

## ***BME 6535 – RADIOLOGICAL PHYSICS, MEASUREMENTS, AND DOSIMETRY - FALL 2021***

### **Instructor:**

Wesley Bolch, PhD, (352) 273-0303, [wbolch@ufl.edu](mailto:wbolch@ufl.edu)

Office Hours: Mondays, 9 to 11 am by zoom. Other times by appointment.

*Email Correspondence: If emailing about class issues, please use the email facility within Canvas.*

### **Student Assistants:**

Bonnie President, Medical Physics PhD Student, [bonnie.president@ufl.edu](mailto:bonnie.president@ufl.edu)

Jarred Baggett, Medical Physics MS Student, [j.baggett@ufl.edu](mailto:j.baggett@ufl.edu)

Office Hours: By appointment

### **Course Description (3 Credits)**

Interactions and measurement techniques for x-rays, gamma rays, neutrons and charged particles with matter; radioactive decay processes, ion chamber measurements, scintillation detectors, and dosimetry techniques. Applications of cavity theory and dosimetry measurement in medical physics.

**Course Prerequisites:** Upper level college physics.

### **Course Objectives:**

Develop an in-depth understanding of the physics of ionizing radiations and their interactions with matter. Students will explore methods of the generation and detection of photons, charged particles, electrons, positrons, and neutrons. Students will become proficient in measurement applications for a variety of radiation sources and the subsequent evaluation of radiation dose.

**Meeting Times:** MWF, Period 5, 11:45 am - 12:35 pm

**Meeting Location:** Benton Hall Room 0328

### **Textbooks:**

*Intro to Radiological Physics and Radiation Dosimetry*  
Frank H. Attix  
Wiley-VCH Verlag GmbH & Company (2004)  
ISBN-13: 978-0-471-01146-0

*Radiation Detection & Measurement*  
Glenn F. Knoll  
John Wiley & Sons, Inc. (2010) – 4<sup>th</sup> Edition  
ISBN: 978-0-470-13148-0 (Hardback)

### **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. Professionalism standards will be enforced on reviewer papers and are subject to plagiarism checks.

<b>Grading Policy</b>	<b>Total Points</b>	<b>Percentage of Final Grade</b>	<b>Exam / Due Dates</b>
Homework Assignments	Variable	20%	
Exam 1	100	20%	<b>Monday - September 27</b>
Exam 2	100	20%	<b>Monday - October 25</b>
Exam 3	100	20%	<b>Wednesday - December 15</b>
Review Papers – Submitted	85	20%	<b>Sunday - November 28</b>
Review Papers – Returned			<b>Sunday - December 5</b>
Review Papers – Resubmitted	15		<b>Sunday - December 12</b>

