TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

INTRODUCTION TO RADIOLOGY PHYSICS

by

Dwi Seno Kuncoro Sihono, M.Si.
Supriyanto Ardjo Pawiro, Ph.D.

Undergraduate Program in Physics
Faculty of Mathematics and Natural Sciences
Universitas Indonesia
Depok

August 2016

PREFACE

Post-1998 reform, the world of education in Indonesia faced global challenges that demanded a paradigm shift in teaching and learning. The old teacher-centered paradigm is no longer able to answer needs in the real world. The new student-centered paradigm, which focuses on students, opens opportunities to fulfill students' need for knowledge under the challenges in the real world.

One of the characteristics of student-centered learning (active learning) is a teaching design that is open to students. Thus, students get comprehensive information about competencies they are going to have, ways to obtain them, and the references they need.

This student work manual is a guide for students to achieve the educational goals. This book was developed from the teaching design of the Introduction to Radiology Physics course. It is expected for students to meet the latest demand of the world of education in Indonesia.

Depok, August 2016

Dwi Seno Kuncoro Sihono, M.Si.

Supriyanto Ardjo Pawiro, Ph.D

I. General Information

1.	Name of Program / Study Level	:	Physics / Undergraduate
2.	Course Name	:	Introduction to Radiology Physics
3.	Course Code	:	SCFI603911
4.	Semester	:	5
5.	Credit(s)	:	2 credits
6.	Teaching Method(s)	:	Collaborative learning
7.	Prerequisite course(s)	:	Modern Physics
8.	Requisite for course(s)	:	Introduction to Radiotherapy Physics, Introduction to Health Physics & Radiation Protection, Introduction to Medical Imaging & Nuclear Medicine, Laboratory Work of Medical Physics & Counter System, Laboratory Work of Radiology Physics, Internship
9.	Integration Between Other Courses	:	None
10.	Lecturer(s)	:	Supriyanto Ardjo Pawiro, Ph.D.
11.	Course Description	:	This course is a key subject in Medical Physics specialization. This course provides knowledge to students about the principles of physics in the field of radiology and dosimetry. Starting with the quantities and units used in radiology, then the interaction of radiation with a matter focuses on energy transfer and dose deposition. Students should understand the exponential attenuation for narrow and broad radiation before learning about shielding design systems for diagnostic and therapeutic facilities. The application of electronic balance and cavity theory underlies dosimetry using ionization chamber

detectors. This course covers the balance system's use in measuring the dose with the ionization chamber or with a solid material detector.

II. Course Learning Outcome (CLO) and Sub-CLO

A. CLO

Students can describe the basic principles and concepts of radiation physics and dosimetry.
(ELO(s) 3, 5, 6, and 7)

B. Sub-CLO

1. To understand and describe the definition and classification of radiation (C3).
2. To understand and describe radiation quantities and their unit (C3).
3. To understand and describe exponential attenuation (C2).
4. To describe direct and indirect ionizing radiation (C3).
5. To describe radiation interactions with matter (C3).
6. To describe radioactive decay (C3).
7. To describe charged-particle and radiation equilibrium (C2).
8. To learn and understand radiation dosimetry (C2).
9. To describe cavity theory (C2).
10. To learn ionization chamber (C2).
11. To describe photon and electron beams calibration with cavity ion chamber (C3).
12. To describe the relative and absolute technique of dosimetry (C3).

III. 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	References
1	1	Radiation classification	Lecturing	100 minutes	100% O, 0% E, 0% F	6	To describe quantities and units in radiation physics, types and sources of direct and indirect ionizing radiation, and description of the ionizing radiation field	1,2,3,4, and 5
2	2	Radiation unit and quantities	Lecturing	100 minutes	30% O, 50% E, 20% F	6	To describe units and quantities to express the radiation field (fluence and fluence rate; energy fluence and energy fluence rate) as well as quantities and units used to express radiation interactions with matter including kerma, collision kerma, radiative kerma, absorption dose, activity, energy transfer, net energy transfer, energy imparted, equivalent dose, and factors of exposure quality	1,2,3,4, and 5
3	3	Exponential attenuation	Lecturing	100 minutes	30% O, 50% E, 20% F	6	To describe simple exponential attenuation: a. Half value layer (HVL), tenth value layer (TVL), attenuation coefficient, cross-section b. Narrow-beam and broad-beam attenuation c. The buildup factor d. Spectral effects e. The reciprocity theorem f. Energy transfer coefficient g. Energy absorbed coefficient h. Calculation of absorbed dose in photon beam interaction	1,2,3,4

