TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

INTRODUCTION TO NUCLEAR PHYSICS

by

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I. General Information

1.	Name of Program / Study Level	:	Physics / Undergraduate
2.	Course Name	:	Introduction to Nuclear Physics
3.	Course Code	:	SCPH603135
4.	Semester	:	5th
5.	Credit	:	3 credits
6.	Teaching Method(s)	:	Lecture and discussion
7.	Prerequisite course(s)	:	Modern Physcs
8.	Requisite for course(s)	:	Nuclear and Particle Physics, Scattering Theory, Physics of Energy
9.	Integration Between Other Courses	:	None
10.	Lecturer(s)	:	1. Prof. Dr. Terry Mart 2. Prof. Dr. Anto Sulaksono 3. Dr. rer. nat. Agus Salam 4. Dr. Imam Fachruddin
11.	Course Description	:	This course aims at lecture participants to be able to explain the properties of the atomic nucleus, nuclear processes, and the benefits of nuclear physics. Formation of matter includes Rutherford scattering, nuclear properties, binding energy, bonding fraction, surface effect, energy separation, nuclear radius, semiempirical mass formula, core spin, core electric moment, nuclear magnetic moment, nuclear instability, radioactivity, core models , nuclear force, particle physics, fundamental interactions, quark models, nuclear astrophysics, accelerators, detectors, nuclear reactors, the benefits of nuclear physics.

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

A. GLO

1. Applying classical and modern physics concepts in solving general physics problems.
2. Formulating problems and solving Physics and its application, as well as interdisciplinary problems related to science and mathematics clumps critically, creatively, and innovatively.

B. CLO

After completing this lecture, Physics students are expected to be able to describe the properties of the atomic nucleus, nuclear processes, and the benefits of nuclear physics.

C. Sub-CLOs

1. Explaining the existence of the atomic nucleus, Rutherford's scattering experiment, the basic structure of the atomic nucleus.
2. Describe the properties of the atomic nucleus, including binding energy, bonding fraction, surface effect, energy separation, nuclear radius, semiempirical mass formula, nuclear spin, nuclear electric moment, nuclear magnetic moment.
3. Describes core instability and radioactivity.
4. Describe core models.
5. Describe the nuclear force at the hadronic level and its properties.
6. Describes energy production and nucleosynthesis in stars.
7. Describes the basic knowledge of particle physics as well as the fundamental weak and strong interactions according to the quark model.
8. Describes the working principles of nuclear and particle physics equipment, such as nuclear accelerators, detectors, and reactors.
9. Explain the benefits of nuclear physics.

II. Teaching Plan

Week	Sub-CLO	Study Materials	Teaching Method	Time Required	Learning Experiences (*O-E-F)	Sub-CLO Weight on Course (%)	Sub-CLO Achievement Indicator	Ref.
1	1	Thomson's atomic model, Rutherford scattering illustration, Rutherford model of atom, the basic structure of the nucleus, some terms regarding the atomic nucleus, magic number	Discussion	150 minutes	Presentation of material - question and answer discussion	8%	Describe the existence of the atomic nucleus and its structure	[1]
2	1	Rutherford scattering calculation, scattering cross section	Discussion	150 minutes	Presentation of material - question and answer discussion	8%	Describe the cross-section of the scattering	[1]
3	2	Binding energy, bonding fraction, surface effect, separation energy, nuclear radius, semiempirical mass formula	Discussion	150 minutes	Presentation of material - question and answer discussion	8%	Explain and calculate binding energy, separation energy, nuclear radius, explain bond fraction, surface effect, semiempirical mass formula	[1]
4	2	Core spin, core electric moment, dipole moment and quadrupole moment, nucleon magnetic moment, core magnetic moment, effective core magnetic moment	Discussion	150 minutes	Presentation of material - question and answer discussion	8%	Describe core spin, core electric moment, dipole moment and quadrupole moment of nucleus, nucleon magnetic moment, core magnetic moment, effective core magnetic moment	[1]
5	3	Core instability, core instability form, dynamic instability, beta instability,	Discussion	150 minutes	Presentation of material - question	8%	Describe dynamic instability, beta	[1]

