PATIENT DOSIMETRY IN MEDICAL IMAGING AND RADIOTHERAPY

BME 4931 *– Section 21658*

Class Periods: *Tuesdays, Periods 8-9 (3:00 – 4:55 pm)*

Class Periods: *Thursdays, Periods 9 (4:05 – 4:55 pm)*

Location: *C1-003 Communicore*

Academic Term: *Spring 2024*

Instructor:
Wesley Bolch, PhD
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(352) 273-0303
Office Hours: By appointment
Please contact through the Canvas website

Teaching Assistants:
Robert Dawson, PhD student in medical physics
Wyatt Smither, PhD student in medical physics
Office Hours: Noon to 2 pm Mondays or by appointment
Please contact through the Canvas website

Course Description (3 Credits)
Students will review the methods and techniques for assessing organ doses in medical imaging and radiotherapy techniques through the use of computational dosimetry. The course L-Series of lectures will discuss various modalities of imaging, preceded by a review of our understanding of how radiation exposure might induce cancer in humans and at what level. The latter portion of the course will cover radiotherapy. The P-Series of practicum sessions will give hands-on experience with computational phantoms and their use with the PHITS radiation transport code.

Course Prerequisites: None

Course Objectives:
Develop an in-depth understanding of the tools and methods used to assess radiation dose to tissues and organs in patients either imaged with ionizing radiation (radiography, fluoroscopy, computed tomography, and nuclear medicine) or treated for cancer using photons, protons, or radiopharmaceuticals. Execute hands on practicum assignments using the Monte Carlo radiation transport codes PHITS developed and distributed by the Japan Atomic Energy Agency.

Required Textbooks and Software:
The course will be based on instructor lecture notes, peer-reviewed journal articles, and selected reports. Registration for the PHITS code will be made through the code's development office at JAEA – Japan Atomic Energy Agency.

Recommended Materials:
None

Course Schedule

Week	*Date*	*Lecture No. and Topic (L – Lecture / P – Practicum)*	*Lecturer*
1	9	**L1 –** Course Introduction / Codes and Software Access	All
	9	**P1 –** Monte Carlo Methods	Dawson/Smither
	11	**P1 –** Monte Carlo Methods	Dawson/Smither
2	16	**P2 –** Introduction to the PHITS Code	Dawson/Smither
	16	**P2 –** Introduction to the PHITS Code	Dawson/Smither
	18	**L2 –** Computational and Physics Human Phantoms for Dose Assessment	Bolch
3	23	**P3 –** Basic Geometries and Sources in PHITS	Dawson/Smither
	23	**P3 –** Basic Geometries and Sources in PHITS	Dawson/Smither
	25	**L3 –** Historical Review of the Effective Dose and its Use in Medicine	Bolch
4	30	**P4 –** Source Modeling for Radiography / Fluoroscopy in PHITS	Smither
	30	**P4 –** Source Modeling for Radiography / Fluoroscopy in PHITS	Smither
	Feb 1	**L4 –** Historical Review of Skeletal Dosimetry	Bolch
5	6	**P5 –** Organ Dosimetry for Radiography / Fluoroscopy in PHITS	Smither
	6	**P5 –** Organ Dosimetry for Radiography / Fluoroscopy in PHITS	Smither
	8	**L5 –** Studies Linking Radiation Exposure to Cancer Induction	Bolch
6	13	**P6 –** Organ Dosimetry for CT in PHITS	Smither
	13	**P6 –** Organ Dosimetry for CT in PHITS	Smither
	15	**L6 –** Dose Dependent Models of Cancer Incidence and Mortality	Bolch
7	20	**P7 –** Organ Dosimetry for Nuclear Medicine in PHITS	Smither
	20	**P7 –** Organ Dosimetry for Nuclear Medicine in PHITS	Smither
	22	**L7 –** Organ Dosimetry in Radiography / Fluoroscopy	Bolch
8	27	**P8 –** Radiation Shielding for Diagnostic Imaging in PHITS	Smither
	27	**P8 –** Radiation Shielding for Diagnostic Imaging in PHITS	Smither
	29	**L8 –** Organ Dosimetry in Computed Tomography	Bolch
9	**Mar** 5	**P9 –** Radiation Detector Modeling in PHITS	Smither
	5	**P9 –** Radiation Detector Modeling in PHITS	Smither
	7	**L9 –** Organ Dosimetry in Diagnostic Nuclear Medicine	Bolch
10	12	***No Classes – Spring Break***	
	12	***No Classes – Spring Break***	
	14	***No Classes – Spring Break***	
11	19	**P10 –** Organ Dosimetry for Brachytherapy in PHITS	Dawson
	19	**P10 –** Organ Dosimetry for Brachytherapy in PHITS	Dawson
	21	**L10 –** Tumor Control Probability (TCP)	Bolch
12	26	**P11 –** Organ Dosimetry for Photon EBRT in PHITS	Dawson
	26	**P11 –** Organ Dosimetry for Photon EBRT in PHITS	Dawson
	28	**L11 –** Normal Tissue Complication Probability (NTCP)	Bolch
13	**Apr** 2	**P12 –** Organ Dosimetry for Proton and Carbon Ion EBRT in PHITS	Dawson
	2	**P12 –** Organ Dosimetry for Proton and Carbon Ion EBRT in PHITS	Dawson
	4	**L12 –** Organ Dosimetry in Photon Radiotherapy	Bolch
14	9	**P13 –** Radiation Shielding for Radiation Therapy in PHITS	Dawson
	9	**P13 –** Radiation Shielding for Radiation Therapy in PHITS	Dawson
	11	**L13 –** Organ Dosimetry in Proton and Carbon Ion Therapy	Bolch
15	16	**P14 –** Therapy Beam Profile Modeling in PHITS	Dawson
	16	**P14 –** Therapy Beam Profile Modeling in PHITS	Dawson
	18	**L14 –** Organ Dosimetry in Radiopharmaceutical Therapy	Bolch