## Lecture Schedule

<i>Date</i>	<i>Lecture No. and Topic (L – Live, R – Recorded)</i>	<i>Reading</i>	<i>Class Activity</i>
<b>August</b>	23	Course Introduction	Course Introduction
	25	#1 – Review of Radiation Interactions (L)	Notes Live Lecture - #1
	27	#2 – Photon Interactions (L)	Attix – Ch 7 Live Lecture - #2
	30	#2 – Photon Interactions (continued) (L)	Attix – Ch 8 Live Lecture - #2
<b>September</b>	1	#3 – Charged Particle and Electron Interactions (L)	Attix – Ch 8 Live Lecture - #3
	3		<b>Review - HW Set #1</b>
	6	<i>No Class – Labor Day Holiday</i>	
	8	#4 – Radiation Fields – Quantities and Units (R)	Attix – Ch 1 Problem Session
	10	#5 – Energy Transfer and Dose – Quantities and Units (R)	Attix – Ch 2 <b>Review - HW Set #2</b>
	13	#6A – Exponential Attenuation – Uncollided Fluence (R)	Attix – Ch 3 Lecture Q&A – #4/5
	15	#6B – Exponential Attenuation – Buildup Factors (R)	Attix – Ch 3 Problem Session
	17		<b>Review - HW Set #3/4</b>
	20	#7 – Charge-Particle and Radiation Equilibria (R)	Attix – Ch 4 Lecture Q&A – #6A/B
	22	#8 – Radioactive Disintegration Processes (R)	Attix – Ch 5 <b>Amy Buhler – UF Libraries</b>
	24		<b>Review - HW Set #5/6</b>
<b>E1</b>	27	#9 – Radioactive Decay Kinetics (R)	Attix – Ch 6 Lecture Q&A – #7/8
	29	#10 – X-Ray Production and Quality (R)	Attix – Ch 9 Problem Session
<b>October</b>	1		<b>Review - HW Set #7/8</b>
	4	#11 – Cavity Theory (R)	Attix – Ch 10 Lecture Q&A – #9/10
	6	#12 – Counting Statistics and Error Prediction (R)	Knoll – Ch 3 Problem Session
	8	<i>No Class – UF Homecoming</i>	
	11	#13 – General Properties of Radiation Detection (R)	Knoll – Ch 4 Lecture Q&A – #11/12
	13	#14 – Ionization Chambers (R)	Knoll – Ch 5 Problem Session
	15		<b>Review - HW Set #9</b>
	18	#15A – Scintillation Detector Design (R)	Knoll – Ch 8 &10 Lecture Q&A – #13/14
	20	#15B – Scintillation Detector Spectroscopy (R)	Knoll – Ch 8 &10 Problem Session
	22		<b>Review - HW Set #10</b>
<b>E2</b>	25	<b>Review Paper Proposals (L)</b>	Lecture Q&A – #15A/B
	27	<b>Review Paper Proposals (L)</b>	Problem Session
	29		<b>Review - HW Set #11</b>
<b>November</b>	1	#16 – Semiconductor Diode Detectors (R)	Knoll – Ch 11 Free Discussion
	3	#17 – Solid-State Detectors (R)	Knoll – Ch 12 Problem Session
	5		<b>Review - HW Set #12</b>
	8	#18 – Luminescent Dosimeters (R)	Knoll – Ch 19 Lecture Q&A – #16/17
	9	#19 – Neutron Interactions & Dosimetry (R)	Notes Problem Session
	12		<b>Review - HW Set #13/14</b>
	15	#20 – Slow Neutron Detection (R)	Knoll – Ch 14 Lecture Q&A – #18/19
	17	#21 – Fast Neutron Detection (R)	Knoll – Ch 15 Problem Session
	19		<b>Review - HW Set #15/16</b>
	22	#22 – Review of Detectors in Medical Imaging (L)	
	24	<i>No Class – Thanksgiving Holiday</i>	
	26	<i>No Class – Thanksgiving Holiday</i>	
	29	#23 – Review of Detectors in Radiotherapy (L)	
<b>December</b>	1		<b>Review - HW Set #17/18</b>
	3	<b>Review Paper Presentations (L)</b>	Presentations

	6	<b>Review Paper Presentations (L)</b>	Presentations
	8	<b>Review Paper Presentations (L)</b>	Presentations
<b>E3</b>	15		

**Homework:** Problems will be assigned for each chapter covered in the course text. Problem sets will be due within one week. Grades will be reduced 20% per day late.

### Homework Schedule by Date

<i>Date</i>	<i>HW Set - Assigned</i>	<i>HW Set - Due</i>
<b>August</b> 30	<b>HW Set #1</b> – Attix Chapter 7	
<b>September</b> 6	<b>HW Set #2</b> – Attix Chapter 8	<b>HW Set #1</b> – Attix Chapter 7
13	<b>HW Set #3</b> – Attix Chapter 1 <b>HW Set #4</b> – Attix Chapter 2	<b>HW Set #2</b> – Attix Chapter 8
20	<b>HW Set #5</b> – Attix Chapter 3 <b>HW Set #6</b> – Attix Chapter 4	<b>HW Set #3</b> – Attix Chapter 1 <b>HW Set #4</b> – Attix Chapter 2
27	<b>HW Set #7</b> – Attix Chapter 5 <b>HW Set #8</b> – Attix Chapter 6	<b>HW Set #5</b> – Attix Chapter 3 <b>HW Set #6</b> – Attix Chapter 4
<b>October</b> 4	<b>HW Set #9</b> – Attix Chapter 9	<b>HW Set #7</b> – Attix Chapter 5 <b>HW Set #8</b> – Attix Chapter 6
11		
18	<b>HW Set #10</b> – Attix Chapter 10	<b>HW Set #9</b> – Attix Chapter 9
25	<b>HW Set #11</b> – Knoll Chapter 3	<b>HW Set #10</b> – Attix Chapter 10
<b>November</b> 1	<b>HW Set #12</b> – Knoll Chapter 4	<b>HW Set #11</b> – Knoll Chapter 3
8	<b>HW Set #13</b> – Knoll Chapter 5 <b>HW Set #14</b> – Knoll Chapter 8	<b>HW Set #12</b> – Knoll Chapter 4
15	<b>HW Set #15</b> – Knoll Chapter 10 <b>HW Set #16</b> – Knoll Chapter 11	<b>HW Set #13</b> – Knoll Chapter 5 <b>HW Set #14</b> – Knoll Chapter 8
22		<b>HW Set #15</b> – Knoll Chapter 10 <b>HW Set #16</b> – Knoll Chapter 11
29	<b>HW Set #17</b> – Knoll Chapter 14 <b>HW Set #18</b> – Knoll Chapter 15	
<b>December</b> 6		<b>HW Set #17</b> – Knoll Chapter 14 <b>HW Set #18</b> – Knoll Chapter 15

