

# OPTI 506 – Radiometry, Sources, & Detectors

**OPTI 506 - Radiometry, Sources and Detectors - Fall, 2023. Radiometric concepts, symbols, units and nomenclature. Radiative transport in free space and through optical systems. Effect of material properties on radiative transport. Blackbodies and other radiation sources. Fundamentals of radiation detectors, including principles of operation, noise and figures of merit. Illustrative imaging and nonimaging radiometric systems.**

<b>Prerequisites:</b>	suggested OPTI 502
<b>Class time:</b>	MW, 12.30 pm - 1.45 pm
<b>Location:</b>	Meinel Optical Sci, Rm 307
<b>Recordings:</b>	Yes (Distance-Learning class)
<b>Synchronous:</b>	Zoom within Meinel 307 (see D2L for links)
<b>Asynchronous:</b>	Panoptic Recording
<b>D2L:</b>	Yes
<b>Instructor:</b>	Ron Driggers
<b>Email:</b>	<a href="mailto:rdriggers@arizona.edu">rdriggers@arizona.edu</a>
<b>Office:</b>	Meinel Room 437
<b>Phone:</b>	407-669-6958
<b>Office Hours:</b>	Right after class or schedule
<b>TA:</b>	Jeff Chen
<b>Email:</b>	Jeff Chen < <a href="mailto:jeffreychen@arizona.edu">jeffreychen@arizona.edu</a> >
<b>Office:</b>	TBD
<b>Office Hours:</b>	TBD

## Course Objectives:

This course covers the generation (sources and radiometry), propagation (radiometry), and measurement (detectors and radiometry) of optical radiation. The theory, units, approximations, instrumentation, and applications will be presented in detail. The majority of the course is based on material that was developed by Dr. John Koshel.

## Learning Outcomes:

1. Understand how to measure optical radiation with physical (radiometric) and psychophysical (photometric) terms,
2. Understand the concept of étendue,
3. Know the types of sources, especially blackbody ones,
4. Know the various type of detectors,
5. Be able to calculate noise and SNR arising from measurement, and
6. Understand the mathematical derivations behind the concepts in the course.

## Course Material and Logistics:

**Lectures:** PDFs will be uploaded to D2L around each lecture time. Note that not all material will be within the PDFs: supplement the lectures with class notes. All lectures will be live online (Zoom) and a recording will be posted to D2L.

**Recitation:** There are no scheduled recitations at this time, but they may be setup as required. Homework, solutions, midterm, labs, and so forth will be discussed at any such meetings. Attendance at any recitation is optional.

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**Homework:** Assignments and solutions will be uploaded to D2L. Assignments may involve lab kits that will be supplied at a later date.

**Other:** Other material will be posted on D2L as warranted

**Absence:** You are expected to follow the [UA Policy](#), but you are adults so I respect your decisions. I follow UA policies for [religious beliefs](#) and [pre-approved absences](#). See end of document.

**DL Students:** You are expected to turn in all assignments by the scheduled time. If you need additional time due to non-UA demands, please request such before the due date. For exams you have up to one additional week to complete the exam.

## Course Outline (75-minute lectures)

This listing is tentative, and the order and topics may change as the semester progresses.

Lecture Number	Topic(s)	Modality
1	Syllabus, What is Radiometry, Units	In Person and Recorded
2	Projections, radiance	In Person and Recorded
3	Exitance, irradiance, intensity, power	In Person and Recorded
4	Invariants	In Person and Recorded
5	Cosine Laws I	In Person and Recorded
6	Cosine Laws II	In Person and Recorded
7	Radiative transfer	In Person and Recorded
8	Configuration factor, integrating sphere	In Person and Recorded
9	Radiometric instruments	In Person and Recorded
10	Material properties I	In Person and Recorded
11	<b>EXAM I (through Lecture 9)</b>	In Person and Distance
12	Material properties II	In Person and Recorded
13	Material properties III	In Person and Recorded
14	Source Introduction	In Person and Recorded
15	Blackbody radiation: Planck's Law	In Person and Recorded
16	Blackbody radiation: working with Planck's Law	In Person and Recorded
17	Blackbody radiation: other laws	In Person and Recorded
18	Blackbody radiation: working with other laws	In Person and Recorded
19	Emissivity	In Person and Recorded
20	Examples	In Person and Recorded
21	Other sources	In Person and Recorded
22	Detector introduction	In Person and Recorded
23	Noise	In Person and Recorded
24	<b>EXAM II (through lecture 21)</b>	In Person and Distance
25	Shot Noise	In Person and Recorded
26	Photon detectors	In Person and Recorded
27	Photoemissive	In Person and Recorded
28	Photoconductive	In Person and Recorded
29	Photovoltaic	In Person and Recorded
30	Thermal Detectors	In Person and Recorded
<b>Final</b>	<b>Exam</b>	

See link for Academic Dates: [Graduate](#)

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Note that the radiometry material is used throughout the lectures that follow the first course section. It is imperative that you understand the first **nine** lectures in order to fully understand the following lectures.

