Department of Physics

College of Education

University of Salahaddin/ Hawler

Subject: Adv. Mathematical Physics

Course Book for (M.SC.) Students

Lecturer's name: Dr. Sattar Othman Hasan

Academic Year: 2023/2024

Course Book

1. Course name	**Adv. Mathematical Physics**
2. Lecturer in charge	**Dr. Sattar Othman Hasan**
3. Department/ College	**Physics / Education**
4. Contact	e-mail: sattar.hasan@su.edu.krd e-mail: star_os2004@yahoo.com **Tel: (0750 4514637)**
5. Time (in hours) per week	**3 HOURS**
6. Office hours	**Sunday:** **From** 8:30 AM To 11:30 PM **Monday:** **From** 12:30 AM To 2:30 AM **Thursday:** **From** 11:30 AM To 2:30 PM

7. Teacher's academic profile: I am a Staff member in physical Department of Education College at Salahaddin University-Erbil.

I earned a BSc degree in Physics at **1990-1991** with first class honour from Physical department of Education college, university of Salahaddin. **MSc** degree in theoretical nuclear physics at **1998-1999** under the title of "The Background Function Effects on the Analysis of Gamma-Ray Spectrum" with honour degree., and a **PhD** in communication "Electromagnetic Theory" at **2006-2007** with the title of "Analysis and Design of Compact Microstrip Antenna Using Cavity Model" from Physical department of Science college, university of Salahaddin.

From **2000-2002**, I was a head of register unit within the college of education. During **2002-2003** I was a deputy of deans of Education College, University of Salahaddin. I was a representative of teaching staff at College of Education for about eight years.

I was a dean of Hawler Tourism Technical Institute during the years of **2008-2010** and also, I was a dean of Hawler Technology Institute during the years of **2010-2014**. I am an assistant professor of theoretical Electromagnetic Theory "Field of Communication", and I have **several** research publications in different field of physics. My research interests span a number of topical themes in electromagnetic wave propagation, theoretical physics, antenna design and mobile communication. Finally, I supervised **Four M.Sc.** students and **Two Ph.D.** in the field of Communication.

8. Course objective: The objective of this course is to introduce the fundamental principles of mathematical physics and apply them to the physical phenomenon in different fields and problem that contain special integration using **Gamma** and **Beta** functions. Moreover, the formation of power series for various mathematical functions by using geometrical series, Taylor and Binomial series and their applications for solving some integrals and limit functions are also described. In addition, the application of **Laplace** transformation and Laplace inverse transform with its inverses will be learned and specified in simplifying various differential equations and verifying their implementation in the field of electrical and communication systems. Moreover, **numerical** differentiation, integration with **interpolation** and **extrapolation** of data with the help of various difference operators and polynomial formulas will be understood and discussed in detail.

9. Forms of teaching: Different forms of teaching will be used to come across with objectives of the course. Power point presentations for the head titles, definitions, graphs and many useful illustrations with summary at the end of each chapter will be presented and discussed.

In addition, the lecture will cover enough information about the description of the subjects, solution of many examples, analysis and derivation for all necessary equations and proving theorems and many problems are presented as a home work for improving student abilities.

10. Assessment scheme: Attaining the requirements set to succeed in this study subject requires developing a mathematical sense, related to this topic, based on emergent analytical and problem-solving skills and memorizing topics cannot secure success.

In this system the **maximum** mark is **(100%)**. The grading system is based on the summation of two categories of **evaluations**:

First, **(30%)** of the **mark** is based on the **academic** semester effort of the student which includes:

- **20%** for **the** semester examination.
- **5%** for preparing a **seminar** about the a subject related to mathematical application to a given physical problem.
- **5%** for solving **home** works.

Second, **(70%)** of the **mark** is based on **final** examination that is comprehensive for the whole of the study material **reviewed** during the academic **season** and it usually occurs after completing the course semester.

11. Student learning outcome: The learning objects and the main goals of studying mathematical physics are summarized in the following important points:

- Student will learn the formation of power series for various mathematical functions by using geometrical series, Taylor and Binomial series and their applications for solving some integrals and limit functions.
- Application of **Gamma** and **Beta** functions for solving special integral functions and applying them to physical integral problems in Quantum mechanics.
- Application of Laplace transform and its inverse transform for solving special integrals and ordinary differential equations in most of the electrical and mechanical problems in physics and engineering.
- Implementation of numerical analysis in finding roots of algebraic and transcendental equations with evaluation of integration and differentiation using different numerical methods.
- Application of interpolation and extrapolation methods for estimating missing practical or statistical data in a given experiment or events using Newton Gregory and Lagrange polynomial methods for finding mathematical functions.

