Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

The sections shown on this interface are based on the templates UG OBTL+ or PG OBTL+
If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to Data Transformation Status for more information.

Expected Implementation in Academic Year	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Lee Cheow Lei James
Course Author Email	jameslee@ntu.edu.sg
Course Title	Medical Physics for Radiotherapy
Course Code	PH3605
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	PH3101 Quantum Mechanics II
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

This course aims to provide you with a good understanding of Radiotherapy Physics and how it is applied to Radiotherapy, 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.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Describe and perform calculations related to atomic structure and equilibrium recovery after excitation and ionization.
ILO 2	Describe direct and indirect ionizing radiation, its interaction with a medium and determine charge particle stopping power and range, photon attenuation coefficients and the different types of photon interactions in a medium.
ILO 3	Describe and explain the basic principle of Monte Carlo method for simulation of radiation transport in matter for photons interactions and pathlength.
ILO 4	Determine the particle fluence, energy transfer and energy deposition by direct and indirect ionizing radiation, KERMA, absorbed dose (Gray) and the condition for charge particle equilibrium.
ILO 5	Demonstrate knowledge of instruments for measurement of radiation dose and explain their working principles of detection.
ILO 6	Describe and explain the method of photon and electron beam generation for high energy MV photons and electrons by Medical Linear Accelerators and CT Simulators for radiotherapy imaging and planning.
ILO 7	Explain how physical quantities are related to beam characteristics in a medium, namely depth doses and lateral beam profiles.
ILO 8	Identify and define the key quantities of depth dose ratios and field size output factors for dose distribution and dose delivery.
ILO 9	Describe and explain isodose distributions, target volumes and treatment accessories for Radiotherapy treatment, including wedges, multi leaf collimators, electron applicators and immobilization devices.
ILO 10	Determine the monitor units for radiotherapy dose delivery.
ILO 11	Describe and explain the basics of radiobiology and its damaging impact on DNA, tissues and organs. This includes applying the concepts of cell survival curve, linear energy transfer, reasons for fractionation and radiation dose toxicity in radiotherapy.
ILO 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.
ILO 13	Describe and explain the basics of Brachytherapy using various types of radioactive sources for intracavity and interstitial treatment.
ILO 14	Describe and explain Intensity Modulated Radiotherapy including inverse planning and modulated beam delivery for advanced conformal radiotherapy.

ILO 15	Describe and explain proton beam therapy physics and its advantages over conventional radiotherapy.

Course Content

Radiation Physics (RP)

Fundamental SI units and physics constants

Derived physics quantities and relations

Simple and multi-electron atomic energy levels

Equilibrium recovery process for excitation and ionization

Electron interaction and stopping power

Types of photon interactions

Photon attenuation coefficients

Radiation Dosimetry and Radiation Detectors (RDRD)

Photon fluence and energy fluence

KERMA

Absorbed Dose

Stopping power and energy deposition

Charge particle equilibrium

Bragg-Gray and Spencer-Attix cavity theory

Ionization chambers

Film Dosimetry

Luminescence Dosimeters

Semiconductor Dosimeters

Physical and Clinical Aspects of Photon and Electron Beams (PCPE)

Linear Accelerators and CT Simulators

Inverse square law

Photon Central axis depth doses and dose ratios

Photon off axis ratios and Beam profiles

Photon Isodose distributions in water and patients

Volume definitions in radiotherapy

Clinical considerations for photon beams

Treatment plan evaluation

Monitor Unit calculations

Basic introduction to physical and clinical aspects of Electron Therapy

Radiobiology and Radiation Protection (RBRP)

Classification of radiations in radiobiology

Cell cycle and cell death

Type of radiation damage

Cell survival curves

Dose response curve

Radiation toxicity

Dose rate and fractionation

Definition of radiation protection units (Sievert)

Radiation dose and risk estimate

Cardinal principles of radiation protection (ALARA)

Brachytherapy (BRACHY) and Advanced Topics (ADV)

Basic introduction to physical and clinical aspects of Brachytherapy

Introduction to Intensity Modulated Radiotherapy (IMRT) inverse planning, optimization technique and modulated dose delivery

Introduction to Proton Beam Therapy and beyond

Reading and References (if applicable)

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)

