Medical Biophysics

Practical Radiotherapy Physics BIOPHYS 9672 (Full Year)

Course Outline for 2023 - 2024

Western University is committed to a **thriving campus**; therefore, your health and wellness matter to us! The following link provides information about the resources available on and off campus to support students: https://www.uwo.ca/health/ Your course coordinator can also **guide you** to resources and/or services should you need them.

1. Technical Requirements:

Stable internet connection

Laptop or computer

Working microphone (suggested)

Working webcam (suggested)

2. Course Overview and Important Dates:

Delivery Mode	Dates	Time	Location
In person	Mondays	These details can be found on the course OWL site	
In person	Thursdays		

*Details about design and delivery of the course are listed below in Section 4

Classes Start	Reading Weeks	Classes End	Exam Dates
September	October 30 – November 5	December	TBD see below
January	February 17 – 25	April	TBD see below

3. Contact Information

Course Instructor	Contact Information

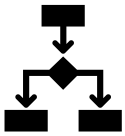
Teaching Assistant	Contact Information

This syllabus will be updated before the start of classes – this is a DRAFT only

4. Course Description and Design

This course covers the concepts, processes, and instrumentation required in the clinical application of ionizing radiation to the treatment of cancer. Topics include: external beam therapy, with a specific focus on the high energy Linac and clinically useful beam production; radiation safety and treatment bunker design; commissioning equipment and techniques; quality assurance processes and scope; dosimetry instruments and dose measurement; image guided radiation therapy (IGRT); medical imaging in the context of radiation treatment planning; dose calculation and beam modelling; radiation dose prescription and translation to beam parameters; radiation dose delivery; brachytherapy dose modelling and dose delivery; other treatment machines and special techniques.

One of the unique aspects of this course is the integration of Radiation Oncology Residents and CAMPEP Graduate Students in a small group setting. Students begin to learn the language of Radiation Oncology and Radiation Physics in a context that requires them to communicate with others who may have trained in a very different manner than themselves. There will be regular opportunities to develop communication and collaboration skills across disciplines. Because of this, attendance at the virtual synchronous meetings is mandatory, as far as the student is able.



☒ Asynchronous pre-work must be completed prior to synchronous sessions
☒ Attendance at synchronous or in person sessions is required
☒ Missed work should be completed before the next class
☒ Slides presented during class will be posted to a common drive within 48 hours of presentation

Course material will not be posted to OWL because this class is provided for both CAMPEP Graduate Students and Radiation Oncology Residents, the latter of whom do not have access to OWL. A common OneDrive folder will be shared with you so that you can access course resource. A folder specific to you, for assignment submission and return, will be shared with you on or around the first day of class.

OWL will be used to submit the Graduate Students' final grades, but grades will also be communicated by email.

If students need assistance, they can seek support on the OWL Help page. Alternatively, they can contact the Western Technology Services Helpdesk. They can be contacted by phone at 519-661-3800 or ext. 83800.

Google Chrome or Mozilla Firefox are the preferred browsers to optimally use OWL; update your browsers frequently. Students interested in evaluating their internet speed, please click here.

5. Learning Outcomes

Upon successful completion of this course, students will be able to:

- describe the energy pathway from wall outlet to cancer cell, as superintended by a high energy linac
- collect the information necessary for a bunker shielding calculation and use it for an estimate of primary barrier thickness
- choose the correct imaging modality for various radiation therapy purposes
- choose the correct radiation modality (high E photons, low E photons, electrons, keV photons, brachytherapy, protons etc) to match the treatment objectives
- design a high-level project for bringing various radiation therapy equipment into clinical service, including aspects of:
    - clinic and community needs
    - radiation safety
    - radiation safety regulations
    - acceptance testing and commissioning
    - measurement requirements
    - auxiliary requirements (ie: integration with other clinic systems, training etc)
- describe the role of the Clinical Medical Physicist in the Oncology Clinical Team

