TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

Mathematical Methods in Physics 3

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 3	**Credit(s)**	**Prerequisite course(s)**	**Requisite for course(s)**	**Integration Between Other Courses**
Course Code	SCPH602112	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	*The application of mathematical methods in the form of special functions, including error functions, Gamma functions, Beta functions, Stirling formulas, Legendre equations, Rodrigues formulas, Legendre series, associated Legendre polynomials, Bessel equations, second type Bessel functions, Hermite functions, Laguerre functions, methods separation of variables in partial differential equations, Poisson's equation, Green's function and integral transformation methods, in physics problems that can be written in one, two or three dimensional partial differential equations*				

Program Learning Outcome (PLO)

PLO-1	Apply mathematical methods to solve physics problems analytically and computationally
Course Learning Outcome (CLO)	
CLO-1	Application of mathematical methods in the form of special functions and partial differential equations in physics problems
Sub-CLO(s)	
Sub-CLO 1	Able to apply Gamma function, Beta function and Stirling formula in solving integrals
Sub-CLO 2	Able to obtain and apply Legendre functions to physics problems
Sub-CLO 3	Able to obtain the solution of the Frobenius series from differential equations, in the form of Bessel, Hermite, Laguerre functions
Sub-CLO 4	Able to apply variable separation to differential equations and obtain solutions in the form of special functions
Sub-CLO 5	Able to apply integral transformation method and get solutions of partial differential equations
Study Materials	- Factorial, Gamma function and its recursive relation. - Beta function, error function, Stirling formula. - Legendre equation, Rodrigues formula, generating function for Legendre polynomials. - Legendre series, associated Legendre polynomials. - Bessel equation, Bessel function, recursion relation. - The second type of Bessel function, orthogonality of the Bessel function. - Hermite function, Laguerre function. - Partial differential equations: Laplace equation, wave equation, diffusion / heat flow equation, Schrodinger equation. - Solution with variable separation 1: Cartesian coordinates. - Variable separation 2: Cylindrical coordinates. - Variable separation 3: Ball coordinates. - Poisson's Equation, Green's function. - Laplace transform.

	- Fourier transform.
Reading List	• Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas). • Mathematical Methods for Physicists, 5th 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	Able to apply Gamma function, Beta function and Stirling formula in solving integrals	Video description of factorial functions, Gamma functions and their recursive relations. [Reference] Chapter 11 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 10 Mathematical Methods for Physicists, 5th 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. Students analyze character and application of functions and formulas in discussion materials **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	Students can analyze the nature of Gamma functions	Students are able to apply the Gamma function in solving integrals	15 %

2		Video description of Beta Functions, Error Functions and Stirling Formula [Reference] Chapter 11 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 10 Mathematical Methods for Physicists, 5th 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 Students analyze character and application of functions in the discussion material **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	Students can analyze characteristic of the Beta function and the Stirling formula	Students are able to apply Beta function and Stirling formula in solving integrals	
3	Able to obtain and apply Legendre functions to physics problems	Video description of Legendre Equation, Rodrigues Formula,	Interactif Lecture, *think pair share, self-study*	**Orientation (30%):** Before the class session, students watch a video of inheritance and the	Students can analyze characteristic of Legendre Series	Students are able to apply Legendre Series in solving integrals	15 %

		generating function for Legendre polynomials [Reference] Chapter 12 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 12 Mathematical Methods for Physicists, 5th Ed (George B. Arfken dan Hans J. Weber)	Discussion in forum and lecture *video conference* : 100 minutes	application of functions in EMAS **Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums Students analyze character and application of functions in the discussion material **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
4		Video description of Legendre Series, Legendre associated [Reference] Chapter 12 Mathematical Methods in the	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 series solutions of differential equations	Students are able to apply the Legendre series in solving physics problems	

		Physical Sciences, 3rd Ed (Mary L Boas) Chapter 12 Mathematical Methods for Physicists, 5th Ed (George B. Arfken dan Hans J. Weber)		Students discuss character and application of functions and formulas through discussion forums Students analyze character and application of functions in the discussion material **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
5	Able to obtain the solution of the Frobenius series from differential equations, in the form of Bessel, Hermite, Laguerre functions	Video description of Legendre Series, Legendre associated [Reference] Chapter 12 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 discuss character and application of functions and formulas through discussion forums	Students can analyze series solutions of differential equations	Students are able to apply the Bessel series in solving differential equations	20 %

		Chapter 11 Mathematical Methods for Physicists, 5th Ed (George B. Arfken dan Hans J. Weber)		Students analyze character and application of functions in the discussion material **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
6		Video description of Legendre Series, Legendre associated [Reference] Chapter 12 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 11 Mathematical Methods for Physicists, 5th Ed (George B.	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 Students analyze character and application of functions in the discussion material	Students can analyze series solutions of differential equations	Students are able to apply the Bessel function in solving differential equations	

		Arfken dan Hans J. Weber)		**Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
7		Video description of Legendre Series, Legendre associated [Reference] Chapter 12 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 13 Mathematical Methods for Physicists, 5th 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 Students analyze character and application of functions in the discussion material **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 Hermite and Laguerre functions in solving differential equations	

				and answers via video conferencing			
8	**Mid – Term Exam**						
9	Able to apply variable separation to differential equations and obtain solutions in the form of special functions	Partial differential equation (PDP) introduction video [Reference] Chapter 13 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 discuss character and application of functions and formulas through discussion forums Students analyze character and application of functions in the discussion material **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	Students can analyze the form of partial differential equations	Students are able to write physics problems in partial differential equations	30 %
10		Video descriptions of	Interactif Lecture, *think*	**Orientation (30%):**	Students can analyze the form	Students are able to write physics	