NOTE: The above readings comprise the foundational readings for the course and more up-to-date relevant readings will be provided when they are available.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Radiation Physics	ILO 1		In-person	In-class learning
2	Interaction with matter: Electron & Photon	ILO 2		In-person	In-class learning
3	Interaction with matter: Photon	ILO 2 and ILO 3		In-person	In-class learning, Tutorial 1 (CA1)
4	Radiation Dosimeters & Radiation Dosimetry	ILO 4 and ILO 5		In-person	In-class learning
5	Radiation Dosimetry & Radiotherapy Machines	ILO 4 and ILO 6		In-person	In-class learning
6	Radiotherapy Machines & Photon Beam: Physical	ILO 6 and ILO 7		In-person	In-class learning
7	Clinical Tutorial	ILO 6, ILO 7 and ILO 8		In-person	Tutorial 2 (CA2), Clinical Tutorial, Site-visit (CA3)
8	Photon Beam: Physical & Photon Beam: Clinical	ILO 7 and ILO 8		In-person	In-class learning, Mid Term Test (CA4)
9	Photon Beam: Clinical & Advanced RT – IMRT and VMAT	ILO 10 and ILO 14		In-person	In-class learning

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
10	Basic Radiobiology	ILO 11		In-person	In-class learning, Tutorial 3 (CA5)
11	Basic Radiobiology & Radiation Protection	ILO 11 and ILO 12		In-person	In-class learning
12	Electron Beam: Physical and Clinical & Brachytherapy	ILO 13		In-person	In-class learning, Tutorial 4 (CA6)
13	Brachytherapy & Proton Therapy and beyond	ILO 13 and ILO 15		In-person	In-class learning
14	Consultation	All ILO			
15	Consultation	All ILO			

Learning and Teaching Approach

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

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Summative Assessment (EXAM): Final exam(Final Examination)	All ILO		60	Individual	Analytic	Relational
2	Continuous Assessment (CA): Assignment(CA1: Assignment)	ILO 1		4	Individual	Analytic	Relational
3	Continuous Assessment (CA): Assignment(CA2: Assignment)	ILO 2 and ILO 3		4	Individual	Analytic	Relational
4	Continuous Assessment (CA): Class Participation(CA3: Clinical Tutorial)	ILO 5, ILO 6 and ILO 7		4	Team	Holistic	Multistructural
5	Continuous Assessment (CA): Test/Quiz(CA4: Mid-term Test)	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5, ILO 6 and ILO 7		20	Individual	Analytic	Relational
6	Continuous Assessment (CA): Assignment(CA5: Assignment)	ILO 3 and ILO 4		4	Individual	Analytic	Relational
7	Continuous Assessment (CA): Assignment(CA6: Assignment)	ILO 10, ILO 11 and ILO 14		4	Individual	Analytic	Relational

Description of Assessment Components (if applicable)

Summative Assessment (Exam) (60%): This is a closed book exam covering all lectures from the course.

CA1 (4%): To test their understanding of how key physics formulas are derived and applied via calculations. This assignment is to reinforce and test their understanding of the preceding relevant lectures.

CA2 (4%): To test their understanding of how key physics formulas are derived and applied via calculations. This is to reinforce and test their understanding of the preceding relevant lectures.

CA3 Clinical Tutorial (4%): This is a Medical Physics subject. Students will visit the National Cancer Centre

Singapore for hands-on teaching on Radiotherapy related machines and equipment and how they are clinically used for Radiotherapy. They will gain practical experience via using or observing how the machines or equipment work and how they are related to the classroom lessons. They are graded on their active class participation and questions asked.

CA4 Mid-term Test (20%): This is a closed book test. Students are tested on their understanding of key concepts taught from the start of the semester and their application.

CA5 (4%): To test their understanding of how key physics formulas are derived and applied via calculations. This is to reinforce and test their understanding of the preceding relevant lectures.

CA6 (4%): To test their understanding of how key physics formulas are derived and applied via calculations. This is to reinforce and test their understanding of the preceding relevant lectures.

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 mid-term test on the common mistakes and issues of understanding.

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

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Care for Society	Intermediate
Ethical Reasoning	Basic
People Orientation	Basic
Problem Solving	Intermediate
Transdisciplinarity	Intermediate

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering 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. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

In general, students are required to attend lectures, be attentive, uphold integrity, and to hand in their assignments punctually. They are to declare the use of AI in their work.

Policy (Absenteeism)

Absence Due to Medical or Other Reasons

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

Send an email to the instructor regarding the absence and request for a replacement class and make-up mid-term.

Submit the Medical Certificate* or official letter of excuse to administrator.

Attend the assigned replacement class (subject to availability) and make-up mid-term.

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

Policy (Others, if applicable)

Diversity and inclusion policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:

- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;
- If you feel like your performance in the class is being impacted by your experiences outside of class;
- If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;

Please speak to your teaching team, our school pastoral officer or a peer or senior (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.