TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

COMPUTATIONAL PHYSICS

by

Arief Syarifudin Fitrianto

Undergraduate Program in Physics
Faculty of Mathematics and Natural Sciences
Universitas Indonesia
Depok
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I. General Information

1.	Name of Program / Study Level	:	Physics / Undergraduate
2.	Course Name	:	Computational Physics
3.	Course Code	:	SCFI602021
4.	Semester	:	4th
5.	Credit	:	4 credits
6.	Teaching Method(s)	:	Interactive lectures (online and offline), independent study
7.	Prerequisite course(s)	:	Mathematical Physics 2, Mathematical Physics 3
8.	Requisite for course(s)	:	Advanced Computational Physics
9.	Integration Between Other Courses	:	None
10.	Lecturer(s)	:	Arief Syarifudin Fitrianto
11.	Course Description	:	After attending this lecture, when students are faced with physics problems that require the help of numerical analysis with computers, students are able to apply the basics of programming algorithms and numerical methods and design computer programs to solve these problems systematically, structurally, and optimally. This lecture teaches students various numerical methods that can be applied in physics as well as programming algorithm design methods to carry out numerical methods with the help of computers, which consist of Solving Linear and Non-Linear Equation Systems, Data Fitting Methods with Approximation and Interpolation, Derivative and Integral Numerics, and Differential Equations. This lecture uses the language of instruction in Indonesian.
12.	Online Class Platform	:	https://emas.ui.ac.id/

II. Graduate Learning Outcome (GLO), Course Learning Outcome (CLO), and Sub-CLOs

A. GLO

1. Able to apply classical and modern physics concepts in solving general physics problems.
2. Able to apply mathematical methods to solve physics problems analytically and computationally.
3. Able to apply knowledge of Physics in society and practical life, as well as identify and adapt to new things.

B. CLO

After completing this lecture, Physics students are expected to be able to apply numerical approaches, create computer programming algorithms to solve physics problems in algebra or calculus form.

C. Sub-CLOs

1. Be able to explain various numerical methods that can be used to solve physics problems quantitatively (C2).
2. Be able to reconstruct physics problems so that they can be solved quantitatively by numerical methods (C3).
3. Be able to design numerical algorithms and numeric programs in Python3 to be run by computers (C3).
4. Be able to analyze the results obtained from numerical methods in order to determine solutions that have precise and accurate physical meanings (C4).
5. Able to make a physics simulation project and the like using various numerical methods that have been studied (C5).

II. Teaching Plan

Week	Sub-CLO	Study Materials	Teaching		Learning Experiences (*O-E-F)		Sub-CLO Achievement Indicator		Ref.
			Method	Mode	Online	Offline	General	Specific	
1	1	Video introduction to mathematical models for physics.	Interactive lectures, independent study In-class lectures (2 x 100 minutes)	*Asynchronous using EMAS UI (self-study & discussion forum) *Synchronous using Video Conference	O: Before the class session, students are expected to watch an introduction video of mathematical models to physics through EMAS (30%) E: Students discuss various mathematical models that can be applied in physics (30%) F: Lecturers provide responses to the results of discussions and questions and answers via video conference (10%)	E: Students do group assignments related to mathematical modeling for Physics (30%)	After participating online and in discussions, students can create mathematical models for physics cases.	Students are able to choose and make appropriate mathematical models for each given physics case	[1], [2]
2 - 3	3	An introductory video to Python3 programming.	Interactive lectures, independent study In-class lectures (4 x 100 minutes)	Asynchronous using EMAS UI (self-study & discussion forum)	O: Students watching videos through EMAS (30%) E: Students practice Python3 programming using	E: Students do independent assignments related	Students are able to make Python3 programs	Able to create Python3 programs for simple problems in physics, such as free fall and straight motion.	[3]

				Synchronous using Video Conference	applications Anaconda/Miniconda and the editor of Spyder3 or Jupyter. F: Lecturers provide advice and direction through discussion forums	to Python3 programming.			
4	2	Video of solving linear systems with the Gaussian method. Video of linear system completion with LU decomposition method.	Interactive lectures, independent study In-class lectures (2 x 100 minutes)	Asynchronous using EMAS UI (self-study & discussion forum) Synchronous using Video Conference	O: Students watching videos through EMAS (30%) E: Students learn to reconstruct physics problems into a system of linear equations. F: The lecturer provides a question and answers session when students experience difficulties during practice.	E: Students are given several physics cases and related fields that can be reconstructed into a linear system to be solved by the method of solving.	Students are able to reconstruct a physics case in the form of a system of linear equations.	Students can reconstruct and solve physics problems in mechanics, magnetic electricity, and others using the linear system method.	[1], [2]
5	2	Video of non-linear equation systems and their solutions using the incremental	Interactive lectures, independent study In-class lectures (2	Asynchronous using EMAS UI	O: Students watching videos through EMAS		Students are able to recognize physics problems that can be solved with a	Students are able to reconstruct physics problems related to	[1], [2]