		introduction of the base of the nuclear reactor			and answer discussion		instability, uranium fuels, chain reactions, general parts of a nuclear reactor	
6	3	Radioactivity, natural radioactive core, radioactive calculations, radioactive quantities and units, radioactive age determination of geological objects and organic objects	Discussion	150 minutes	Presentation of material - question and answer discussion	8%	Describe the phenomenon of radioactivity, calculate radioactive quantities	[1]
7		**Mid-Term Exam**						
8	4	Core model types: independent and collective, liquid drop model, Fermi gas model	Discussion	150 minutes	Presentation of material - question and answer discussion	8%	Describes the independent and collective core models, liquid drop models, Fermi gas models	[1]
9	4	Skin model, rotational model, vibrational model, Nilsson model, alpha model	Discussion	150 minutes	Presentation of material - question and answer discussion	8%	Describe skin models, rotational models, vibrational models, Nilsson models, alpha models	[1]
10	5	Nuclear force / strong interaction at the hadronic level, Yukawa's idea, carrier mass relationship and interaction range, nucleon-nucleon (NN) interactions as pawn exchanges, types of NN interaction models, empirical properties of NN interactions, NN scattering and deuteron	Discussion	150 minutes	Presentation of material - question and answer discussion	8%	Describe Yukawa's ideas, carrier mass relations and interaction range, nucleon-nucleon (NN) interactions as pawn exchanges, types of NN interaction models, empirical properties of NN interactions, NN and deuteron scattering	[1]

11	6	First generation star formation, proton cycle, energy production and nucleosynthesis in first generation stars, star evolution, second generation star formation, energy production and nucleosynthesis in second generation stars	Discussion	150 minutes	Presentation of material - question and answer discussion	8%	Describes first generation stars, second generation stars, energy production and nucleosynthesis, stellar evolution	[1]
12	7	The fundamental force and its carrier, classifying particles as hadrons and leptons, classifying hadrons as mesons and baryons, antiparticles, leptons number, baryon number, strangeness number, quark and lepton model (standard model of particle physics), charm number, topness number, number beauty, strong interaction and weak interaction according to the quark model	Discussion	150 minutes	Presentation of material - question and answer discussion	8%	Describe the fundamental force and its carrier, hadron, lepton, meson, baryon, antiparticle, lepton number, baryon number, strangeness number, quark, gluon, strong interaction and weak interaction according to the quark model	[1]
13	8	Type of collision: fixed target collision and head on collision, accelerator, detector	Discussion	150 minutes	Presentation of material - question and answer discussion	5%	Describe the working principle of nuclear and particle physics equipment	[1]
14	9	The benefits and applications of nuclear physics in life	Discussion	150 minutes	Presentation of material - question and answer discussion	7%	Describe the benefits and applications of nuclear physics to life	[1]
15	**Final Exam**							

*) O : Orientation
E : Exercise
F : Feedback

References:

[1] P. E. Hodgson, E. Gadioli, E. Gadioli Erba, *Introductory Nuclear Physics*, Oxford U. Press, 2000.

[2] W. E. Meyerhof, *Elements of Nuclear Physics*, McGraw-Hill Book Co., 1989.

III. Assignment Design

Week	Assignment Name	Sub-CLOs	Assignment	Scope	Working Procedure	Deadline	Outcome
13	Presentation on nuclear and particle physics equipment	8	Describe and explain the working principles of nuclear and particle physics equipment	The working principle of nuclear and particle physics equipment	As a group, explain and explain the working principles of nuclear and particle physics equipment, then answer questions in the discussion	1 week	Presentation and discussion
14	Presentation on the benefits of nuclear physics	9	Describe and explain the benefits of nuclear physics	Benefits of nuclear physics	As a group, explain and explain the benefits of nuclear physics, then answer the questions in the discussion	1 week	Presentation and discussion

IV. Assessment Criteria (Learning Outcome Evaluation)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
1st Group Presentation	8	Presentation and discussion	1	20
2nd Group Presentation	9	Presentation and discussion	1	20
Mid-Term Exam	1 - 3	Written test	1	30
Final Exam	4 - 7	Written test	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	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