applied Mathematics for Engineers and Physicists; Pipes & Harvill; McGraw Hill (1970)
2. Chaos and Nonlinear Dynamics; Robert C Hilborn; Oxford University Press (1994
3. Nonlinear Physics with Mathematica for Scientists and Engineers; Richard H. Enns, George C. McGuire Birkhäuser (2001)
4. Nonlinear waves, solitons and Chaos ;E. Infeld and G. Rowlands; Cambridge University Press (1990)
5. Solitons: An Introduction; P. G. Drazin and R. S. Johnson; Series: Cambridge Texts in Applied Mathematics; Publisher: Cambridge University Press,(1989)

**Course Evaluation:**

Homework/Assignments/Projects (15%), Mid-term (30%), Quizzes (15%), Final (40%)

**Attendance and Grading Scale policy:**

Students must attend all the lectures. If attendance of any student falls below 70%, he/she

will not be allowed to sit in the final exam. FCCU grading scale policy will be followed to

calculate grades and quality points. There will be no makeup quiz or exam if you miss any

except for medical reasons with doctor’s verification.