Extended Syllabus

Course Title	Mathematical physics 2	Semester	2022 Fall
Credit	3	Course Number	PHY2006
Class Time	Mon. Wed. 12:00~13:15	Enrollment Eligibility	2nd/3rd Year physics major

Instructor's Photo	Name: Lee, Hyun Cheol	Homepage: http://cmt.sogang.ac.kr
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Ⅰ. Course Overview

1. Description

Classical mechanics, classical electrodynamics, and quantum mechanics requires mathematical methods beyond calculus. In this semester we continue the study initiated in the spring semester. We will start with detailed studies on the ordinary differential equations including a treatment of Green's functions. Then we cover the theory of functions of complex variables which turns out to be extremely powerful tool in diverse areas of physics. We briefly study a calculation of variation to motivate the partial differential equations. Then we embark on the study of partial differential equation, covering Green's function, integral equation along the way. Tensor analysis is the next topic to be covered, laying rudiments for differential geometry. If schedule permits, we will discuss the elements advanced linear algebra which are relevant for the quantum information and quantum computing.

2. Prerequisites

(1) Mathematical physics 1

(2) General Physics I and II

(3) Calculus and matrix algebra at the level of freshman courses.

(4) You should be familiar with Taylor expansions, and various integration techniques.

4. Course Format (%)

Lecture	Discussion	Experiment /Practicum	Field study	Presentations	Other
100%	%	%	%	%	%

4. Evaluation (%)

Mid-term Exam	Final exam	Quizzes	Presentations	Projects	Assignments	Participation	Other
30%	40%	30%	%	%			%

Ⅱ. Course Objectives

(1) Understanding of the basic structure of (mostly linear) ordinary and partial differential equations. We begin with the essential elements of the theory of ordinary differential equation, and based on these we proceed to study PDE, such as three typical types of problems. Then we introduce Green's function to attack the inhomogeneous linear PDE, and in course of it the integral equation is treated as reformulation of PDE.

(2) Understanding the powerful technique of complex variable theory, such as contour integration.

(3) Most of physical quantities are tensors. Tensors in the context of most general coordinate transformation are introduced, and important class of tensors such as metric tensor, Riemann curvature tensor, and totally antisymmetric tensors (a.k.a differential forms) are studied. The depth of the study will depend on the course schedule.

(4) The importance of quantum information can be hardly overemphasized. We will discuss the aspects of advanced linear algebra relevant to the quantum computation such as Schmidt decomposition.

Ⅲ. Course Format

(* In detail)

(1) A recitation session may be held every other week (The schedule will be notified later), and you are expected to attend it on a regular basis.[조교배정여부에 따라 유동적]

(2) An assignment will be posted in Cyber-Campus (approximately) every 1 and 1/2 week, which typically consists of 7~10 problems from the main text or supplementary readings.

(3) The instructor will provide model solutions for each assignment.

(4) The problems in assignments will be discussed in recitation session

(5) The grader for assignments **is not** expected, thus you **do not** have to submit homework. However, you are **strongly encouraged** to work out the assignments before consulting the model solutions.

Ⅳ. Course Requirements and Grading Criteria

(1) Quiz is equivalent to a second midterm examination.

(2) The first midterm and the final examinations will be held in regular examination period.

(3) The instructor will post the model solution immediately after each examination and will accept complaints for a certain period. The grading guide (or criteria) will be provided in Cyber-Campus.

Ⅴ. Course Policies

(1) You are expected to comply with the standard mobile phone etiquette.
(2) Cheating will be severely punished in accordance with the college regulations.

VI. Materials and References

Main text

Arkfen, Weber, and Harris

"Mathematical Methods for physicists", (7th international edition) Elsevier. (comprehensive edition)

ISBN: 978-0-12-384654-9

This text contains more than enough materials to be covered even for a full year course.

References

M. Boas, "Mathematical Methods in the Physical Sciences" (3rd edition) Wiley

ISBN: 978-0471198260

Another popular text for mathematical physics.

