TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

ADVANCED COMPUTATIONAL PHYSICS

by

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

TEACHING INSTRUCTIONAL DESIGN

Course Name	Advanced Computational Physics	**Credit(s)**	**Prerequisite course(s)**	**Requisite for course(s)**	**Integration Between Other Courses**
Course Code	SCPH603702	3	SCPH602214 Computational Physics	-	(See two columns to the left)
Relation to Curriculum	Elective Course				
Semester	6				
Lecturer(s)	Muhammad Aziz Majidi, Imam Fachruddin				
Course Description	This course aims to have participants able to apply numerical approaches, make microprogramming algorithms, and translate them to a computer program using the Fortran programming language or its equivalent, to solve problems in physics. The study materials in this course include finding the roots of functions, solving systems of linear equations, fitting using the least-square method, interpolation, numerical integration, solving ordinary and partial differential equations with boundary conditions, solving eigenvalue problems using the power method, solving secular equations or characteristic polynomial matrices.				

Program Learning Outcome (PLO)	
PLO-2	Applying mathematical methods to solve Physics problems analytically and computationally.
Course Learning Outcome (CLO)	
CLO-1	Apply numerical methods in calculations to solve problems in Physics.
CLO-2	Use the Fortran programming language or its equivalent to do calculations using numerical methods.
Sub-CLO(s)	
Sub-CLO 1	Make computer programs in the Fortran programming language or its equivalent.
Sub-CLO 2	Calculate the roots of functions using the bisection, false position, Newton-Raphson, and secant method.
Sub-CLO 3	Solve systems of linear equations using the Gauss elimination, LU decomposition, Jacobi iteration, and Gauss-Seidel iteration method.
Sub-CLO 4	Do data fitting using the Least-square method.
Sub-CLO 5	Make multidimensional interpolation using the Lagrange, cubic Lagrange, cubic Hermite, and cubic spline method.
Sub-CLO 6	Calculate integrals using the trapezoid, Simpson, and Gaussian method.
Sub-CLO 7	Calculate the solution to ordinary differential equations using the Euler, modified Euler, improved Euler, Runge-Kutta, and finite differences method.
Sub-CLO 8	Calculate the solution to elliptical, parabolic, and hyperbolic partial differential equations.
Sub-CLO 9	Solve eigenvalue equations.
Study Materials	finding the roots of functions, solving systems of linear equations, fitting using the Least-square method, interpolation, numerical integration, solving ordinary and partial differential equations with boundary conditions, solving eigenvalue problems using the power method, solving secular equations or characteristic polynomial matrices.
Reading List	**Required:** 1. P. L. DeVries, A First Course in Computational Physics (John Wiley & Sons, Inc., New York, 1994)

	2. M. Metcalf & J. Reid, Fortran 90/95 Explained (Oxford University Press, New York, 1998) **Supplementary:** W. H. Press, et. al., Numerical Recipes in Fortran 77, 2nd Ed. (Cambridge University Press, New York, 1992)

I. Teaching Plan

Week	Sub-CLO	Study Materials [with reference]	Teaching Method [with est. time]	Learning Experiences (*O-E-F)	Sub-CLO Achievement Indicator (*General-Specific)	Sub-CLO Weight on Course (%)
1	Make computer programs in the Fortran programming language or its equivalent (part 1)	Program structure, types of data, constants and variables, operators, branches, loops. M. Metcalf & J. Reid, *Fortran 90/95 Explained* (Oxford University Press, New York, 1998)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can explain program structure, types of data, constants and variables, operators, branches, and loops.	8%
2	Make computer programs in the Fortran programming language or its equivalent (part 2)	Subprograms, input and output, double-precision, and dynamic allocation of variable arrays. M. Metcalf & J. Reid, *Fortran 90/95 Explained* (Oxford University Press, New York, 1998)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can make a simple program.	8%
3	Calculate the roots of functions using the bisection, false position, Newton-Raphson, and secant method.	Bisection and false position methods, absolute and relative error. P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can calculate the roots of functions using the bisection method.	7%
4	Calculate the roots of functions using the bisection,	Newton-Raphson and secant methods.	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can calculate the roots of functions using the secant method.	7%

	false position, Newton-Raphson, and secant method.	P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)				
5	Solve systems of linear equations using the Gauss elimination, LU decomposition, Jacobi iteration, and Gauss-Seidel iteration method.	Gauss elimination and basic LU decomposition methods. P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can explain the solution to systems of linear equations using the Gauss elimination and basic LU decomposition methods.	7%
6	Solve systems of linear equations using the Gauss elimination, LU decomposition, Jacobi iteration, and Gauss-Seidel iteration method.	Gauss elimination, LU decomposition with row exchange, Jacobi iteration, Gauss-Seidel iteration methods. P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can solve systems of linear equations using the complete LU decomposition and Jacobi iteration methods.	7%
7	Do data fitting using the Least-square method.	Least-square method. P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can do data fitting using the Least-square method and make relevant graphs.	7%
8	Midterm Exam					
9	Make multidimensional interpolation using the Lagrange, cubic	Lagrange, cubic Lagrange, cubic Hermite, and cubic spline methods.	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can make multidimensional interpolations using the Lagrange and cubic Hermite methods.	7%

