Jimma University, College of Natural Sciences
Department of Physics

Course Title and Code: ***Mathematical Methods of Physics II*** (Phys 2032)
Credits 3 Cr. hrs - Lecture: (3 hrs) + Tutorial: (1 hr)
Prerequisite(s): _______________ Co-requisite(s): ______________
Academic Year: 2012 E.C. **Semester/Year:** II/II
College/Faculty: *Natural Science* **Department:** Physics **Program:** Undergraduate **Enrollment:** Regular
Instructor: Jifar Raya (Lecturer) **Email Address**: jifarraya3@gmail.com

Course Rationale

This course aims to give learners a deeper understanding of and greater competence in some central mathematical ideas and techniques used in Physics with the emphasis on practical skills rather than formal proof. Students will acquire skills in some key techniques related directly to the advanced courses they will meet in their final year.

Learning Outcomes

Upon completion of this course students should be able to:

- solve partial differential equations by separation of variables;
- calculate eigenvalues and eigenvectors and apply the techniques to physical problems;
- use basis vectors to transform differential operator equations to matrix form and hence apply eigen equation techniques;
- obtain approximate solutions to differential equations through the use of perturbation theory.
- develop analytical and numerical skills in mathematics;
- formulate problems logically;
- present and justify mathematical techniques and methods;

Course Description

Vectors and Matrices algebra of vectors, basis vectors and components, vector spaces, matrix algebra, numerical methods for matrices, coordinate transformation, Four vectors, eigen value problem.

Vector Calculus time derivatives of vectors, fluid kinematics, fluid dynamics, fields and the gradient, fluid flow and the divergence, circulation and the curl, conservative forces and the Laplacian, electric and magnetic fields, vector calculus expressions and identities.

Waves and Fourier Analysis: waves, partial differentiation, the wave equation, principle of superposition, standing waves and harmonics Fourier series, Parseval's theorem and frequency spectra, solution of inhomogeneous Des, Fourier Transforms and the Dirac Delta Function;

Complex Variables: functions of a complex variable, differentiation and integration, Cauchy integral formula and Laurent Expansion; Singularities, poles and residues, Applications.

Partial Differential Equations: introduction to PDEs, the wave equation, Laplace's equation, Orthogonal functions and the Sturm-Liouville problem; Special Functions: Legendre, Bessel and Hermite Equations.

Course Outline

1. **Vectors and Matrices** (**10 hrs**.)
    - 1.1. Algebra of Vectors
    - 1.2. Basis Vectors and Components
    - 1.3. Vector Spaces
    - 1.4. Matrix Algebra
    - 1.5. Numerical Methods for Matrices
    - 1.6. Coordinate Transformations
    - 1.7. Four- Vectors
    - 1.8. The Eigenvalue Problem
2. **Vector Calculus** (**12 hrs.)**
    - 2.1. Time derivatives of vectors
    - 2.2. Fluid kinematics and dynamics
    - 2.3. Fields and the Gradient
    - 2.4. Fluid flow and the Divergence
    - 2.5. Circulation and the Curl
    - 2.6. Conservative Forces and the Laplacian
    - 2.7. Electric and Magnetic Fields
    - 2.8. Vector Calculus Expressions and Identities
3. **Complex Variables** (8 hrs.)
    - 3.1. Functions of a Complex Variable
    - 3.2. Differentiation and Integration
    - 3.3. Cauchy Integral Formula and Laurent Expansion
    - 3.4. Singularities, Poles and Residues
    - 3.5. Applications
4. **Partial Differential Equations (PDEs)** (16 hrs.)
    - **4.1. Introduction to PDEs**
        - 4.1.1. Simple second order differential equations and common varieties
        - 4.1.2. Harmonic oscillator, Schrödinger equation
        - 4.1.3. Poisson’s equation
        - 4.1.4. wave equation and diffusion equation
    - **4.2. Wave Equation Revisited**
    - **4.3. Laplace’s equation**
        - 4.3.1. Laplacian family of equations in Physics
        - 4.3.2. Mechanics of the techniques,
        - 4.3.3. Separation of variables
        - 4.3.4. Form of solutions
        - 4.3.5. General solutions in series form
        - 4.3.6. Relation to Fourier series
        - 4.3.7. Initial conditions: spatial boundary conditions and time dependence
    - **4.4. Orthogonal functions and the Sturm-Liouville Problem;**
    - **4.5. Special Functions**
        - 4.5.1. Hermite
        - 4.5.2. Legendre
        - 4.5.3. Bessel

Method of Teaching

Presentation of the course is through lecture, a related guided problems section with demonstrator assistance and additional assessed coursework. Online learning resources.

Assessment

- ✓ Homework will consist of selected end of chapter problems: **20%**
- ✓ In-class participation (asking questions, discussing homework, answering questions): **5%**
- ✓ quizzes and Tests or Mid-Exam **(25%),**
- ✓ Final Semester Examination ***(50%)***

Recommended References

Course Textbook

- ❖ Arfken G.B. and Weber H.J., Mathematical methods for physicists (6th ed.), Academic Press, 2006.
- ❖ Spiegel M.R., Advanced Mathematics for Engineers and Scientists, Schaum Outline Series, McGraw-Hill, (1971).

References

1. Spiegel M.R., Advanced Mathematics for Engineers and Scientists, Schaum Outline Series, McGraw-Hill, 1971.
2. Stroud K.A., Engineering Mathematics (5th ed.), Paulgrave, 2001.
3. Donald A. Mc Quarric, Mathematical Methods for Scientists and Engineers, University Science Books, 2003.
4. Lambourne R. and Tinker M. Further Mathematics for the Physical Sciences, Wiley, 2000.
5. Mathews J. and Walker R.L., Mathematical Methods of Physics, 2nd ed., 1970.