Course Specification

(Postgraduate Programs)

Course Title:	Mathematical Methods in Physics
Course Code:	PHY 6131
Program:	Master of Science in Physics
Department:	Physics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University
Version:	3
Last Revision Date:	*26/09/2024*

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A. General information about the course:

1. Course Identification:

1. Credit hours: 4				
2. Course type				
A.	☐ University	☐ College	☒ Department	☐ Track
B.	☒ Required		☐ Elective	
3. Level/year at which this course is offered: Level 1/Year 1				
4. Course General Description:				
This course provides an overview of the essential mathematical methods illustrated by applications to problems from various branches of physics. It is designed to provide first-year graduate students with the mathematical background for subsequent studies of advanced mechanics, classical electrodynamics, quantum theory, advanced statistical physics, and advanced solid-state physics.				
5. Pre-requirements for this course (if any): None				
6. Pre-requirements for this course (if any): None				
7. Course Main Objective(s):				

At the end of this course, students will be able to:

- **Demonstrate knowledge of fundamental concepts in mathematical methods in Physics and apply this knowledge to solve problems;**
- **Find in Mathematical Methods in Physics a wholly new and counterintuitive way of thinking about the world;**
- **Develop physical intuition, mathematical reasoning, and problem solving skills;**
- **Deal with conceptually rich and technically difficult theoretical problems;**
- **Know how to use the theory to discuss physics phenomena quantitatively;**
- **Have learned the techniques to solve, through discussion and reading, a wide range of specific theoretical problems, including their backgrounds and implications;**
- **Have experienced the adept application of physics and mathematics to solve real life problems;**
- **Prepare for the necessarily rigorous sequence in physics.**

2. Teaching Mode: (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	75	100%
2	E-learning		
3	Hybrid • Traditional classroom • E-learning		
4	Distance learning		

3. Contact Hours: (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	**45**
2.	**Laboratory/Studio**	**0**
3.	**Field**	**0**
4.	**Tutorial**	**30**
5.	**Others (specify)……**	**0**
	Total	**75**

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods:

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	**Interpret the mathematical methods and its governing laws.**	**K1, K3**	▪ Lectures. ▪ Tutorials. ▪ Class discussions.	▪ Exams. ▪ Participation. ▪ Discussions.
1.2	**Describe the techniques to solve problems in physics and state the importance of mathematical methods in physics.**	**K1, K3**	▪ Lectures. ▪ Tutorials. ▪ Class discussions.	▪ Exams. ▪ Homework. ▪ Quizzes.

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.3	**Discuss the important of mathematical methods in the development of Physics.**	**K1, K2**	▪ Lectures. ▪ Class discussions. ▪ Tutorials.	▪ Participation. ▪ Exams. ▪ Discussions. ▪ Homework.
2.0	**Skills**			
2.1	**Explain and summarize the basic knowledge gained from studying mathematical physics course.**	**S1, S2**	▪ Lectures. ▪ Class discussions. ▪ Tutorials.	▪ Exams. ▪ Discussions. ▪ Participation.
2.2	**Develop the students ability to solve and analyze problems in physics related the topics covered by the course.**	**S2, S3**	▪ Problem classes and group tutorial. ▪ Homework assignments as well as problems solutions.	▪ Exams. ▪ Discussions. ▪ Homework.
2.3	**Communicate in a clear and concise manner orally, and using IT for acquiring and analyzing information.**	**S4**	• Lectures. • Class discussions. ▪ Tutorials. ▪ Encourage students to use electronic mail and internal network for submitting homework and assignments. ▪ Use digital library.	▪ Exams. ▪ Participation and activities of students in the course community and blackboard. ▪ Homework.
3.0	**Values, autonomy, and responsibility**			
3.1	**Show the collaboration and inter-professionalism in class discussions or team works, as well as solve problems independently.**	**V1, V2, V3**	▪ Small team tasks ▪ Open discussion at classroom. ▪ Office hours.	▪ Participation ▪ Homework. ▪ Mini-project(s).

C. Course Content:

No	List of Topics	Contact Hours
1.	**Vector Analysis in Curved Coordinates and Tensors:** Orthogonal coordinates in R3, Differential vector operators, Special coordinate systems, Circular cylinder coordinates, Spherical polar coordinates, Tensor	12

	analysis, Contraction, Direct product, Quotient rule, Pseudotensors, Dual tensors, General tensors, Tensor derivative, Operators.	
2.	**Vector Spaces:** Vectors in function spaces, Gram-Schmidt Orthogonalization, Operators, Self-adjoint operators, Unitary operators, Transformations of operators, Invariants, Summary-vector space notation.	10
3.	**Group Theory:** Introduction to group theory, Generators of continuous groups, Orbital angular momentum, Angular momentum coupling, Homogeneous Lorentz group, Lorentz covariance of Maxwell's equations, Discrete groups, Differential forms.	8
4.	**Infinite Series:** Fundamental concepts, Convergence tests, Alternating Series, Algebra of Series, Series of functions, Taylor's expansion, Power series, Elliptic integrals, Bernoulli numbers, Euler–Maclaurin formula, Asymptotic series, Infinite products.	8
5.	**Functions of a Complex Variable:** Complex algebra, Cauchy–Riemann conditions, Cauchy's integral theorem, Calculus of residues.	11
6.	**The Gamma Function (Factorial Function):** Definitions, Simple properties, Digamma and polygamma functions, Stirling's series, The beta function.	8
7.	**Differential Equations:** Partial differential equations, First-order differential equations, Separation of variables, Frobenius Method.	10
8.	**Integral Transforms:** Integral transforms, Development of the Fourier integral, Fourier transform-inversion theorem, Fourier transform of derivatives, Laplace transforms, Laplace transform of derivatives.	8
Total		**75**

D. Students Assessment Activities:

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	**Class Activities (class quizzes, homework, solving problems, etc.....)**	**weekly**	**20 %**
2.	**Midterm Exam 1**	**6th week**	**20 %**
3.	**Midterm Exam 2**	**12th week**	**20 %**
4.	**Final Exam**	**16th week**	**40 %**

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.)

E. Learning Resources and Facilities:

1. References and Learning Resources:

Essential References	***-G.B. Arfken, Mathematical Methods for Physicists, 2005.***
Supportive References	***-H.W. Wyld, Mathematical Methods for Physics, Perseus Books Publishing, 1999.*** ***-R. Courant, D. Hilbert, Methods of Mathematical Physics, John Wiley and Sons, 1st Edition, 1965.***

Electronic Materials	https://units.imamu.edu.sa/colleges/en/science/Pages/default.aspx
Other Learning Materials	Multimedia associated with the textbook and the relevant websites.

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	- Classrooms
Technology equipment (Projector, smart board, software)	- Classroom equipped with a whiteboard and a projector.
Other equipment (Depending on the nature of the specialty)	

F. Assessment of Course Quality:

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	- Students. - Second examiner.	Indirect (The student will complete evaluation forms at the end of semester. Final exam is evaluated by the second examiner)
Effectiveness of students' assessment	- Instructors.	Direct (exams, HW, project, ...)
Quality of learning resources	- Faculty. - Students.	Indirect (surveys)
The extent to which CLOs have been achieved	- Instructors. - Program Leaders.	Direct (excel sheet)
Other		

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval Data:

COUNCIL /COMMITTEE	Quality Unit-Physics Department
REFERENCE NO.	Department council No. 6
DATE	*25/09/2024*