		PDP examples:: Laplace equation, Wave equation, Diffusion / Heat flow equation, Schrodinger equation [Reference] Chapter 13 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas)	*pair share, self-study* Discussion in forum and lecture *video conference* : 100 minutes	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 Students analyze character and application of functions in the discussion material **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	of partial differential equations	problems in partial differential equations	
11		Video description of the solution with variable separation 1: Cartesian coordinates	Interactif Lecture, *think pair share, self-study*	**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 1 dimensional partial differential equations	Students are able to apply partial differential equation solutions to 1-dimensional physics problems	

		[Reference] Chapter 13 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 8 Mathematical Methods for Physicists, 5th Ed (George B. Arfken dan Hans J. Weber)	Discussion in forum and lecture *video conference* : 100 minutes	**Exercise (30%)**: Students discuss character and application of functions and formulas through discussion forums Students analyze character and application of functions in the discussion material **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
12		Video description of the solution with variable separation 2: Cylinder coordinates [Reference] Chapter 13 Mathematical Methods in the	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	Students can analyze the form of 2-dimensional partial differential equations	Students are able to apply partial differential equation solutions to 2-dimensional physics problems	

		Physical Sciences, 3rd Ed (Mary L Boas) Chapter 8 Mathematical Methods for Physicists, 5th Ed (George B. Arfken dan Hans J. Weber)		through discussion forums Students analyze character and application of functions in the discussion material **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
13		Video description of the solution with variable separation 3: Ball Coordinates [Reference] Chapter 13 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 8 Mathematical	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 Students analyze character and application	Students can analyze the form of 3 dimensional partial differential equations	Students are able to apply partial differential equation solutions to 3-dimensional physics problems	

		Methods for Physicists, 5th Ed (George B. Arfken dan Hans J. Weber)		of functions in the discussion material **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
14	Able to apply integral transformation method and get solutions of partial differential equations	Video description of Poisson Equation and Green Function [Reference] Chapter 13 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 8 Mathematical Methods for Physicists, 5th 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 Students analyze character and application of functions in the discussion material **Feedback (10%)** :	Students can analyze the nature of the Poisson equation	Students are able to apply the Green function in solving physics problems	20 %

				Lecturers provide responses to the results of discussions and questions and answers via video conferencing			
15		Video description of Poisson Equation and Green Function [Reference] Chapter 13 Mathematical Methods in the Physical Sciences, 3rd Ed (Mary L Boas) Chapter 15 Mathematical Methods for Physicists, 5th 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 Students analyze character and application of functions in the discussion material **Feedback (10%)** : Lecturers provide responses to the results of discussions and questions and answers via video conferencing	Students can analyze the transformation of functions	Students are able to apply functional transformations to differential equations	

16	**Final Exam**

II. Assignment Design

Week	Assignment Name	Sub-CLOs	Assignment	Scope	Working Procedure	Deadline	Outcome
2	Individual Assignment 1	1	Problem Set	Application of Gamma Function, Beta, and Stirling Formula	Individual Homework	1 week	Curve and file. pdf
4	Individual Assignment 2	2	Problem Set	Application of Legendre Function in Physics Problems	Individual Homework	1 week	File. Pdf
6	Group Assignment 1	3	Problem Set	Derivation of special functions	Group Homework	1 week	Slide. Ppt
10	Individual Assignment 3	4	Problem Set	Series solutions of partial differential equations	Individual Homework	1 week	Curve and file. pdf
13	Group Assignment 2	4	Problem Set	Variable separation of pdp differential equations	Group Homework	1 week	Slide. Ppt
15	Individual Assignment 4	5	Problem Set	Transformation Function	Individual Homework	1 week	File. Pdf

III. Assessment Criteria (Learning Outcome Evaluation)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Individual Assignment	1, 2, 4, 5	Written Exam via EMAS	4x	20
Group Assignment	3, 4	Presentation	2x	20
Mid – Term Exam	1, 2, 3	Synchronous Exam and Submission via EMAS	1x	25
Final Exam	4, 5	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	Score	Indicator
Introduction	4	Contains: (1) background for the preparation of the report, (2) problem identification / gap analysis, (3) questions (4) objectives, and (5) citing relevant and current references
	3	Loads the goal and 3 of the other 4 items
	2	Loading objective and 2 of the other 4 items
	1	Does not contain the purpose of preparing the report, there are one or more than 4 other items
	0	Does not contain objectives and 4 other items
Content	4	Structured & cohesive, conducts a comprehensive literature review and performs a complete critical analysis

	3	Structured, conduct a comprehensive literature review and complete critical analysis
	2	Less structured, conducting literature reviews but less comprehensive and carrying out simple critical analysis
	1	Unstructured & cohesive, review of literature is not comprehensive and does not contain critical analysis
Conclusion	4	Related to the implementation of tasks and there are suggestions for feasible improvements to the next assignment
	3	It is related to the implementation of tasks and there are suggestions for improvement of the next assignment but it is not feasible
	2	Regarding the implementation of the task but no suggestions
	1	Not related to the execution of duties and no suggestions
	4	The report is neat and attractive, complete with cover and photo / picture
	3	The report is neat and attractive, with a cover or photo / image
	2	The report includes a cover or photo / image but is not neat or attractive
	1	The report is not neat and unattractive, does not have a cover and photo / image
	4	Easy to understand, correct word choice, and spelling all right
	3	Easy to understand, correct word choice, some misspellings
	2	Less understandable, inaccurate word choice, and some misspellings
	1	It is not easy to understand, the choice of words is not quite right, and there are lots of misspellings