**Exams:** Three non-cumulative exams will be given during the semester. Depending upon continuing circumstances regarding COVID-19 restrictions during the Fall 2021 semester, these exams will most likely be given as time-limited and open book/notes format on a date to be announced within a week of the exam distribution. If, however, arrangements can be made to safely give the exam in person and on campus under CDC guidelines, we will make those arrangements. Make-up exams will only be considered for exceptional circumstances and will be implemented by the instructor on a case-by-case basis. Notice of the absence must be given to the instructor prior to the start of each exam.

**Review Papers:** Students are asked to select a topic related to radiation detection or dosimetry, and perform a detailed literature review of that topic. The review article will follow the Instructions to Contributors for the journal *Medical Physics*. Grades for the final manuscripts will be based upon (1) technical content, (2) writing style, and (3) adherence to journal article submission guidelines.

Students are asked to follow the author instructions, except for the following:

- Limit your total number of pages of text (Abstract to Conclusions) to no more than 15 pages and no fewer than 10 pages. This page count does not include embedded figures and tables.
- Submit only one copy of the Cover Letter and one copy of the Manuscript (including all tables and figures) all in MS Word format
- Use the following file names:
  - Cover Letter – Last\_Name.docx,
  - Paper – Last\_Name.docx.
- Each paper must have at least two tables and two figures.
- Each paper must have cited at least 10 peer-reviewed journal article citations (beyond textbooks or conference proceedings).

Each manuscript will be submitted with a cover letter to the appropriate Editor-in-Chief noting why you think your work is worthy of publication. Final manuscripts are due by email on Sunday, **November 28**. Reviewed manuscripts will be returned by Sunday, **December 5**. A resubmitted manuscript with Response to Comments will be due by Sunday, **December 12**. **All papers will be subject to plagiarism review using Turnitin software.**

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## Homework Policy

Wesley E. Bolch

1. Homework sets will be assigned on Mondays as noted above. They will be due by upload to the Canvas course website on the date and time indicated. Grades will be decreased 20% for each day late (20% the following Monday, 40% the following Tuesday, etc.).
2. Homework to be turned in must be neat and legible, and submitted in PDF format of high-quality. As a general practice, work each homework problem on a scratch paper and recopy when thought to be correct and complete. All homework problems will be graded; however, **the instructor reserves the right to give zero credit for any problem that does not appear neat, legible, and easy to follow.**
3. For each problem...
  - a) Start each problem on a separate page.
  - b) Paraphrase the problem to be solved.
  - c) State all given and pertinent data, and specify the sources for each.
  - d) List all pertinent formulas or laws needed to solve the problem.
  - e) State clearly all assumptions made.
  - f) Solve the equations specified above with minimal calculation of intermediate values. When reporting intermediate values, carry 2-3 extra significant digits until the final answer is given.
  - g) Within each equation to be solved, show units for every numerical value substituted. Perform a unit analysis for both intermediate and final answers.
  - h) Label and box your final answer. Give no more than one significant digit beyond those of your input data.
  - i) **The instructor reserves the right to give zero credit to a problem if any one of these steps are not followed.**
4. Partial credit will be given for each worked problem.
5. Turn in each homework with the homework assignment as a cover page.

## ***Grading Policy***

<b>Percent</b>	<b>Grade</b>	<b>Grade Points</b>
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/>.

### ***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 and 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](mailto:jpennacc@eng.ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto: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 Fall 2021:**

- 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](mailto: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](mailto: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](mailto: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 support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto: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>.