6. Course Outline (approx. number of classes as indicated)

1. Introduction (1/2)
    a. What is cancer? And how does radiation kill it? **(Group assignment #1)**
2. The Basics (1/2)
    a. What is radiation?
    b. Fundamental particles and the atom
    c. Mass and energy relationship
    d. Structure of matter
    e. Waves and photons
3. External Beam Radiation Therapy: Focus on The Linac (~14)
    a. Overview of the Basic Components of a Linac
    b. Room Layout and Patient Set-up
    c. **Mini Lab #1:** “field trip” to see a linac (no grade)
    d. Electron Gun and Accelerating Waveguide (1)
        i. Operational theory of waveguides
        ii. Bending magnet systems
    e. Photon Beam Production (2)
        i. Electron interactions with matter, including Bremsstrahlung
        ii. Target design
        iii. Photon beam characteristics before modification
        iv. The flattening filter and beam hardening

    f. Photon Beam Delivery (3)
        i. Dose Deposition part 1
            1. Photon interactions in matter **(Group assignment #2)**
                a. Compton
                b. Pair Production
                c. Photoelectric Effect
        ii. Collimation
            1. Penumbra
            2. Cross beam dose curves
            3. Beam Shaping

iii. Dose Deposition part 2
1. Dose deposition by electrons
2. KERMA, exposure and dose
3. Depth dose curves
4. Inverse square law

iv. **Mini Lab #2:** exploring dose deposition using planning software

g. Beam Monitoring (2)
i. MU chambers
ii. Other radiation and dose monitoring devices
1. Farmer chambers
2. Geiger counters
3. Diodes
4. TLD's

h. Introduction to CPQR (1)
i. Group assignment #3

i. Bunker Design and Radiation Safety in an RT Context (1)
i. Primary and secondary barriers
ii. Room design considerations
iii. Monitors and signage
iv. Licenses and dose limits
v. **Mini Lab #3:** exploration of a radiation bunker

j. Linac Commissioning and QA (1)
i. Beam data and reference conditions
ii. Overview of QA Tests and their frequency

k. Treatment Field Imaging (1)
i. Portal imaging, including EPID
ii. 2D kV imaging
iii. 3D kV imaging
iv. **Mini Lab #4-1:** image matching with CBCT

4. Imaging for Radiation Therapy (2)
a. CT
i. x-ray production
ii. CT scanners
iii. CT simulators
b. MRI
c. PET
d. Ultrasound
e. **Mini Lab #4-2:** image fusion with CT Sim & other modalities

5. Dose Calculation and Beam Modelling (3)
a. Dosimetric Parameters (2)
i. PDD, TAR, TPR etc…
b. Contour Corrections (1/2)
i. Photon beams
ii. Electron beams
c. Inhomogeneity Corrections (1/2)
i. Photon beams
ii. Electron beams
d. Modern Dose Modelling Algorithms (1)
i. Source Data
ii. Algorithms used by Philips' Pinnacle and by Varian's Eclipse
iii. Monte Carlo Modelling – the future?
e. **Mini Lab #5-1:** exploration of treatment planning

6. Electron Beam Dose Delivery (2)
a. Electron dose deposition (quick review of 3.f.i.2)

   b. Depth dose curves
   c. Cross beam dose curves, including penumbra
   d. Field size limitations
   e. **Mini Lab #5-2:** electron beam dose deposition

7. Brachytherapy (3)
   a. Clinical Considerations
   b. Clinical Machines
   c. Radioactivity Physics (1)
      i. Isotopes
      ii. Activity and Half Life
      iii. Specific Activity
      iv. Types of Decay (alpha, beta, e^- capture; daughter products)
   d. Air Kerma Strength and Apparent Activity
   e. Dose Calculation (TG-46)
   f. **Mini Lab #5-3:** brachytherapy dose planning
8. Special Topics Journal Club (1-2)
9. Radiation Safety and the Role of the Physicist (1)

7. Participation and Engagement: Online or In-Person

☒ Students are expected to participate and engage with content as much as possible

☒ Students are expected to participate and engage during class time as much as possible

8. Assessment

Summary: More information forthcoming on each, as they are assigned.