12. Course Reading List and References:

1. George B. Arfken and Hans J. Weber, "Mathematical Methods for Physics", Fifth Edition, 2001.
2. Mary L. Boas, "Mathematical Methods in the Physical Sciences " , Second Edition, John Wiley and Sons, 1983.
3. T.K.V. Iyengar and etc., " Mathematical Methods", Ram Nagar-New Delhi-110055 , 2000
4. S.K. Chung , "Understanding Basic Calculus" , 2007.
5. John H. Mathews, "Numerical Methods for Computer Science, Engineering and Mathematics", Prentice-Hall International Editions, 1993.
6. H. K. Dass , " Advanced Engineering Mathematics" , Ram Nagar-New Delhi-110055 , 2008.
7. Calculus , International Edition, By Thomas' , 2005.
8. Calculus , 11th Edition, By Thomas' , 2013.

13. The Topics:	Syllabus
CHAPTER ONE **Sequences and Power Series** **2 Weeks**	I-1: Sequences • Arithmetic Sequence • Geometric Sequence I-2: Convergent and Limit of Sequence I-3: Infinite Series I-4: Convergent, Divergent and Oscillatory Series I-5: Geometric Series and Combining Series I-6: Adding or Deleting Series Terms I-7: Power Series and Convergent I-8: Taylor and McLaurin Series I-9: Binomial Series for Powers and Roots
CHAPTER TWO **Gamma and Beta Function** **2 Weeks**	2-I: Introduction 2-2: Definition of Gamma Function and Recursion Formula. 2-3: The Gamma Function of Negative Numbers 2-4: Some Important Formula Involving Gamma Function 2-5: Transformation of Gamma Function 2-6: Beta Function 2-7: Transformation and Properties of Beta Function • Interchanging the location of $(q\ ,p)$ • Transformation of Integration Range • Transformation to Trigonometric form of Beta Function • Transformation to Rational form of Beta Function
CHAPTER THREE **Laplace and Laplace Inverse Transformation** **3 Weeks**	3-I: Introduction 3-2: Some Important Formula for L-Transformation 3-3: Properties of L-Transformation • Laplace Transformation of the Derivative of $f(t)$ • Laplace Transformation of Integral of $[f(t)]$ • Laplace Transformation of $[t\ .f(t)]$ and $\left[\frac{1}{t}f(t)\right]$ 3-4: Evaluation of Integrals 3-5: Inverse Laplace Transform • Multiplication by (s) *and* $\left(\frac{1}{s}\right)$ • Inverse Laplace-Transforms of Derivatives • Inverse Laplace-Transforms of Integrals 3-6: Inverse Laplace-Transforms by Partial Fractions Method 3-7: Solution of Differential Equations by Laplace Transforms

CHAPTER FOUR **Numerical- Solution of Algebraic and Transcendental Equations** **2 Weeks**	4-I: Introduction 4-2: Objective 4-3: Initial Approximation to a Root 4-4: Bisection Method 4-5: Regula-False Method 4-6: Newton-Raphson Method 4-7: Secant-Method 4-8: Successive-Iteration Method 4-9: Iterative-Methods for Solving Simultaneous Linear Equations • Gauss-Jacobi's Iteration Method • Gauss-Seidel's Iteration Method
CHAPTER FIVE **Difference Operators and Interpolation** **3 Weeks**	5-I: Introduction 5-2: Finite Difference Operators • Forward Difference Operator • Backward Difference Operator • Shift Operator 5-3: Relations among Operators 5-4: Interpolation Newton's Forward Difference Formula 5-5: Interpolation Newton's Backward Difference Formula 5-6: Lagrange Interpolation Formula
CHAPTER SIX **Numerical Differentiation and Integration** **2 Weeks**	6-I: Introduction 6-2: Solution of Differential Equations • Taylor's-Series Method • Euler's-Method and Modified Euler's-Method • Runge-Kutta Methods 6-3: Numerical Integration 6-4: Newton-Cote's Quadrature Formula 6-5: Trapezoidal-Rule 6-6: Simpson's $\left(\frac{1}{3}\right)$ −Rule 6-7: Simpson's $\left(\frac{3}{8}\right)$ −Rule

14. Examinations: Different types of questions will be provided to the student as an exercise and also in examinations such as mathematical **derivation** and **explanation** questions for different subjects.

15. Extra notes: Due to a number of **unforeseen** reasons that may lead to the **shifting** of the academic season **program**, it may be subjected to **modifications**. Also extra **curriculum** hours may be **needed** to cover all the **topics** mentioned above. The students shall be **notified** of the **changes** if and when they may **occur**.