Practicum Sessions – Brief Description

P1* – *Monte Carlo Methods	Basic principles of Monte Carlo sampling and its application to radiation transport. General description of stylized, voxel, and mesh-type computational phantoms and their uses within Monte Carlo radiation transport code systems.
P2* – *Introduction to PHITS Code	Description of PHITS input and output file structure including card sections and tallies. General description of constructing irradiation geometries. Overview of the PHITS manual and associated sources.
P3* – *Basic Geometries and Sources in PHITS	Creation of PHITS input file for point, plane, and volume sources and scoring of radiation field quantities using tallies in various environments. Subsequent output files will demonstrate proper calculation by visualization of various problem iterations.
P4* – *Source Modeling for Radiography/Fluoroscopy in PHITS	Creation of PHITS input file to demonstrate bremsstrahlung x-ray production within a radiographic x-ray tube and subsequent spectra generation. Analysis on x-ray spectrum generation via HVL measurements and demonstration of anode heel effect.
P5* – *Organ Dosimetry for Radiography/Fluoroscopy in PHITS	Creation of PHITS input file to demonstrate how to calculate organ dose coefficients and to generate a virtual radiographic image for common general radiographic and fluoroscopic examinations on the ICRP reference family of voxel computational phantoms. Review and implementation of UF SNIPs protocols.
P6* – *Organ Dosimetry for CT in PHITS	Creation of PHITS input file to demonstrate slice-specific organ dose coefficient computation using pre-built CT source term and ICRP mesh reference computational phantoms. Post-processing of output files to compute organ doses for common CT exams. Review and implementation of method outlined in Turner *et al.* (2009).
P7* – *Organ Dosimetry for Nuclear Medicine in PHITS	Creation of PHITS input files for common radioisotopes used in nuclear medicine. General overview of MIRD schema and direct calculation of radionuclide S values with comparison between reference voxel and mesh-type computational phantoms.
P8* – *Radiation Shielding for Diagnostic Imaging in PHITS	Creation of PHITS input files modeling a general radiography room with validation of room shielding from both direct and scatter radiation across all walls.
P9* – *Radiation Detector Modeling in PHITS	Creation of PHITS input files modeling common radiation detectors and description of their computational model validation workflow.
P10* – *Organ Dosimetry for Brachytherapy in PHITS	Creation of PHITS input files for simulation of common brachytherapy treatments in adult MRCPs. Demonstrate utility of mesh-type phantoms over voxel phantoms.
P11* – *Organ Dosimetry for Photon EBRT in PHITS	Creation of PHITS input files for simulation of linear accelerator radiotherapy on MRCPs. Quantification and comparison of organ dose contributions from direct (focal) and indirect (extra-focal) radiations.
P12* – *Organ Dosimetry for Proton and Carbon Ion EBRT in PHITS	Creation of PHITS input files for simulation of proton and carbon ion radiotherapy on MRCPs. Quantification and comparison of organ dose contributions from direct (focal) and indirect (extra-focal) radiations.
P13* – *Radiation Shielding for Radiation Therapy in PHITS	Creation of PHITS input files modeling a general linear accelerator treatment vault with validation of room shielding from both direct and scatter radiations across all walls.
P14* – *Therapy Beam Profile Modeling in PHITS	Creation of PHITS input files to demonstrate PDD and beam profiles across each axis as a function of depth for both photon and proton beams. Description of beam profiles with flattening filters versus flattening filter free beams. Consultation of AAPM TG-51.

Attendance and Expectations:
Students are expected to attend all classes either in person or by zoom. Students must notify the instructor of expected absence in advance and make arrangements to make up missed material. Excused absences must be consistent with university policies in the undergraduate catalog and require appropriate documentation. Attendance will be monitored through periodic verification in class. During class, all students must put away all cell phones. Students are encouraged to bring laptops to class to for class note taking. Excused absences must be consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/) and require appropriate documentation.

Evaluation of Grades

Grading Assignment	Total Points	Percentage of Final Grade	Exam Dates
Practicum Assignments	100	60% (14 x 5% each)	
Midterm Exam	100	15%	**TBA**
Final Exam	100	15%	**TBA**

Grading Policy

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil

proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third-party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code / Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Conduct Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Undergraduate Program Coordinator
- HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources - *Health and Wellness*

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Campus Resources - *Academic Resources*

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.ufl.edu/.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/ and https://care.dso.ufl.edu.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.