Ⅶ. Course Schedule

(* Subject to change)

Week 1 (9/5,7)	**Learning Objectives**	Understanding of Ordinary Differential Equation
	Topics	First and second order ODE, the Frobenius method.
	Class Work (Methods)	Lecture (online or offline)
	Materials (Required Readings)	Chapter 7 of the main text
	Assignments	To be posted
Week 2 (9/12, 14)	**Learning Objectives**	Understanding of Ordinary Differential Equation
	Topics	Inhomgeneous equation, Green's functions
	Class Work (Methods)	Lecture (Sep 12th is holiday. Zoom make up lecture)
	Materials (Required Readings)	Chapter 7 of the main text

	Assignments	To be posted
Week 3 (9/19, 21)	**Learning Objectives**	Sturm-Liouville theory
	Topics	Hermitian differential operator and eigenvalue problems
	Class Work (Methods)	Lecture
	Materials (Required Readings)	Chapter 8 of the main text and additional reading materials.
	Assignments	To be posted
Week 4 (9/26, 28)	**Learning Objectives**	Complex variable part 1
	Topics	Cauchy-Riemann equation, Cauchy integral formula
	Class Work (Methods)	Lecture
	Materials (Required Readings)	Chapter 11 of the main text
	Assignments	To be posted
Week 5 (10/3, 5)	**Learning Objectives**	Complex variable part 2
	Topics	Laurent expansion, the calculus of Residues
	Class Work (Methods)	Lecture (October 3rd, zoom make up lecture)
	Materials (Required Readings)	Chapter 11 of the main text
	Assignments	To be posted
Week 6 (10/10,12)	**Learning Objectives**	Complex variable part 3
	Topics	Conformal mapping and Asymptotic expansion
	Class Work (Methods)	Lecture (October 10th, zoom make up lecture)
	Materials (Required Readings)	Chapter 11 and 12 of the main text
	Assignments	To be posted

Week 7 (10/17,19)	**Learning Objectives**	Partial Differential equation 1
	Topics	General aspects of PDE
	Class Work (Methods)	Lecture
	Materials (Required Readings)	Chapter 9of the main text (or supplementary reading from Jackson?)
	Assignments	To be posted
Week 8 (10/24,26)	**Learning Objectives**	Mid-term examination
	Topics	Mid-term examination
	Class Work (Methods)	Mid-term examination
	Materials (Required Readings)	N/A
	Assignments	N/A
Week 9 (10/31,11/2)	**Learning Objectives**	Partial differential equation 2
	Topics	Separation of variables, three types of PDE
	Class Work (Methods)	Lecture
	Materials (Required Readings)	Chapter 9 and 10 of the main text
	Assignments	To be posted
Week 10 (11/7, 9)	**Learning Objectives**	Partial differential equation 3
	Topics	Green's function and calculus of variation
	Class Work (Methods)	Lecture
	Materials (Required Readings)	Chapter 10 and 22 of the main text and supplementary reading
	Assignments	To be posted

Week 11 (11/14,16)	**Learning Objectives**	Integral equation
	Topics	General theory and Hilbert-Schmidt theory
	Class Work (Methods)	Lecture
	Materials (Required Readings)	Chapter 21 of the main text
	Assignments	To be posted
Week 12 (11/21,23)	**Learning Objectives**	Tensor 1
	Topics	General aspects of tensors, transformation laws
	Class Work (Methods)	Lecture
	Materials (Required Readings)	Chapter 4 of the main text
	Assignments	To be posted
Week 13 (11/28,30)	**Learning Objectives**	Tensor 2
	Topics	Covariant derivatives, curvature tensor.
	Class Work (Methods)	Lecture
	Materials (Required Readings)	Chapter 4 of the main text and supplementary materials
	Assignments	To be posted
Week 14 12/5, 7)	**Learning Objectives**	Advanced linear algebra 1
	Topics	Normal operators and singular value decomposition
	Class Work (Methods)	Lecture
	Materials (Required Readings)	Chapter 5 and 6 of the main text
	Assignments	To be posted

Week 15 (12/12,14)	**Learning Objectives**	Advanced linear algebra 2
	Topics	Schmidt decomposition, elementary aspects of quantum information
	Class Work (Methods)	Lecture
	Materials (Required Readings)	Chapter 5 and 6 of the main text. Supplementary readings.
	Assignments	To be posted
Week 16 (12/19,20)	**Learning Objectives**	Final examination
	Topics	
	Class Work (Methods)	
	Materials (Required Readings)	
	Assignments	N/A

Ⅷ. Special Accommodations

Special students such as the challenged,
foreigners and North Korean defectors who need accommodations should contact the instructor or teaching assistant at the beginning of the semester.

IX. Aid for the Challenged Students

Lecture notes will be provided for the challenged and disabled students upon request.
Also, examinations can be rescheduled for their convenience if necessary.