4	4	Direct and indirect ionizing radiation	Lecturing	150 minutes	50% O, 30% E, 20% F	8	To describe: 1. Indirect ionizing radiation : photon beam - X-ray transition, characteristic radiation, ionization, and exitation - Moseley's law, X-ray spectrum, Hartree-Fock theory for many-electron system - Radiation of accelerated charged particles, bremsstrahlung formation, Larmor formula - X-ray target, bremsstrahlung - Beam quality and filtration - Energy deposition in tissue by photon beam. 2. Direct ionizing radiation - Types of charged particle beam used for clinical purposes - Source of charged particle beam - Energy deposition in tissue by charged particle beam	1,2,3,4
5,6	5	Radiation interaction with matter	Lecturing	150 minutes	50% O, 30% E, 20% F	8	To describe: 1. Photon interaction with matter a. Thomson scattering b. Raleigh scattering c. Photoelectric effect d. Compton effect e. Pair and triplet production f. Photonuclear interactions g. Predominant individual effects h. Effects following individual photon interaction, resulting fluorescence, Auger effect. i. Contribution of individual	1,2,3,4, and 5

							effect on attenuation coefficient, energy transfer coefficient, and energy absorption coefficient. 2. Interaction of direct ionizing radiation with matter a. Stopping power (collision and radiative), scattering power, range, straggling b. Restricted stopping power, linear energy transfer c. Orbital electron interaction d. Nuclear interaction e. Calculation of absorbed dose in interaction with charged particle	
7	6	Radioactive decay	Lecturing	100 minutes	50% O, 20% E, 30% F	6	To describe total and partial decay constant, average lifetime and half-life, parent-daughter relation, transient and secular equilibrium, harvesting of daughter product, radioactivation by nuclear interaction, exposure rate and air kerma rate constant.	1,2,3,4
8	**Mid-Term Exam**							
9	7	Charged-particle and radiation equilibrium	Lecturing	100 minutes	50% O, 20% E, 30% F	6	To describe radiation equilibrium, charged-particle equilibrium (CPE), relation of absorbed dose, collision kerma, and exposure to CPE, CPE failure, transient CPE	1,2,3,4
10	8	Radiation dosimetry	Lecturing	100 minutes	50% O, 20% E, 30% F	6	To describe general types and characteristics of dosimeter, definition of units and quantities based on ICRU, absolute and relative techniques of dosimetry, and interpretation of dosimeter measurement.	1,2,3,5
11	9	Cavity theory	Lecturing	100 minutes	50% O, 20% E, 30% F	6	To describe Bragg-Gray theory and its consequences, Spencer-Attix and Burlin cavity theory, the Fano theorem, averaging stopping powers, and dose near interfaces	1,2,3,5

12	10	Ionization chamber	Lecturing	100 minutes	50% O, 20% E, 30% F	6	To describe conventional designs of ionization chambers, novel free-air-chamber designs, thimble-type chambers, extrapolation chambers, charge and current measurements, average energy of ion pair, ion-chamber saturation, ionic recombination, diffusion loss	1,2,3,5
13	11	Photon and electron beams calibration with cavity ion chamber	Lecturing	100 minutes	50% O, 20% E, 30% F	6	To describe absolute cavity ion chambers, air kerma and dose in water, dosimetry protocols: AAPM TG-21, AAPM TG-51, IAEA TRS-398, phantom material for photon and electron beam	1,2,3,5
14,15	12	Relative and absolute technique of dosimetry	Lecturing	100 minutes	50% O, 20% E, 30% F	6	To describe: a. Thermoluminescence dosimetry (TLD) b. Photographic dosimetry c. Semiconductor dosimeter: diode d. Optically stimulated luminescence (OSL) e. MOSFET dosimetry (metal oxide semiconductors-field effect transistor), and diamond detector f. Gel dosimetry g. Geiger-Muller (GM) and proportional counters h. Scintillation dosimetry i. Survey meter j. Neutron detector k. SSDL and PSDL l. Tracebility detector	1,2,3,5
16	**Final Exam**							