☒ Assignments (three). Individual effort.

☒ Mini-labs, including associated assignments (five). Individual effort.

☒ Group work (three). In class and between class group effort.

☒ Mid-term exam. Oral (via Zoom). Questions will be accompanied by visual prompts.

☒ Term paper assignment. Details of this assignment will be provided by the end of September. Includes written assignment, presentations and collaboration.

☒ Final exam. Written, if in-person allowed. Otherwise, oral via Zoom.

9. Evaluation

Below is the evaluation breakdown for the course. Any deviations will be communicated.

Assessment	Format	Weighting	Due Date
Assignments x3	Take home	15%	In schedule
Mini Labs	In Class & take home	15%	In schedule
Group Work	In Class & virtual	5%	In schedule
Midterm Exam	Oral (via Zoom)	15%	mid December
Term Paper Part 1 Final	Long Form Report	10%	end December
Term Paper Part 2 Interim	Point Form Report	2%	end December
Term Paper Part 2 Final	Long Form Report	13%	mid February
Term Paper Part 2 Presentation	Pitch style present'n + Questions	5%	March
Term Paper Part 1 Presentation	Class lesson (small group presentation)	5%	April
Final Exam (cumulative over the whole year)	Written, if in-person allowed, otherwise Oral via Zoom	15%	April

☒ All assignments are due at 11:55 pm EST unless otherwise specified

☒ Rubrics will be used to evaluate assessments and will be available after evaluation, upon request

☒ After an assessment is returned, students should wait 24 hours to digest feedback before contacting their evaluator; to ensure a timely response, reach out within 7 days

☒ Individualized term paper assignment and information will be provided by October 6th.

Click here for a detailed and comprehensive set of policies and regulations concerning examinations and grading. The table below outlines the University-wide grade descriptors.

A+	90-100	One could scarcely expect better from a student at this level
A	80-89	Superior work which is clearly above average
B	70-79	Good work, meeting all requirements, and eminently satisfactory
C	60-69	Competent work, meeting requirements
D	50-59	Fair work, minimally acceptable
F	below 50	Fail

Information about late or missed evaluations:

☒ Late assessments without self-reported absences will be subject to a late penalty 5%/day

☒ Late assessments with self-reported absences should be submitted within 24 hours of the end of the 48-hour period

☒ An assessment cannot be submitted after it has been returned to the class; the weight will be transferred to the final grade

☒ A make-up time for oral exams will be arranged if original time missed

☒ If a make-up assessment is missed, the student will receive an INC and complete the task the next time the course is offered

10. Communication:

☒ A weekly update will be provided by email

☒ Students should email their instructor and teaching assistant directly; to ensure a timely response, email both the instructor and TA

☒ Emails will be monitored daily; students will receive a response in 24 – 48 hours

☒ This course will use Microsoft Teams for discussions

☒ Students should post all course-related content on the discussion forum so that everyone can access answers to questions

☒ The discussion forums will be monitored daily by instructors or teaching assistants

11. Office Hours:

☒ Due to Dr. Surry's clinical responsibilities, please request a meeting time via email; several meeting times within the next 5 business days will be made available

☒ To meet with the TA, please email to find a mutually agreeable time.

12. Resources

☒ The material in this course can mostly be found in Podgorsak:

Radiation Physics for Medical Physicist 3rd edition
EB Podgorsak. Springer, 2018.

Radiation Oncology Physics: A Handbook for Teachers and Students
EB Podgorsak. Published by the IAEA, 2005.
http://www-pub.iaea.org/mtcd/publications/pdf/pub1196_web.pdf

☒ The following may also be useful:

A Primer on Theory and Operation of Linear Accelerators in Radiation Therapy. 3rd Ed.
CJ Karzmark & RJ Morton. Ed. by J Lamb. Medical Physics Publishing, 2017.

Introduction to Radiological Physics and Radiation Dosimetry
F Attix. John Wiley & Sons, 1999.

The Physics of Radiation Therapy, 5th Edition
FM Khan & JP Gibbons. Lippincott Williams & Wilkins, 2014.