		search, bisection, newton-raphson, secant method. Video of solving linear systems using the Newton-Raphson method. Video of solving complex linear systems using the Laguerre method.	x 100 minutes)	Synchronous using Video Conference	E: Students solve problems related to finding the value 0 (root) of a function F: Lecturers provide advice and direction through discussion forums	E: Students work on assignments in the form of solving physics problems that can be reconstructed as a non-linear system.	system of non-linear equations.	mechanics, heat, magnetic electricity, and optics into non-linear system problems that can be solved numerically.	
6	2, 4	Video data fitting with Lagrange interpolation. Video data fitting with Newton interpolation.	Interactive lectures, independent study In-class lectures (2 x 100 minutes)	Asynchronous using EMAS UI Synchronous using Video Conference	O: Students watching videos through EMAS E: Students do assignments related to fitting observational data in physics. F: Lecturers provide advice and direction through online and offline discussions.	E: Students are given the task of processing simple data from observations, measurements, and experiments.	Students understand and are able to apply the interpolation method to the measurement result data.	Students are able to find the relationship between variables in the data through the fitting of the measurement/ observation data curve.	[1], [2]
7	4	Video examples of solving numerical cases in physics and mid-term exam preparation.	Interactive lectures, independent study In-class lectures (2 x 100 minutes)	Asynchronous using EMAS UI	O: Students watching videos through EMAS E: Students practice the preparation of the	E: Students work on cases given in	Students are able to solve cases given by groups.	Students successfully complete cases and present their work via video conferencing.	

					mid-term exam in groups and present the results F: Lecturers provide suggestions and directions after students make presentations.	groups, prepare presentations.			
8	2, 4	Video fitting data using the least-square approximation method.	Interactive lectures, independent study In-class lectures (2 x 100 minutes)	Asynchronous using EMAS UI Synchronous using Video Conference	O: Students watching videos through EMAS E: Students do assignments related to fitting observational data in physics. F: Lecturers provide advice and direction through online and offline discussions.	E: Students are given the task of processing simple data from observations, measurements, and experiments.	Students understand and are able to apply the least-square method to measurement data.	Students are able to find the relationship between variables in the data through the fitting of the measurement/ observation data curve.	[1], [2]
9	2, 4	Learning videos on numerical integration.	Interactive lectures, independent study In-class lectures (2 x 100 minutes)	Asynchronous using EMAS UI	O: Students watching videos through EMAS E: Students do assignments related to numerical integration of data and functions.	E: Students work on assignments related to the numerical integration method to solve several	Students are able to explain and apply the trapezoid integration method, Simpson, and Romberg.	Students are able to solve cases in Basic Physics with the numerical integration method.	[1], [2]

				Synchronous using Video Conference	F: Lecturers provide advice and direction through online and offline discussions.	physics problems and related fields.			
10	2, 4	Learning videos on numerical differentials.	Interactive lectures, independent study In-class lectures (2 x 100 minutes)	Asynchronous using EMAS UI Synchronous using Video Conference	O: Students watching videos through EMAS E: Students do assignments related to numerical differentials on data and functions. F: Lecturers provide advice and direction through online and offline discussions.	E: Students work on assignments related to finite difference methods for numerical differentials to solve several physics problems and related fields.	Students are able to explain and apply the method of finite difference and Richardson's extrapolation for numerical differentials.	Students are able to solve physics cases related to the differentiation of a function against certain variables.	
11- 12	2, 4	Video for learning 1st-order differential equations. Video for learning 2nd-order differential equations.	Interactive lectures, independent study In-class lectures (3 x 100 minutes)		O: Students watching videos through EMAS E: Students work on assignments related to differential equations in physics.	E: Students work on assignments related to numerical differential equations to solve several physics problems and related fields.	Students are able to explain and apply the Euler and Runge-Kutta methods to solve numerical differential equations.	Students are able to reconstruct physics problems into differential equations that can be solved by numerical methods.	

					F: Lecturers provide advice and direction through online and offline discussions.				
Start from 3, presented on 13-14	5	Physics Simulation Project	Independent and group study	Asynchronous, independent learning	O: Students get explanations related to simulation projects and numerical applications in physics. E: Students make project proposals and upload them to EMAS, then present the results of the projects they make. F: Lecturers provide suggestions and directions for the proposed project proposals.	E: Students design a physics simulation project or apply numerical methods in the field of physics, make reports on work and results, create simulation programs.	Students are able to apply numerical methods to a physics simulation project, physics education, and physics applications in various fields.	Students are able to produce a computer application product that applies various numerical methods that have been studied.	