*) O : Orientation
E : Exercise
F : Feedback

References:

1. Podgorsak, *Radiation Oncology Physics: Handbook for Teacher and Student*. (IAEA, 2005)
2. Metcalfe, et al, *The Physics of Radiotherapy X-rays and Electron*. (Medical Physics Publishing, 2007)
3. F. H. Attix. *Introduction of Radiological Physics and Radiation Dosimetry* (John Willey and Sons, New York, NY, 1986)
4. H. E. Johns and J. R. Cunningham. *The Physics of Radiology*, 4th ed. (Charles C. Thomas, Springfield, IL, 1983)
5. J. F. Knoll. *Radiation Detection and Measurement*. 3rd. ed. (John Willey and Sons, New York, NY, 2000).

IV. Assignment Design

Week	Assignment Name	Sub-CLO	Assignment	Scope	Working Procedure	Deadline	Outcome
1	Quiz	1-12	Problem set	Radiation unit and quantities; Exponential attenuation; Direct and indirect ionizing radiation; Radiation interaction with matter; Radioactive decay; Charged-particle and radiation equilibrium; Radiation dosimetry; Cavity theory; Ionization chamber; Photon and electron beams calibration with cavity ion chamber; Relative and absolute technique of dosimetry	Homework	1 week	Written report
2	Group Assignment 1	2	Problem set	Radiation unit and quantities	Group work	1 week	Group paper and presentation
3	Group Assignment 2	3	Problem set	Exponential attenuation	Group work	1 week	Group paper and presentation
4	Group Assignment 3	4	Problem set	Direct and indirect ionizing radiation	Group work	1 week	Group paper and presentation
5,6	Group Assignment 4	5	Problem set	Radiation interaction with matter	Group work	1 week	Group paper and presentation
7	Group Assignment 5	6	Problem set	Radioactive decay	Group work	1 week	Group paper and presentation
8	**Mid-Term Exam**						
9	Group Assignment 6	7	Problem set	Charged-particle and radiation equilibrium	Group work	1 week	Group paper and presentation
10	Group Assignment 7	8	Problem set	Radiation dosimetry	Group work	1 week	Group paper and presentation
11	Group Assignment 8	9	Problem set	Cavity theory	Group work	1 week	Group paper and presentation
12	Group Assignment 9	10	Problem set	Ionization chamber	Group work	1 week	Group paper and presentation
13	Group Assignment 10	11	Problem set	Photon and electron beams calibration with cavity ion chamber	Group work	1 week	Group paper and presentation

14,15	Group Assignment 11	12	Problem set	Relative and absolute technique of dosimetry	Group work	1 week	Group paper and presentation
16	**Final Exam**						

V. Assessment Criteria (Learning Outcome Evaluation)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Quiz	1-12	Quiz	2	20
Group Assignment	1-12	Presentation	12	30
Mid-Term Exam	1-6	Essay	1	25
Final Exam	7-12	Essay	1	25
Total				**100**

VI. Rubric(s)

A. Criteria of Group Paper Score

Nilai	Paper Delivery
90-100	Students can apply basic concepts in explaining natural phenomena and technology with 80-90% accuracy, coherently, in the correct language.
70-89	Students can apply basic concepts in explaining natural phenomena and technology with 60-79% accuracy and good language.
60-69	Students can apply basic concepts in explaining natural phenomena and technology with 59% accuracy and good language.

B. Criteria of Presentation Score

Nilai	Presentation Delivery
90-100	Students master the materials and can present them using correct Indonesian with clear and understandable explanations and good body language.
70-89	Students master the materials and can present them with clear and understandable explanations and good body language.
60-69	Students can present the materials with clear and understandable explanations and good body language.

C. Quiz, Mid-Term Exam, and Final Exam

[1] Able to express ideas in solving problems (25%)

[2] Able to determine the right basic concepts in solving problems (35%)

[3] Able to formulate final solutions (30%)

[4] Able to use appropriate units and significant figures (10%)