	Lagrange, cubic Hermite, and cubic spline method.	P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)				
10	Calculate integrals using the trapezoid and Simpson method.	Trapezoid, Simpson, and composite integration methods. P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can calculate numerical integrals using the trapezoid and composite Simpson methods.	7%
11	Calculate integrals using the Gaussian method.	Gauss-Legendre method, special cases in numerical integration. P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can explain integrals using the Gauss-Legendre method.	7%
12	Calculate the solution to ordinary differential equations using the Euler, modified Euler, and improved Euler method.	Euler, modified Euler, and improved Euler methods. P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can explain the solution to 1st order ordinary differential equations using the improved Euler method.	7%
13	Calculate the solution to ordinary differential equations using the Runge-Kutta, and finite	Runge-Kutta and finite differences methods. P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can calculate the solution to 2nd order ordinary differential equations using the Runge-Kutta and finite differences methods.	7%

	differences method.					
14	Calculate the solution to elliptical, parabolic, and hyperbolic partial differential equations.	Numerical formulation of elliptical, parabolic, and hyperbolic partial differential equations. P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can calculate the solution to parabolic partial differential equations.	7%
15	Solve eigenvalue equations.	Power method, and secular equations or polynomial characteristic matrices. P. L. DeVries, *A First Course in Computational Physics* (John Wiley & Sons, Inc., New York, 1994)	Discussion 150 minutes	Presentation of materials – question and answer discussion	Students can calculate eigenvalues using the power method.	7%
16	Final Exam					

II. Assignment Design

Week	Assignment Name	Sub-CLOs	Assignment	Scope	Working Procedure	Deadline	Outcome
2	Assignment 1	Make computer programs in the Fortran programming language or its equivalent	Making a simple program in the Fortran language or its equivalent	Simple program	Individual Assignment	1 week	Program file
3	Assignment 2	Calculate the roots of functions using the bisection, false position, Newton-Raphson, and secant method.	Making a bisection program	Finding the roots of functions using the bisection method	Individual Assignment	1 week	Program file
4	Assignment 3	Calculate the roots of functions using the bisection, false position, Newton-Raphson, and secant method.	Making a secant program	Finding the roots of functions using the secant method	Individual Assignment	1 week	Program file
6	Assignment 4	Solve systems of linear equations using the Gauss elimination, LU decomposition, Jacobi iteration, and Gauss-Seidel iteration method.	Making a LU decomposition program	Solving systems of linear equations using the LU decomposition method	Individual Assignment	1 week	Program file, inputs, and outputs
7	Assignment 5	Do data fitting using the Least-square method.	Making a least-square program	Data fitting using the Least-square method	Individual Assignment	1 week	Program file, inputs, outputs, and graphs
9	Assignment 6	Make multidimensional interpolation using the Lagrange, cubic Lagrange, cubic Hermite, and cubic spline method.	Making an interpolation program	Interpolation using the Lagrange and cubic Hermite method	Individual Assignment	1 week	Program file, inputs, outputs, and graphs

10	Assignment 7	Calculate integrals using the trapezoid, Simpson, and Gaussian method.	Making a Simpson program	Calculating integrals using the Simpson method	Individual Assignment	1 week	Program file
13	Assignment 8	Calculate the solution to ordinary differential equations using the Euler, modified Euler, improved Euler, Runge-Kutta, and finite differences method.	Making a Runge-Kutta program	Solving 2nd order ordinary differential equations using the Runge-Kutta method	Individual Assignment	1 week	Program file, inputs, outputs, and graphs
14	Assignment 9	Calculate the solution to elliptical, parabolic, and hyperbolic partial differential equations.	Making a parabolic program	Solving parabolic partial differential equations	Individual Assignment	1 week	Program file, inputs, outputs, and graphs
15	Assignment 10	Solve eigenvalue equations.	Making an eigenvalue program	Calculating eigenvalues using the power method	Individual Assignment	1 week	Program file

III. Assessment Criteria (Learning Outcome Evaluation)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Assignment 1	Sub-CLO 1	Fully functional computer program	1	4
Assignment 2	Sub-CLO 1 and 2	Fully functional computer program	1	4
Assignment 3	Sub-CLO 1 and 2	Fully functional computer program	1	4
Assignment 4	Sub-CLO 1 and 3	Fully functional computer program	1	4
Assignment 5	Sub-CLO 1 and 4	Fully functional computer program	1	4
Assignment 6	Sub-CLO 1 and 5	Fully functional computer program	1	4
Assignment 7	Sub-CLO 1 and 6	Fully functional computer program	1	4
Assignment 8	Sub-CLO 1 and 7	Fully functional computer program	1	4
Assignment 9	Sub-CLO 1 and 8	Fully functional computer program	1	4
Assignment 10	Sub-CLO 1 and 9	Fully functional computer program	1	4
Midterm Exam	Sub-CLO 1 to Sub-CLO 4	Fully functional computer program	1	30
Final Exam	Sub-CLO 1, Sub-CLO 5 to Sub-CLO 9	Fully functional computer program	1	30
			Total:	

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