The Physics & Technology of Radiation Therapy
PN McDermott & CG Orton. Medical Physics, 2010.

The Modern Technology of Radiation Oncology
J Van Dyk. Medical Physics Publishing, 1999.

Hendee's Physics of Medical Imaging, 5th Edition
Samei & Peck, Wiley Blackwell 2019

The Physics of Radiology, 4th Edition
HE Johns & JR Cunningham. Charles C Thomas, 1983.

Radiobiology for the Radiologist, 7th Edition
E Hall & A Giaccia. Lippincott Williams & Wilkins, June 2011.

Basic Clinical Radiobiology, 4th Edition
M Joiner & A van der Kogel. Hodder Arnold, 2009.
(3rd Edition edited by G Steel, 2002)

☒ These AAPM Task Group (TG) Reports are core to a Medical Physicist's work:
They are all publicly available at http://www.aapm.org/pubs/reports/default.asp

TG-25: Electron Beam Dosimetry
TG-34: Pacemaker Dose Limits
TG-36: Fetal Dose Limits
TG-40: QA Protocols
TG-43: Brachytherapy Dose Calculations
TG-45: Linac Commissioning and QA
TG-51: High Energy Dosimetry
TG-56: Brachytherapy Practice
TG-65: Tissue Inhomogeneity Corrections for MV
TG-66: CT-Sim QA

☒ Other Reports

ICRU-50: Prescribing, Recording and Reporting Photon Beam Therapy (1993)
ICRU-51: Quantities and Units in Radiation Protection Dosimetry (1993)
ICRP-60: Recommendations of the International Commission on Radiological Protection (1990)
NCRP-151: Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies up to 10 MeV (2005)
IAEA-47 Safety Reports Series: Radiation Protection in the Design of Radiotherapy Facilities (2006) https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1223_web.pdf

13. Professionalism & Privacy:

Western students are expected to follow the Student Code of Conduct. Additionally, the following expectations and professional conduct apply to this course:

☒ Students are expected to follow online etiquette expectations provided on OWL

☒ All course materials created by the instructor(s) are copyrighted and cannot be sold/shared

☒ Recordings are not permitted (audio or video) without explicit permission

☒ Permitted recordings are not to be distributed

☒ Students will be expected to take an academic integrity pledge before some assessments

☒ All recorded sessions will remain within the course site or unlisted if streamed

Western is committed to providing a learning and working environment that is free of harassment and discrimination. All students, staff, and faculty have a role in this commitment and have a responsibility to ensure and promote a safe and respectful learning and working environment. Relevant policies include Western's Non-Discrimination/Harassment Policy (M.A.P.P. 1.35) and Non-Discrimination/Harassment Policy – Administrative Procedures (M.A.P.P. 1.35).

Any student, staff, or faculty member who experiences or witnesses' behaviour that may be harassment or discrimination must report the behaviour to the Western's Human Rights Office. Harassment and discrimination can be human rights-based, which is also known as EDI-based, (sexism, racism, transphobia, homophobia, islamophobia, xenophobia, antisemitism, and ableism) or non-human rights-based (personal harassment or workplace harassment).

14. How to Be Successful in this Class:

Students enrolled in this class should understand the level of autonomy and self-discipline required to be successful.

1. Take notes as you go through the lesson material. Treat this course as you would a face-to-face course. Keeping handwritten notes or even notes on a regular Word document will help you learn more effectively.
2. Connect with others. One of the key outcomes of this course is connecting with "the other side": relationships developed between Physicists and Physicians are key to the success and safety of a Radiation Therapy program.
3. Do not be afraid to ask questions. If you are struggling with a topic, check the online discussion boards or contact your instructor and teaching assistant.
4. Reward yourself for successes. It seems easier to motivate ourselves knowing that there is something waiting for us at the end of the task.