*) O : Orientation
E : Exercise
F : Feedback

Asynchronous : learning interactions are carried out flexibly and not necessarily at the same time, for example using a discussion forum or independent study/student assignments.

Synchronous : learning interactions between lecturers and students are carried out at the same time, using video conferencing or chat technology.

References:

[1] Burden & Faires, *Numerical Analysis*, 10 ed.

[2] Stephen Chapra, *Numerical Methods for Scientist and Engineer*, 7 ed.

[3] Hans P Langtangen, *A Primer on Scientific Computing with Python 3*, 5ed.

III. Assignment Design

Week	Assignment Name	Sub-CLOs	Assignment	Scope	Working Procedure	Deadline	Outcome
2	T1	1, 3	Students create mathematical models for several cases in Basic Physics and the Python3 program for solving them.	Mathematical modeling for physics as well as Python3 programming for science.	Independent assignments and uploaded to EMAS	1 week	Answer sheets to work on questions in PDF form and Python3 programs in zip/7z files.
4	T2	2, 3, 4	Students solve linear and non-linear system problems in Physics.	Linear Equation System	Independent assignments and uploaded to EMAS	1 week	Answer sheets to work on questions in PDF form and Python3 programs in zip/7z files.
6	T3	2, 3, 4	Students solve non-linear problems in physics along with data fitting with interpolation.	Non-linear systems and data interpolation.	Independent assignments and uploaded to EMAS	1 week	Answer sheets to work on questions in PDF form and Python3 programs in zip/7z files.
9	T4	2, 3, 4	Students solve problems related to data fitting with least-squares and numerical integration.	Data fitting with least-square numerical integrals.	Independent assignments and uploaded to EMAS	1 week	Answer sheets to work on questions in PDF form and Python3 programs in zip/7z files.
12	T5	2, 3, 4	Students solve physics problems with numerical differential equations.	Differential and numerical differential equations.	Independent assignments and uploaded to EMAS	1 week	Answer sheets to work on questions in PDF form and Python3 programs in zip/7z files.
3-12	T6	1, 2, 3, 4, 5	Students make a numerical method application project in Physics.	All material in this course.	Independent assignments and uploaded to EMAS	10 weeks	Project work reports, project results papers, presentation materials, and Python3 codings of applications made.

IV. Assessment Criteria (Learning Outcome Evaluation)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Mid-Term Exam	1, 2, 3, 4	Written test via EMAS	1	25
Final Exam	1, 2, 3, 4	Written test via EMAS	1	25
Weekly assignments and quizzes	1, 2, 3, 4	Assessment forms via EMAS	7	20
Project Report Presentation	1, 2, 3, 4, 5	Project assessment form	1	30
			Total	**100**

V. Rubric(s)

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 (75)	C (60)	D (50)
Organization (Overall sequence, flow, and transition)	Information is presented in an effective order. The excellent structure of paragraphs and transitions improves	Information is logically ordered by paragraphs and transitions. Within a section, the order in which ideas are presented may	Information is scattered and needs further development.	There is no clear sequence of paragraphs, so there is no progressive flow of ideas. The details and examples are

	readability and comprehension. The Executive Summary or abstract is presented first, allowing the reader to easily follow the rest of the report.	be confusing at times.		disorganized, difficult to follow and understand.
Information Quality	Supporting details are specific to the topic and provide the necessary information.	Some details do not support the topic of the report.	Details are a bit vague.	Unable to find certain details.
Introduction	The introductory paragraph is clearly stated, has a sharp focus, is different, and increases the impact of the report.	The introductory paragraph is clearly stated with focus.	The introductory paragraph is unclear.	The introductory paragraph is unclear.
Conclusion	Conclude paragraphs summarize and draw clear, effective conclusions and increase the impact of the report.	Summarize the following paragraphs and summarize the discussion report and draw conclusions.	Closing paragraphs are only remotely related to the topic of the report.	Closing paragraphs are not clear.
Use of language (choice of words, grammar, and sentence structure)	Sentences are complete and grammatical, and they flow together easily.	For the most part, sentences are complete and grammatical, and they flow	Minor mistakes in sentence structure and grammar are frequent enough	Major mistakes in sentence structure and grammar are frequent enough

