**Al al-Bayt University**
**Qality and Assurance Department**

بســـم الله الرحمن الرحيم

جامعة آل البيت

***Faculty of Science***
***Physics Department***

## Course Outline of Mathematical Physics

### 1. Instructor's Information

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|---|---|
| Instructor's / Coordinator's Name: | Prof. Hatem Widyan |
| Office Hours: | 10-11, 12-1: Sunday, Tuesday, Thursday |
| Office and Phone: | Bukhari 2nd Floor (2172) |
| Email: | widyan@aabu.edu.jo |
| Research and Teaching Assistant / Supervisor / Technical (if any): | NA |

### 2. Course Information

| | | |
|---|---|---|
| Course No.: 402781 | Course Title: Mathematical Physics | Level: Master |
| Course Type: Theoretical | Prerequisite: Calculus II | Class Time: 2:00-5:00 |
| Academic Year:2020-2021 | Semester: Fall | Study hours: |

### 3. Course Description

This is an advanced course in mathematical physics for graduate students. We begin by reviewing the complex numbers. After that we introduce complex variables and functions, Cauchy-Riemann conditions, Cauchy integral theorem. We discuss singularities and Laurent expansion. Residues theorem and evaluating definite integrals are also discussed. We introduce Sturm-Liouville theory and the meaning of Hermitian operators is discussed. The concept of Green functions is discussed and we learn how to obtain them for one-dimensional problems. After that integral transforms are discussed: Fourier as well as Lapalce transforms. Application of them to physical problems are introduced. Finally we discuss the integral equations and why they are useful in physics.

## 4. Course Objectives:

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|---|---|
| a- | Solving complicated integrals using residue theorem. |
| b- | Solving Sturm-Liouville problems |
| c- | Solving complicated problems in physics using Green's functions. |
| d- | Solving complicated integrals and differential equations using Fourier and Laplace transformation. |
| e- | Transform differential equations to integral equations and solving them. |
| f- | Use Fourier series to expand and periodic function in terms of sine and cosine. |

## 5. Course Learning Outcomes (CLO)
## (Knowledge, Skills, and Competencies) (K,S,C)

Upon successful completion of the course, the students will be able to:

**CLO 1:** Define various quantities related to the course. (K)
**CLO 2**: Evaluate integrals problems using residue theorem. (S,C)
**CLO 3**: Define Hermitian operators and solve Sturm-Liouville problems. (S,C)
**CLO 4**: Obtain Green's functions. (S,C)
**CLO 5**: Solve physical problems using Fourier and Laplace Transforms. (S)
**CLO 6**: Define integral equations. (S,C)

## 6. Course Content

| Week | Topic | Comments | Course Outcome |
|---|---|---|---|
| **1** | **CHAPTER : OVERTURE** | We review the concept of complex numbers | CLO1+CLO2 |
| **2-6** | **Complex Variable Theory**<br>➢ Complex variables and functions<br>➢ Cauchy-Riemann conditions<br>➢ Cauchy integral formula<br>➢ Laurent expansion and singularities<br>➢ Residue theorem<br>➢ Evaluation of definite integrals | To define the complex variables and functions. We define Cauchy-Riemann conditions. We learn Cauchy integral formula. We learn how to evaluate Laurent expansion. We define residue theorem and use it to evaluate definite integrals. | CLO1+CLO2 |
| **7** | **Sturm-Liouville Theory**<br>➢ Hermitian operators<br>➢ ODE eigenvalue problems | To define Hermitian operators. We learn how to solve ODE eigenvalue problems using variation method. We learn Gram- | CLO1+CLO3 |

| | | | |
|---|---|---|---|
| | ➢ Variation methods<br>➢ Gram-Schmidt orhogoanlization | Schmidt orthogonaliztion technique. | |
| **~Mid EXAM on End of November ( 30%)** | | | |
| **8-9** | **Green's Functions**<br>➢ One dimensional problems<br>➢ Problems in two and three dimensions. | In this chapter, we discuss Green functions. We learn how to obtain them for different operators. We discuss various problems in all dimensions. | CLO1+CLO4 |
| | | | |
| **10-12** | **Integral Transforms**<br>➢ Introduction<br>➢ Fourier transforms<br>➢ Properties of Fourier transforms<br>➢ Fourier convolution theorem<br>➢ Laplace transforms<br>➢ Properties of Laplace transforms<br>➢ Laplace convolution transforms<br>➢ Inverse Laplace transforms | We define Fourier transforms and their properties. We learn Fourier convolution theorem. We discuss inverse Fourier transforms. We do the same thing for Laplace transforms. | CLO1+CLO5 |
| **13-15** | **Integral Equations**<br>➢ Introduction<br>➢ Some special methods<br>➢ Neumann series<br>➢ Hilbert Schmidt theory | Integral equations have a wide applications in physics. So, we learn how to solve them using special methods. | CLO1+CLO6 |
| **16** | Review | Review | **Final Exam** |

## 7. Teaching and Learning Strategies and Evaluation Methods

| **No.** | **Learning Outcomes** | **Teaching Strategies** | **Learning Activities** | **Evaluation /Measurement Method (Exam/ presentations/ discussion/ assignments)** |
|---|---|---|---|---|
| 1 | (CLO1) | trad. lect. | Discussion & Problem Solving | HW & First Exam & Final Exam |
| 2 | (CLO2) | trad. lect. | Discussion & Problem Solving | HW & First Exam & Final Exam |
| 3 | (CLO3) | trad. lect. | Discussion & Problem Solving | HW & Second Exam & Final Exam |
| 4 | (CLO4) | trad. lect. | Discussion & Problem Solving | HW & Final Exam |
| 5 | (CLO5) | trad. lect. | Discussion & Problem Solving | HW & Final Exam |
| 6 | (CLO6) | trad. lect. | Discussion & Problem Solving | HW & Final Exam |

## 8. Assessment

| Methods Used | Assessment Time | Distribution of grades |
|---|---|---|
| 1- Semester work (report, assignments, attendance) | During semester | 20% |
| 3- Mid Exam | 8th week | 30% |
| 4- Final Exam | Week of the final exams | 50% |

## 9. Textbook

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| Main Reference | Mathematical Methods for Physicists |
| Author | George Arfken, Hans J. Weber and Frank E. Harris |
| Publisher | Academic Press |
| Year | 2013 |
| Edition | 7nd |
| Textbook Website | - |

## 10. Extra References (books and research published in periodicals or websites)

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|---|---|
| **1-** | Mathematical Methods in the Physical Sciences, Mary L. Boas, Third Edition, John Wiley & Sons, 2006. |
| **2-** | Mathematical physics, Eugene Butkov, First Edition, Addison-Wesley, 1968 |