TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

Mathematical Methods in Physics 2

by

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UNIVERSITAS INDONESIA
FACULTY OF MATHEMATICS AND NATURAL SCIENCES
PHYSICS UNDERGRADUATE STUDY PROGRAM

TEACHING INSTRUCTIONAL DESIGN

Course Name	Mathematical Methods in Physics 2	**Credit(s)**	**Prerequisite course(s)**	**Requisite for course(s)**	**Integration Between Other Courses**
Course Code	SCPH602111	4	Calculust 2, Mathematical Methods in Physics 1	Classical Mechanics, Computational Physics, Quantum Physics 1, Statistical Physics	
Relation to Curriculum	Compulsory Course				
Semester	3rd				
Lecturer(s)	Dr. Adam Badra Cahaya				
Course Description	*After finishing this lecture, if students are required to solve physics problems related to the function of complex variables analytically, students are able to systematically and optimally perform analytical calculations by applying mathematical methods in the form of complex variable functions, including complex functions, Cauchy-Riemann theorem, Laurent series. , Cauchy contour integral, residue theorem, conformal mapping, Fourier series and coefficients, Dirichlet condition, Parseval theorem, Fourier transforms, Euler's equation in calculus of variation, brachistochrone, geodesic, minimum area, Hamilton principle (minimum action principle), Euler-Lagrange equation with constraints*				

Program Learning Outcome (PLO)	
PLO-2	Apply mathematical methods to solve physics problems analytically and computationally
PLO-4	Formulating problems and solving Physics and its application, as well as interdisciplinary problems related to science and mathematics clumps critically, creatively, and innovatively
Course Learning Outcome (CLO)	
CLO-1	After completing this course, students are able to systematically and optimally analyze physics problems using mathematical methods in the form of complex variable functions, Fourier series, and calculus of variations. (C4)
Sub-CLO(s)	
Sub-CLO 1	Able to explain (C2) theorems in the integral of complex variable functions
Sub-CLO 2	Able to explain (C2) the Euler-Lagrange equation in the calculus of variations
Sub-CLO 3	Able to apply (C3) complex variable function theorems in contour integral computation
Sub-CLO 4	Able to apply (C3) calculus of variations in physics problems
Sub-CLO 5	Able to analyze (C4) Fourier transforms with theorems in the contour integral of complex variable functions
Sub-CLO 6	Able to analyze (C4) physics problems with the calculus of variations
Study Materials	- Complex Function - Cauchy – Rieman Theorrm - Laurent Series - Cauchy Contour Integral - Residue Theorm - Conformal Mapping - Fourier Series and Coefficients - Dirichlet condition, - Parseval theorem,

	- Fourier Transform, - Euler's Equation in the Calculus of Variations, - Brachistochrone - Geodesic - Minimum Area - Hamilton Principle (Principle of Minimum Action), - Euler-Lagrange Equations with Constraints.
Reading List	1. Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) 2. Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)

I. Teaching Plan

Week	Sub-CLO	Study Materials [with reference]	Teaching Method [with est. time]	Learning Experiences (*O-E-F)	Sub-CLO Achievement Indicator		Sub-CLO Weight on Course (%)
					General	Specific	
1	1	Review of complex numbers and complex functions [Reference] Chapter 14 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 6 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	Students can analyze the characteristic of Gamma functions	Students are able to apply the Gamma function in solving integrals	15 %
2	1	Cauchy – Rieman Theorrm [Reference]	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video*	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS	Students can analyze the characteristic of the Beta function and	Students are able to apply the Beta function and the Stirling formula in	15 %

		Chapter 14 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 6 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	*conference* : 100 minutes	**Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	the Stirling formula	solving integrals	
3	1	Cauchy Contour Integral [Reference] Chapter 14 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 6 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of	Students can analyze the nature of the Legendre generator function	Students are able to apply the Legendre generator function in solving physics problems	15 %

				discussions and questions and answers via video conferencing			
4	1	Laurent Series [Reference] Chapter 14 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 6 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	Students can analyze the properties of the Legendre series	Students are able to apply the Legendre series in solving physics problems	15 %
5	3	Residue Theorem [Reference] Chapter 14 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video*	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS	Students can analyze series solutions of differential equations	Students are able to apply the Bessel series, in solving differential equations	20 %

		Chapter 7 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	*conference* : 100 minutes	**Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
6	3	Application of Residue Theorem [Reference] Chapter 14 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 7 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions	Students can analyze series solutions of differential equations	Students are able to apply Bessel's function in solving differential equations	20 %

				and answers via video conferencing			
7	3	Conformal Mapping [Reference] Chapter 14 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 6 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	Students can analyze series solutions of differential equations	Students are able to apply Hermite and Laguerre functions in solving differential equations	20 %
8	**Mid Term Exam**						
9	5	Fourier Series and Coefficients [Reference]	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video*	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS	Students can analyze the form of partial differential equations	Students are able to explain physics problems in partial differential equations	30 %

