Academic Year	2020/2021	**Semester**	2
Course Coordinator	James Lee Cheow Lei		
Course Code	PH4605		
Course Title	Medical Physics for Radiotherapy		
Pre-requisites	PH3101 – Quantum Mechanics ll or Approval by Division of Physics & Applied Physics		
No of AUs	4 AU		
Contact Hours	Lecture: 39 hours, Tutorials: 12 hours (3 hr – lecture; 1 hr – tutorial each week)		
Proposal Date	12 October 2020		

Course Aims

This course aims to provide the student with a good understanding of Radiotherapy Physics, namely ionizing radiation physics, radiation dosimetry and the physical and clinical aspects of radiation beams related to Radiotherapy. It also introduces the basic concepts of radiobiology and radiation protection for Radiotherapy and general applications.

Intended Learning Outcomes (ILO)

Upon the successful completion of this course, you (as a student) would be able to **describe, explain and determine** the following concepts:

Radiation Physics (RP)

1. Describe and perform calculations related to atomic structure with excitation, ionization and physics of charge particle scatter.
2. Describe direct and indirect ionizing radiation, its interaction with a medium and determine charge particle stopping power, photon attenuation coefficients and the different types of photon interactions in medium.
3. Describe and explain the basic principle of Monte Carlo method for simulating radiation transport in matter.

Radiation Dosimetry and Radiation Detectors (RDRD)

4. Determine the fluence, energy transfer and energy deposition by direct and indirect ionizing radiation, KERMA, absorbed dose (Gray) and charge particle equilibrium.
5. Demonstrate knowledge of the instruments for measurement of radiation dose and explain their principles of detection

Physical and Clinical Photon and Electron Beams (PCPE)

6. Describe and explain the processes of photon and electron beam generation for low kV energy X-rays by X-ray tubes and high energy MV photons and electrons by Linear Accelerators.
7. Explain how physical quantities relate to beam characteristics in medium, namely depth doses, lateral beam profiles.
8. Identify the key quantities of depth dose ratios and field size output factors that relate to dose delivery.

9. Describe and explain isodose distributions, target volumes and treatment accessories for Radiotherapy treatment, including wedges, multi leaf collimators, electron applicators and immobilization devices.
10. Determine monitor units for radiotherapy dose delivery.

Radiobiology and Radiation Protection (RBRP)

11. Describe and explain the basics of radiobiology and its damaging impact on human cells and tissues. This includes applying the concepts of Linear Energy Transfer, equivalent dose, fractionation in Radiotherapy and dose toxicity for radiotherapy to perform related calculations.
12. Describe and explain the basics of radiation protection, including applying the definition of dose received (Sievert), risk estimates, radiation monitoring, and the cardinal principles for radiation protection of time, distance and shielding to perform related calculations.

Brachytherapy (BRACHY) and Advanced Topics (ADV)

13. Describe and explain the basics of Brachytherapy using various types of radioactive sources for intracavity and interstitial treatment.
14. Describe and explain Intensity Modulated Radiotherapy including inverse planning and modulated beam delivery for highly conformal advanced radiotherapy
15. Describe and explain Proton Beam Therapy physics and its applications

Course Content

Radiation Physics (RP)

Fundamental SI units and physics constants
Derived physics quantities and relations
Rutherford and Bohr's model of Atomic Structure, Multi-electron atomic structure, Excitation and Ionization
Direct and indirectly ionizing radiation
Electron-orbital electron
Electron-nucleus interactions
Electron stopping power
Electron scattering power
Photon attenuation in medium
Types of photon interactions
Effects following photon interactions
Basic principle of Monte Carlo method for simulating radiation transport in matter.

Radiation Dosimetry and Radiation Detectors (RDRD)

Photon fluence and energy fluence
KERMA
Absorbed Dose
Stopping power and energy deposition
Charge particle equilibrium
Bragg-gray cavity theory
Stopping power ratios
Properties of radiation dosimeters
Ionization chambers
Film Dosimetry
Luminescence Dosimetry
Semiconductor Dosimetry

Physical and Clinical Aspects of Photon and Electron Beams (PCPE)
X-ray beam machines
Gamma-ray machines
Particle Accelerators
Linear Accelerators
Inverse square law
Photon beam into a medium
Radiation treatment parameters
Photon Central axis depth doses and ratios
Photon off axis rations and Beam profiles
Photon Isodose distributions in water and patients
Volume definitions in radiotherapy
Patient data acquisition and simulation
Clinical considerations for photon beams
Treatment plan evaluation
Treatment time and Monitor Unit calculations
Electron central axis depth doses
Electron beam dosimetric parameters
Clinical considerations for electron beams

Radiobiology and Radiation Protection (RBRP)
Classification of radiations in radiobiology
Cell cycle and cell death
Irradiation of cells
Type of radiation damage
Cell survival curves
Dose response curve
Radiation toxicity
Oxygen effect
Relative radiobiological effectiveness
Dose rate and fractionation
Radiation and environment
Definition of radiation protection units (Sievert)
Radiation dose and risk estimate
Cardinal principles of radiation protection

Brachytherapy (BRACHY) and Advanced Topics (ADV)
Brachytherapy photon source characteristics
Dose distribution around sources
Remote afterloader
Clinical use and dosimetry system
Advanced topics:
Introduction to Intensity Modulated Radiotherapy
IMRT inverse planning, optimization technique and clinical dose distributions
Introduction to Proton Beam Therapy
Physics of proton beam therapy, beam delivery and dose forming techniques, and clinical dose distributions

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team / Individual	Assessment Rubrics
1. Final Examination	All	Competence	60%	Individual	Point-based marking
2. Continuous Assessment 1 (CA1): Assignment	RP	Competence	5%	Individual	Point-based marking
3. CA2: Assignment	RDRD	Competence	5%	Individual	Point-based marking
4. CA3: Clinical practical tutorial	RDRD PCPE BRACHY ADV	Competence	5%	Individual	Point-based marking
5. CA4: Mid-term test	RP RDRD PCPE	Competence	20%	Individual	Point-based marking
6. CA5: Assignment	PCPE RBRP	Competence	5%	Individual	Point-based marking
Total			100%		

Formative feedback

Students will receive formative feedback through discussion within lectures and tutorial lessons. Feedback is always provided for student response to each question.

