

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

Course Overview

Expected Implementation in Academic Year (New format)	AY2026-2027
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Tan Hong Qi
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Course Title	Radiobiology and Radiation Protection
Course Code	PH3304
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

The main objective of the course is to give you an introduction to radiobiology and radiation protection which are core knowledge for a practicing medical or health physicist. In radiobiology, you will learn the radiobiological basis of radiotherapy treatment and understand how the radiobiological impact of radiotherapy is a complex function of doses, dose rate, linear energy transfer (LET) and biological endpoint. Various mathematical models of the cell survival curve will also be introduced. In radiation protection, you will learn the physical basis behind radiation protection which includes operational dosimetry quantities, radiation protection detectors and shielding calculations. Lastly, you will learn the regulatory aspect of radiation protection based on guidelines from NEA and ICRP. The theoretical bases of the study material will be given via lectures, tutorials and e-learning, whereas ample hands-on experience will also be provided for the various modalities.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Explain the basic of tumour biology and carcinogenesis
ILO 2	Describe the radiation physics and radiation chemistry processes during the interaction of radiation with biological system
ILO 3	Describe the DNA damage sensor and repair pathway after irradiation
ILO 4	Explain the concept of linear energy transfer (LET)
ILO 5	Describe the different type of cell death and the cell survival curve
ILO 6	Compare linear quadratic model and other advanced mathematical model for characterizing the cell survival curve
ILO 7	Explain the concept of relative biological effectiveness (RBE) and its dependence on dose and LET
ILO 8	Discuss the role of oxygen in modulating radiobiological effect.
ILO 9	Calculate EUD, NTCP and TCP based on dose volume histogram (DVH) data
ILO 10	Explain the concept of tolerance dose and volume based on QUANTEC
ILO 11	Explain the rationale of hypo- and hyper-fractionation in radiotherapy
ILO 12	Recognize the historical and current importance of radiation protection
ILO 13	Describe the interaction of alpha, beta, gamma and neutron radiation with matter
ILO 14	Explain and compute the operational dosimetry quantities
ILO 15	Explain the role and working principles of various radiation protection detectors
ILO 16	Calculate the TVL and HVL from the attenuation for various radiation protection materials
ILO 17	Assess shield adequacy based on shielding calculation formula
ILO 18	State the radiation protection guidelines based on ICRP and NEA publications
ILO 19	Explain how to handle radiation emergency response situation and radiation waste management

Course Content

- Lecture 1: Introductory tumour biology and carcinogenesis
- Lecture 2: Radiation physics and chemistry in radiation interaction with biological system
- Lecture 3: Introducing DNA damage sensor and repair pathway after irradiation
- Lecture 4: Cell survival curve
- Lecture 5: Relative biological effectiveness
- Lecture 6: A review of radiobiological dose models
- Lecture 7: Radiobiological basis of fractionation in radiotherapy
- Lecture 8: Historical perspective of radiation protection
- Lecture 9: Radiation protection quantities and operational dosimetry
- Lecture 10: Radiation protection detector and measurement
- Lecture 11: Shielding calculation
- Lecture 12: Radiation protection guidelines and safety assessment I
- Lecture 13: Radiation protection guidelines and safety assessment II

Reading and References (if applicable)

- Michael C Joiner and Albert van der Kogel (2025). Basic Clinical Radiobiology Sixth Edition. CRC Press. (1032243813)
- INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Oncology Physics, Non-serial Publications , IAEA, Vienna (2005)
- Thomas E. Johnson (2017). Introduction to Health Physics Fifth Edition. McGraw Hill. (ISBN 9780071835275)
- Sarah Baatout (2023). Radiobiology Textbook. Springer. (ISBN 3031188098)

Planned Schedule

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
1	1. Basic cancer biology 2. Hallmark of cancer, carcinogenesis, oncogenes and tumour suppressor genes 3. Role of radiotherapy in cancer treatment	1	In-person	Classroom lecture	
2	4. Ionizing radiation interaction with biological system 5. Time-scale of effects 6. Radiation physics and radiation chemistry 7. Radiation-induced damage and DNA damage response	2,3	In-person	Classroom lecture	
3	8. DNA damage sensor and repair pathway 9. Linear energy transfer (LET) 10. Cell death after irradiation	3,4,5	In-person	Classroom lecture	
4	11. Cell survival curve and clonogenic assay 12. Linear quadratic model of cell survival curve 13. Advanced mathematical models of cell survival	5,6	In-person	Classroom lecture	
5	14. Introducing Relative biological effectiveness (RBE) 15. RBE versus LET, dose, dose rate 16. RBE in tumour and normal tissue 17. Oxygen effect and oxygen enhancement ratio (OER)	7,8	In-person	Classroom lecture + Tutorial 1	