15. Western Academic Policies and Statements

Absence from Course Commitments

Policy on Academic Consideration for Student Absences

If you are unable to meet a course requirement due to illness or other serious circumstances, you must seek approval for the absence as soon as possible. Approval can be granted either through a **self-reported absence** or via the **Academic Counselling** unit. Students have two self-reports to use throughout the academic year; absence from course commitments including tests, quizzes, presentations, labs, and assignments that are worth 30% or less can be self-reported. Self-reported absences cover a student for 48 hours (yesterday + today or today + tomorrow). Your instructor will receive notification of your consideration; however, you should contact your instructor immediately regarding your absence. Students are expected to submit missed work within 24 hours of the end of the 48-hour period. Please review details of the university's policy on academic consideration for student absences.

If you have used both their self-reported absences or will miss more than 48 hours of course requirements, a Student Medical Certificate (SMC) should be signed by a licensed medical or mental health practitioner and you should contact academic counselling. Academic Counselling will be operating virtually this year and can be contacted at scibmsac@uwo.ca.

Accommodation for Religious Holidays

The policy on Accommodation for Religious Holidays can be viewed here.

Special Examinations

A Special Examination is any examination other than the regular examination, and it may be offered only with the permission of the Dean of the Faculty in which the student is registered, in consultation with the instructor and Department Chair. Permission to write a Special Examination may be given on the basis of compassionate or medical grounds with appropriate supporting documents. To provide an opportunity for students to recover from the circumstances resulting in a Special Examination, the University has implemented Special Examinations dates. These dates as well as other important information about examinations and academic standing can be found here.

Academic Offenses

"Scholastic offences are taken seriously, and students are directed here to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence.

Accessibility Statement

Please contact the course instructor if you require material in an alternate format or if you require any other arrangements to make this course more accessible to you. You may also wish to contact Accessible Education (AE) at 661-2111 x 82147 for any specific question regarding an accommodation or review The policy on Accommodation for Students with Disabilities.

Correspondence Statement

The centrally administered **e-mail account** provided to students will be considered the individual's official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at his/her official university address is attended to in a timely manner. You can read about the privacy and security of the UWO email accounts here.

Turnitin and other similarity review software

All assignments will be subject to submission for textual similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. Students will be able to view their results before the final submission. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between Western University and Turnitin.com.

16. BMSUE Academic Policies and Statements

Cell Phone and Electronic Device Policy (for in-person tests and exams)

The Schulich School of Medicine & Dentistry is committed to ensuring that testing and evaluation are undertaken fairly across all our departments and programs. For all tests and exams, it is the policy of the School that any electronic devices, i.e., cell phones, tablets, cameras, or iPod are strictly prohibited. These devices MUST be left either at home or with the student's bag/jacket at the front of the room and MUST NOT be at the test/exam desk or in the individual's pocket. Any student found with one of these prohibited devices will receive a grade of zero on the test or exam. Non-programmable calculators are only allowed when indicated by the instructor. The program is not responsible for stolen/lost or broken devices.

Copyright and Audio/Video Recording Statement

Course material produced by faculty is copyrighted and to reproduce this material for any purposes other than your own educational use contravenes Canadian Copyright Laws. You must always ask permission to record another individual and you should never share or distribute recordings.

Rounding of Marks Statement

Across the Basic Medical Sciences Undergraduate Education programs, we strive to maintain high standards that reflect the effort that both students and faculty put into the teaching and learning experience during this course. All students will be treated equally and evaluated based only on their actual achievement. ***Final grades*** on this course, irrespective of the number of decimal places used in marking individual assignments and tests, will be calculated to one decimal place and rounded to the nearest integer, e.g., 74.4 becomes 74, and 74.5 becomes 75. Marks WILL NOT be bumped to the next grade or

GPA, e.g. a 79 will NOT be bumped up to an 80, an 84 WILL NOT be bumped up to an 85, etc. The mark attained is the mark you achieved, and the mark assigned; requests for mark “bumping” will be denied.

17. Support Services

The following links provide information about support services at Western University.

Academic Counselling (Science and Basic Medical Sciences)

Appeal Procedures

Registrarial Services

Student Development Services

Student Health Services