Feedback is given after midterm on the common mistakes and issues of understanding.

Finally, past exam questions and examiner’s report are also made available for students.

Learning and Teaching approach

Approach	How does this approach support students in achieving the learning outcomes?
Problem solving (tutorial and lecture)	Develop competence and perseverance in solving physics problems.

Reading and References

1. Radiation Oncology Physics: a handbook for teachers and students / editor E. B. Podgorsak (2005), ISBN No. 92–0–107304–6. [Text]
2. Handbook of Radiotherapy Physics: Theory and Practice, / edited by P. Mayles, A. Nahum and J. C. Rosenwald (2007), ISBN No. 978-0-7503-0860-1
3. Radiation Physics for Medical Physicists (3rd edition), E.B. Podgorsak (2016), ISBN No. 978-3-319-25382-4 (eBook)

Course Policies and Student Responsibilities

Absence Due to Medical or Other Reasons

If you are sick and unable to attend your class / Mid-terms, you have to:

1. Send an email to the instructor regarding the absence and request for a replacement class and make-up mid-terms.
2. Submit the original Medical Certificate* or official letter of excuse to administrator.
3. Attend the assigned replacement class (*subject to availability*) and make-up mid-terms.

* The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

Academic Integrity

The quality of your work as a student relies on adhering strictly to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. It is therefore your responsibility to understand and apply the principles of academic integrity in all the work you do at NTU.

There is no tolerance for academic dishonesty. Please refer to academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
James Lee Cheow Lei	National Cancer Centre Singapore	81257094	jameslee@ntu.edu.sg trdjas@nccs.com.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Radiation Physics (RP)	RP 1	In-class learning
2	Radiation Physics (RP)	RP 2, RP 3	In-class learning
3	Radiation Physics (RP), Radiation Dosimetry and Radiation Detectors (RDRD)	RP 3, RDRD 1	In-class learning, tutorial assignment
4	Radiation Dosimetry and Radiation Detectors (RDRD)	RDRD 2	In-class learning

5	Radiation Dosimetry and Radiation Detectors (RDRD)	RDRD 3	In-class learning	
6	Physical and Clinical Aspects of Photon and Electron Beams (PCPE)	PCPE 1	In-class learning, tutorial assignment	
7	Physical and Clinical Aspects of Photon and Electron Beams (PCPE)	PCPE 2	Clinical tutorial at clinical site	
8	Physical and Clinical Aspects of Photon and Electron Beams (PCPE)	PCPE 3	In-class learning, tutorial assignment	
9	Physical and Clinical Aspects of Photon and Electron Beams (PCPE)	PCPE 4	In-class learning, Mid term test	
10	Physical and Clinical Aspects of Photon and Electron Beams (PCPE), Radiobiology and Radiation Protection (RBRP)	PCPE 5, RBRP 1	In-class learning	
11	Radiobiology and Radiation Protection (RBRP)	RBRP 2	In-class learning, tutorial assignment	
12	Brachytherapy (BRACHY), Advanced Topics (ADV)	BRACHY, ADV 1	In-class learning	
13	Advanced Topics (ADV), Revision	ADV 2	In-class learning	

What we want our graduates from Physics and Applied Physics to be able to do:

Upon the successful completion of the PHY, APHY and PHMA programs, graduates should be able to:

Competency	1	demonstrate a rigorous understanding of the core theories and principles of physics involving (but not limited to) areas such as classical mechanics, electromagnetism, thermal physics and quantum mechanics demonstrate a rigorous understanding of the core theories and principles of mathematical sciences involving (but not limited to) areas such as analysis, algebra and statistical analysis
	2	read and understand undergraduate level physics content independently;
	3	make educated guesses/estimations of physical quantities in general;
	4	apply fundamental physics knowledge, logical reasoning, mathematical and computational skills to analyse, model and solve problems;
	5	develop theoretical descriptions of physical phenomena with an understanding of the underlying assumptions and limitations;
	6	critically evaluate and distinguish sources of scientific/non-scientific information and to recommend appropriate decisions and choices when needed;
	7	demonstrate the ability to design and conduct experiments in a Physics laboratory, to make measurements, analyse and interpret data to draw valid conclusions.

Creativity	1	propose valid approaches to tackle open-ended problems in unexplored domains;
	2	offer valid alternative perspectives/approaches to a given situation or problem.

Communication	1	describe physical phenomena with scientifically sound principles;
	2	communicate (in writing and speaking) scientific and non-scientific ideas effectively to professional scientists and to the general public;
	3	communicate effectively with team members when working in a group.

Character	1	uphold absolute integrity when conducting scientific experiments, reporting and using the scientific results;
	2	readily pick up new skills, particularly technology-related ones, to tackle new problems;
	3	contribute as a valued team member when working in a group.

Civic Mindedness	1	put together the skills and knowledge into their work in an effective, responsible and ethical manner for the benefits of society.