ENU 6623 / BME 4931 – PATIENT DOSIMETRY IN MEDICAL IMAGING AND RADIOTHERAPY - Spring 2022

Course Description (3 Credits)
This course 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 review radiation dosimetry quantities and units, including the effective dose, and human phantoms – both computational and physical – for dose assessment in the clinic. Latter topics will include organ dosimetry of the patients, including radiography, fluoroscopy, computed tomography, and nuclear medicine, 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 organ dosimetry in patients treated by radiotherapy using photon, proton, or radiopharmaceuticals. This section will be preceded by reviews of tumor control probability, normal tissue complication probability, the biologically effective dose concept, and how toxicities might be induced in non-targeted normal tissues and organs following out-of-field exposure in radiotherapy. The course P-Series of practicum sessions will give hands-on experience with the development of both voxel and mesh human computational phantoms and their use with the PHITS and TOPAS radiation transport codes for organ dosimetry.

Course Prerequisites (ENU 6623): BME 6535 – Radiation Physics, Measurement, and Dosimetry

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. Hands on work will include the use of the PCXMC Monte-Carlo based code for assessment of imaging dose to patients and the Monte Carlo radiation transport codes PHITS and TOPAS.

Instructor:
Wesley Bolch, PhD, (352) 273-0303, wbolch@ufl.edu
Office Hours: By appointment

Teaching Assistants:
Camilo Correa, PhD student in medical physics, ccorreaalfonso@ufl.edu
Sean Domal, PhD student in medical physics, sdomal@ufl.edu
Office Hours: By appointment

Meeting Times: Tuesdays – Practicum Series – Periods 7 and 8 (1:55 pm to 3:50 pm)
Thursdays – Lecture Series – Period 7 (1:55 pm to 2:45 pm)
Meeting Location: UF Health Science Center Communicore Video Conference Room C2-033

Textbooks:
The course will be based on instructor lecture notes, peer-reviewed journal articles, and selected reports.

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 graduate catalog (https://catalog.ufl.edu/graduate/regulations) 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.

Grading Policy	Total Points	Percentage of Final Grade	Exam Dates
Practicum Assignments	100	60%	
Midterm Exam	100	20%	**TBA**
Final Exam	100	20%	**TBA**

Lecture Schedule

Week	*Date*		*Lecture No. and Topic (L – Lecture / P – Practicum)*	*Lecturer*
1	**Jan**	6	**L1 –** Course Introduction / Codes and Software Access	Bolch / Correa / Domal
2		11	**P1 –** Monte Carlo Methods	Correa / Domal
		11	**P1 –** Monte Carlo Methods	Correa / Domal
		13	**L2 –** Computational and Physical Human Phantoms for Dose Assessment	Bolch
3		18	**P1 –** Monte Carlo Methods	Correa / Domal
		18	**P2 –** Stylized Phantoms and the PCXMC Code	Correa / Domal
		20	**L3 –** Historical Review of the Effective Dose and its Use in Medicine	Bolch
4		25	**P3 –** Voxel Phantoms from CT Images	Correa / Domal
		25	**P3 –** Voxel Phantoms from CT Images	Correa / Domal
		27	**L4 –** Historical Review of Skeletal Dosimetry	Bolch
5	**Feb**	1	**P4 –** Mesh Phantoms from CT Images / Conversion from Voxel Phantoms	Correa / Domal
		1	**P4 –** Mesh Phantoms from CT Images / Conversion from Voxel Phantoms	Correa / Domal
		3	**L5 –** Studies Linking Radiation Exposure to Cancer Induction	Bolch
6		8	**P5 –** X-Ray Spectra Generation and Matching to HVL	Correa / Domal
		8	**P5 –** X-Ray Spectra Generation and Matching to HVL	Correa / Domal
		10	**L6 –** Dose Dependent Models of Cancer Incidence and Mortality	Bolch
7		15	**P6 –** The PHITS Radiation Transport Code System	Correa / Domal
		15	**P6 –** The PHITS Radiation Transport Code System	Correa / Domal
		17	**L7 –** Organ Dosimetry in Radiography and Fluoroscopy	Bolch
8		22	**P7 –** Use of PHITS for Depth-Dose Calculations for Photons	Correa / Domal
		22	**P7 –** Use of PHITS for Depth-Dose Calculations for Photons	Correa / Domal
		24	**L8 –** Organ Dosimetry in Computed Tomography	Bolch
9	**Mar**	1	**P8 –** Use of PHITS for Depth-Dose Calculations for Protons and Carbon Ions	Correa / Domal
		1	**P8 –** Use of PHITS for Depth-Dose Calculations for Protons and Carbon Ions	Correa / Domal
		3	**L9 –** Organ Dosimetry in Diagnostic Nuclear Medicine	Bolch
10		8	***No Classes – Spring Break***	
		8	***No Classes – Spring Break***	
		10	***No Classes – Spring Break***	
11		15	**P9 –** Organ Dosimetry in Occupational Fields using ICRP Mesh Phantoms (PHITS)	Correa / Domal
		15	**P9 –** Organ Dosimetry in Occupational Fields using ICRP Mesh Phantoms (PHITS)	Correa / Domal
		17	**L10 –** Tumor Control Probability (TCP)	Bolch
12		22	**P10 –** Organ Dosimetry in Radiography Using ICRP Mesh Phantoms (PHITS)	Correa / Domal
		22	**P10 –** Organ Dosimetry in Radiography Using ICRP Mesh Phantoms (PHITS)	Correa / Domal
		24	**L11 –** Normal Tissue Complication Probability (NTCP)	Bolch
13		29	**P11 –** Organ Dosimetry in CT Using ICRP Mesh Phantoms (PHITS)	Correa / Domal
		29	**P11 –** Organ Dosimetry in CT Using ICRP Mesh Phantoms (PHITS)	Correa / Domal
		31	**L12 –** Biologically Effective Dose (BED) and Equieffective Dose (EQD2)	Bolch
14	**Apr**	5	**P12 –** Organ Dosimetry Nuclear Medicine Using ICRP Mesh Phantoms (PHITS)	Correa / Domal
		5	**P12 –** Organ Dosimetry Nuclear Medicine Using ICRP Mesh Phantoms (PHITS)	Correa / Domal
		7	**L13 –** Organs at Risk and Dose Thresholds for Toxicity	Bolch
15		12	**P13 –** Organ Dosimetry in Radiotherapy Using ICRP Mesh Phantoms (PHITS)	Correa / Domal
		12	**P13 –** Organ Dosimetry in Radiotherapy Using ICRP Mesh Phantoms (PHITS)	Correa / Domal
		14	**L14 –** Organ Dosimetry in Therapy Nuclear Medicine	Bolch