	The word is chosen for its proper meaning.	together easily. Every mistake is minor and doesn't distract the reader. Repetition of the same words and phrases is avoided.	that they detract from the reader and distract from meaning. There are unnecessary repetitions of the same words and phrases.	that they distract the reader and interfere with meaning. There are unnecessary repetitions of the same words and phrases.
Use of images	All figures, graphics, and pictures are accurate, consistent with the text, and of good quality. They increase understanding of the text. All are properly labeled according to engineering standards and referenced in the text.	For the most part, numbers, graphics, and images are accurate, consistent with the text, and are of good quality. They are generally labeled correctly according to engineering standards. All referenced in the text.	Few of the numbers, graphics, and images are accurate, consistent with the text, and of good quality. They are not labeled properly.	Numbers, graphics, and images are of poor quality, have a lot of inaccuracies, and are mislabeled, or may be missing. There may be appropriate explanatory text or there may be redundancy with the text.
Bibliography	All sources are cited and appear in the correct format.	All sources are cited but appear in an incorrect format.	Several sources cited appear but are not all. Not formatted properly.	The source is not cited in the paper or the proper format is not used.
Critical	This report discusses strengths and weaknesses and suggests ways that could be improved	This report discusses strengths and weaknesses.	This report discusses either the strengths or weaknesses of the findings but not both.	This report does not mention strengths or weaknesses.
Connection	This report creates a suitable	Reports create appropriate	Reports create unclear or	The report does not establish a

	relationship between all the key components (problem solution, problem to problem, solution to solution).	relationships between several components.	inappropriate relationships between components.	connection, only displays components.
Analysis	This paper succeeds in breaking down arguments, problems, or problems into relevant sections. The relationship between the parts is clear and very accurate.	This paper is successful in breaking down arguments, problems, or problems into relevant sections. The relationship between the parts is quite accurate.	This paper breaks down an argument, problem, or problem into sections, but some sections may be missing or unclear. The relationship between the components is somewhat accurate.	The parts identified are not correct and/or relevant. The relationships between the parts are completely inaccurate.
Analysis depth	The results were analyzed carefully and objectively. Interpretations are made using appropriate equations, models, or theories.	The analysis is detailed enough to aid understanding but is not enhanced by equations, models, or theories.	The analysis is so vague that the reader is barely able to evaluate the validity of the interpretation of the findings.	The analysis is so inadequate that the reader is unable to evaluate the validity of the interpretation of the findings.
Synthesis	This paper succeeded in integrating all the relevant sections from various places into a coherent	This paper integrates the most relevant passages from the various places into a largely coherent	This paper integrates several sections from various places into a rather coherent whole. The	The parts to be integrated are unclear and/or relevant. The relationship between the parts is unclear.

	whole. The relationship between the components is clear and insightful.	whole. The connections between the sections are generally clear.	relationship between the components is somewhat unclear.	
Professionalism				
Visual format	This document is visually appealing. The white space and color are just right for separating blocks of text and adding emphasis. Readers can easily navigate documents.	Using white space and color helps readers navigate the document, although layouts can be more effective and attractive.	The document is not visually appealing and there are several "cues" to help the reader navigate the document.	This document is unattractive and has no visual cues.
Ability to define terms and jargon	Terms and jargon are used correctly. They define it at the start of the report.	For the most part, terms and jargon are used correctly. There have been several attempts to define them.	?	Excessive terms and jargon without adequate explanation.
Self Evaluation				
Group analysis (the process and the role of the individual in it)	Clear articulation of what is working well and why, what is not working well and why, and ways of increasing the effectiveness and efficiency of the group in the	Only discuss two of the three; discuss groups without discussing themselves, discussing themselves without discussing groups.	Doesn't articulate one of the three - what works well and why, what doesn't work well and why, how to improve.	

	process for the future, remembering oneself as well as others.			

C. **Assessment rubric: presentations**

Criteria	A (90)	B (75)	C (60)	D (50)
Get the audience's attention.	Provide a funny detail or fact, a series of questions, a short demonstration, colorful visuals, or a personal reason why they chose this topic.	Do two introductory sentences, then start the speech.	Not trying to get the audience's attention, just starting the speech.	
Style	The presentation level is appropriate for the audience. Planned presentation, conversation, pacing for audience understanding. This is not a paper reading. The speakers are clearly comfortable at the front of the group and can be heard by all.	The presentation level is generally appropriate. The pacing is sometimes too fast or slow. The presenter seems a little uncomfortable and the audience occasionally has a hard time hearing the presenter.	The presentation aspect is too basic or too sophisticated for the audience. The presenter seems uncomfortable and can be heard only if the listener is very attentive. Most of the information is read.	Presentations are consistently too basic or too sophisticated for the audience. Information is read to the audience. The presenter was clearly anxious and inaudible.
Use of communication aids (slides, posters,	Communication helps improve presentations. They are	Communication helps contribute to the quality of the presentation.	Poorly prepared or improperly used communication	No communication aids were used, or they were so

handouts, etc.)	prepared in a professional manner. The fonts on the visuals are large enough for all to see. Information is organized to maximize audience understanding. Minimized details.	The font size is suitable for reading. Appropriate information is included. Some materials are not supported by visual aids.	tools. Fonts are too small to be seen easily. Too much information included. Unimportant material is highlighted. The listener may be confused.	ill-equipped that they detracted from the presentation.