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
6	18. Radiobiological dose model 19. Tumour control probability (TCP) 20. Normal Tissue Control Probability (NTCP) 21. Equivalent uniform dose (EUD) 22. Tolerance dose and volume (QUANTEC)	9,10	In-person	Classroom lecture	
7	23. Radiobiological basis of fractionation 24. Equivalent dose in 2 Gy (EQD2) 25. Biological effective dose (BED) 26. Hypo- and hyper-fractionation in radiotherapy	11	In-person	Classroom lecture + tutorial 2	
8	27. Introduction and historical perspective of radiation protection 28. Interaction of radiation with matter (Alpha, Beta, Gamma, Neutron)	12,13	In-person	Classroom lecture	
9	29. Radiation protection quantities and operational dosimetry	14	In-person	Classroom lecture	
10	30. Radiation protection detector and measurement	15	In-person	Classroom lecture	
11	31. Exponential attenuation and tenth value layer (TVL) 32. Shielding calculation	16,17	In-person	Classroom lecture + tutorial 3	

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
12	33. Safety assessment of facilities and activities 34. Legal framework for radiation protection 35. Planned exposure situation	18	In-person	Classroom lecture	
13	36. Emergency exposure situation 37. Radiation transport and waste management	19	In-person	Classroom lecture + tutorial 4	

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures	The lectures aim at providing you with basic information about the subject, but more importantly also a strong motivation to look into the detailed literature of the subject and to read the mandatory course literature, but also the relevant scientific literature available in the internet and in form of textbooks and scientific publications.
Tutorials	The tutorials aim to assess your understanding about the subject and determine your ability to explain technical knowledge. It also serves as a feedback to the instructors to emphasize on the areas where you are lacking.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Test/Quiz(Test/Quiz(Midterm Test 1 & 2))	All	Not Applicable	30		Individual	Analytic	Relational
2	Continuous Assessment (CA): Assignment(Assignment(Tutorial))	All	Not Applicable	10		Individual	Analytic	Multistructural
3	Summative Assessment (EXAM): Final exam(Final exam)	All	Not Applicable	60		Individual	Analytic	Extended Abstract

Description of Assessment Components (if applicable)

You will be given the tutorial questions at least 1 week before the tutorial week and you are required to submit the tutorial on the respective tutorial day (Week 5/8/11). The tutorial solution will be discussed on the tutorial day itself. You will need to physically attend all clinical tutorial and Midterm test unless you are absent due to legitimate reason.

Formative Feedback

You will receive formative feedback through discussion within tutorial lessons.

Feedback is also given after each term test on the common mistakes and level of difficulty of the problems. Past exam questions and content of previous examiner's report will be discussed in lecture.

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	Basic
Problem Solving	Intermediate
Transdisciplinarity	Basic
Critical Thinking	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)

You are expected to complete all assigned readings, activities, assignments, attend all classes punctually and complete all scheduled assignments by due dates. You are expected to take responsibility to follow up with assignments and course related announcements. You are expected to participate in all project critiques, class discussions and activities.

Policy (Absenteeism)

In-class activities make up a significant portion of your course grade. Absence from class without a valid reason will affect your participation grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. Make-up mid-term tests would be offered upon the receipt of a valid reason of absenteeism.

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.

Technical Skills To Be Developed

All skills to be developed for this course:

Rubrics (Appendix)

1) Mid-term test (30%)

Mid-Term test will consist of long-answer questions. In the first mid-term, the student will be tested on radiobiology from materials taught in week 1 to 6. In the second mid-term, the student will be tested on radiation protection from materials taught in week 8 to 12. The student must be able to provide clear and correct answers, and the assessment will be based on point-based marking.

2) Final exam (60%)

A comprehensive examination assessing conceptual understanding and problem-solving ability across the full syllabus. The assessment will be based on point-based marking.

3) Assignment (10%)

There will be four tutorials comprising of four problem set on early-course topics assessing correct methods, reasoning, and clear presentation of solutions.