		Chapter 7 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 14 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	*conference* : 100 minutes	**Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
10	5	Dirichlet condition, Form Complex for Fourier Series [Reference] Chapter 7 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 14 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions	Students can analyze the form of partial differential equations	Students are able to explain physics problems in partial differential equations	30 %

				and answers via video conferencing			
11	5	Parseval Theorem, Fourier Transform [Reference] Chapter 7 and 15 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 15 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	Students can analyze the form of 1D partial differential equations	Students are able to apply partial differential equation solutions to 1D physics problems	30 %
12	2	Introduce Calculus Variation Euler Equation [Reference] Chapter 9 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**:	Students can analyze the form of 2D partial differential equations	Students are able to apply partial differential equation solutions to 2D physics problems	30 %

		Chapter 17 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)		Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
13	2, 4	Application of Euler Equation : Braschistochrone, Geodesic, Minimum Area [Reference] Chapter 9 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 17 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions	Students can analyze the form of 3D partial differential equations	Students are able to apply partial differential equation solutions to 3D physics problems	30 %

				and answers via video conferencing			
14	4, 6	Hamilton : Euler – Lagrange Equation [Reference] Chapter 9 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 17 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	Students can analyze the nature of the Poisson equation	Students are able to apply the Green function in solving physics problems	20 %
15	4, 6	Hamilton : Euler – Lagrange Equation with Constraints [Reference] Chapter 9 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas)	Interactif Lecture, *think pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	**Orientation (30%):** Before the class session, students watch a video of inheritance and the application of functions in EMAS **Exercise (30%)**:	Students can analyze the transformation of functions	Students are able to apply functional transformations to differential equations	20 %

		Chapter 17 Mathematical Methods for Physicists, 6th Ed (George B. Arfken dan Hans J. Weber)		Students discuss character and application of functions and formulas through discussion forums. **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
16	**Final Exam**						

II. Assignment Design

Week	Assignment Name	Sub-CLOs	Assignment	Scope	Working Procedure	Deadline	Outcome
2	Individual Assignment 1	1, 3	Essay	Cauchy – Teimann Theorem	Individual Homework	1 week	Curve and file pdf
4	Individual Assignment 2	5	Essay	Laurent Series and Residue Theorm on Cauchy Contour Integral	Individual Homework	1 week	File pdf
7	Individual Assignment 3	1, 3, 5	Presentation	Application of contour integrals to physics problems	Group Homework	1 week	Slide ppt
10	Group Assignment 1	2, 4	Essay	Fourier Transform	Individual Homework	1 week	Curve and file pdf
13	Group Assignment 1	2, 4, 6	Presentation	Eulure Equation	Group Homework	1 week	File pdf
15	Individual Assignment 4	6	Essay	Euler – Lagrange Equation	Individual Homework	1 week	Slide ppt

III. Assessment Criteria (Learning Outcome Evaluation)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Individual Assignment	1,3, 4, 6	Written Test on EMAS	4x	30
Group Assignment	2, 4, 5	Presentation	2x	20
Mid – Term Exam	1, 3	Synchronous Exam and Submission via EMAS	1x	25
Final Exam	2, 4, 5, 6	Synchronous Exam and Submission via EMAS	1x	25
Total				100

IV. Rubric(s)

This rubric is used as a guideline for assessing or giving levels of student performance results. a rubric usually consists of assessment criteria that include the dimensions / aspects that are assessed based on indicators of learning achievement. This assessment rubric is useful for clarifying the basics and aspects of the assessment so that students and lecturers can be guided by the same thing regarding the expected performance demands. Lecturers can choose the type of rubric according to the assessment given.

A. Conversion of the student's final score

Score	Grade	Equivalent
85 - 100	A	4.00
80 - < 85	A-	3.70
75 - < 80	B+	3.30
70 - < 75	B	3.00
65 - < 70	B-	2.70
60 - < 65	C+	2.30
55 - < 60	C	2.00
40 - < 50	D	1.00
< 40	E	0.00

B. Assessment rubric: project report and papers

Criteria	A (90)	B (70)	C (60)	D (50)
Mathematical Formulation	Students are able to explain correct differential equations	Students are able to find the right symmetry but the written differential equations are not quite right	Students find that the symmetry is not quite right and the differential equation is written incorrectly	Students are not able to find the wrong symmetry and the written differential equations are incorrect
Determination of Boundary conditions	Students are able to write the exact boundary conditions	Students are able to find the right symmetry but the boundary conditions that are written aren't	Students find that the symmetry is not quite right and the boundary conditions are written incorrectly	Students are not able to find the right symmetry and the boundary conditions are

		quite right		written incorrectly
Contour Selection	Students are able to choose equations and apply the right theorems	Students are able to choose equations but the theorem applied is not quite right	Students choose equations that aren't quite right and the theorem is applied incorrectly	Students do not choose the right equation and the theorem is applied incorrectly