16	19	**P14 –** Other Radiation Transport Systems	Correa / Domal
	19	**P14 –** Other Radiation Transport Systems	Correa / Domal

Practicum Sessions – Brief Description

P1 – Monte Carlo Methods	Basic principles of Monte Carlo sampling and its application to radiation transport. Example applications such as determination of the volume of an organ within a human computational phantom. Use of random numbers in the transport of a photon in tissue.
P2 – Stylized Phantoms	General description of body contours and internal organs within a stylized computational phantom. Structure and use of the PCXMC code which performs photon transport with scalable versions of the ORNL stylized phantoms.
P3 – Voxel Phantoms	Demonstration of the use of 3D slicer and Rhinoceros 3D to convert patient CT images to a voxel phantom (organ and body contour segmentation).
P4 – Mesh Phantoms	Demonstration of the use of Rhino 3D and Blender to convert both CT images and/or a voxel phantom to a polygon mesh phantom. Use of Poly2Tet for conversion to a tetrahedral phantom.
P5 – X-Ray Spectra	Use of SPECKTR and other software to generate generic x-ray photon spectra in the diagnostic imaging region. Review and apply the methods of Turner et al. (2009) to refine a given x-ray spectrum to match a measurement of HVL_1 and potentially HVL_2
P6 – PHITS Code	Overview of the PHITS radiation transport code system – file structure, input files, output files, ALRADS tools for phantom coupling.
P7 – Depth Dose for Photons	Use of the PHITS code to compute absorbed dose and kerma as a function of depth in a water phantom, including lateral dose profiles. Explore both monoenergetic photons and then diagnostic and therapy x-ray spectra.
P8 – Depth Dose for Protons	Use of the PHITS code to compute absorbed dose and kerma as a function of depth in a water phantom including lateral dose profiles. Compare to photon results. Verify ICRU values of ranges and stopping powers.
P9 – Occupational Exposures	Couple PHITS to the ICRP Adult Mesh Phantoms. Compute organ dose coefficients for monoenergetic photons in the AP, PA, RLAT, and LLAT directions. Compare to values in ICRP Publication 116 and 145.
P10 – Radiography Dosimetry	Use PHITS and the ICRP Adult Mesh Phantoms to compute organ doses for a few radiographic imaging fields. Compare to those from PCXMC for the corresponding stylized phantoms.
P11 – CT Dosimetry	Use PHITS and the ICRP Adult Mesh Phantoms to compute organ doses for a few computed tomography imaging fields. Compare to those from existing literature.
P12 – NM Dosimetry	Use PHITS and the ICRP Adult Mesh Phantoms to compute values of specific absorbed fraction and radionuclide S values for a few source/target organ combinations. Compare results to the MIRDcalc code.
P13 – Radiotherapy Dosimetry	Use PHITS and the ICRP Adult Mesh Phantoms to compute in-field, near-field, and out-of-field organ doses for simple radiotherapy beams. Compare to those from existing literature.

P14 – Other Monte Carlo Codes	Overview of other radiation transport code systems. Review of existing Monte-Carlo based TPS systems in radiotherapy.

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:
UF Graduate Catalog
Grades and Grading Policies

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/.

Online Course Recording
Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

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 Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0903, jpennacc@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

Covid-19 Precautions for Spring 2022:

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the UF Health Screen, Test & Protect website for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

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 Resource 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.