## Texts (recommended) – see D2L > Library Tools for easy access to some:

1. [The Art of Radiometry](#), James Palmer & Barbara Grant, SPIE Press, (2010).
  - a. GET THIS ONE!
  - b. You can get it for free through SPIE since the UA has a site license – look at D2L > Library Tools – should be accessible on and off campus
  - c. Off campus & (b) does not work, login with [VPN to the UA](#) (requires [UA NetID+](#))
  - d. Go to the [SPIE website](#) and download
2. [Radiometry and the Detection of Optical Radiation](#), Robert W. Boyd, Wiley-Interscience (1983).
  - a. GET THIS ONE too!
  - b. Great book IMO, but the notation is different than #1
3. [Optical Radiation Detectors](#), Eustace Dereniak and Devon G. Crowe, Wiley Series in Pure and Applied Optics (1984).
  - a. Another good book written by individuals with a connection to OpSci
4. [Introduction to Radiometry](#), William L. Wolfe, SPIE Press (1998).
5. [Handbook of Optics](#), Volume II, 3<sup>rd</sup> Ed., ed. Michael Bass, V. N. Mahajan, and Eric Van Stryland, McGraw Hill (2010).
  - a. See chapters on radiometry, illumination, photometry, sources, etc.
6. [Field Guide to Geometric Optics](#), John Greivenkamp, SPIE Press (2003).
  - a. Download the lite version on the [iPhone App](#) (there are other versions)
  - b. See #1 then visit the [SPIE website](#) and download
7. [Field Guide to Illumination](#), Angelo V. Arcchi, Tahar Messadi, R. John Koshel, SPIE Press (2007).
  - a. See #1 then visit the [SPIE website](#) and download
  - b. Illumination is based on the field of radiometry
8. [Illumination Engineering: Design with Nonimaging Optics](#), R. John Koshel, Wiley-IEEE Press (2013).

**Exams:** There will be two regular exams – in class or take home (TBD).

**Assignments:** Homework assignments will be given, and they may involve computer simulations or physical measurements with apparatus to be supplied. Students are encouraged to work together on homework assignments, but the final write-ups must be independent. Homework is to be turned in by the end of the day it is due. Expect 7-8 homework assignments.

**Grading:**

Assignments	10%	(1 day late -25%, 2 days late -50%, no credit later)
Exam I	20%	(in class or take home)
Exam II	20%	(in class or take home)
Final Exam	25%	Format TBD (may be an oral exam)
Paper	25%	(due end of last week of classes)

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**Grading:** The grade will be determined according to the cumulative percentage earned such that 90-100% = A, 80- 89% = B, 70-79% = C, 60-69% = D, below 60% = E.

## **For Graduates:**

- A: Excellent – has demonstrated a more than acceptable understanding of the material; exceptional performance; exceeds expectations
- B: Good – has demonstrated an acceptable understanding of the material; adequate performance; meets expectations
- C: Average – has not demonstrated an acceptable understanding of the material; inadequate performance; does not meet expectations
- D: Poor – little to no demonstrated understanding of the material; exceptionally weak performance
- E: Failure – usually reserved for non-attendance

## **CLASSROOM BEHAVIOR**

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.).

## **THREATENING BEHAVIOR**

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See <http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students>.

## **ACADEMIC INTEGRITY**

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: <http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity>.

The University Libraries have some excellent tips for avoiding plagiarism, available at <http://new.library.arizona.edu/research/citing/plagiarism>.

*Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are*

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subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.

## NONDISCRIMINATION AND ANTI-HARASSMENT

The University is committed to creating and maintaining an environment free of discrimination; see <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>.

## ACCESSIBILITY AND ACCOMODATIONS

At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, <https://drc.arizona.edu/>) to establish reasonable accommodations.

## SPECIAL NOTES

- **COVID-19:** Per UArizona's direction, which is likely to change in the next few weeks, we will comply with university policy on in-person attendance (or possible modification to zoom or other means), masks, distancing, etc. We will review university policy at the beginning of the course.
- **Classroom attendance:**
  - If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.
  - Notify your instructors if you will be missing an in person or online course.
  - Visit the [UArizona COVID-19](#) page for regular updates.
- **Academic advising:** If you have questions about your academic progress this semester, or your chosen degree program, please note your advisor [Jini Kandyil](#) and the [Advising Resource Center](#) can guide you toward university resources to help you succeed.
- **Life challenges:** If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The [Dean of Students Office](#) can be reached at 520-621-2057 or [DOS-deanofstudents@email.arizona.edu](mailto:DOS-deanofstudents@email.arizona.edu).
- **Physical and mental-health challenges:** If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520-621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.
- **Equipment and software requirements:** For this class you may need daily access to the following hardware: computer or similar; regular access to reliable internet signal; ability to download and run the following software: web browser and Adobe Acrobat.
- **Remain flexible:** If pandemic conditions warrant, the University may require that we return to remote operations. If that is the case, we will notify you by D2L Announcement and email that we are moving to remote operations.

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- **Class Recordings:**
  - For lecture recordings, which are used at the discretion of the instructor, students must access content in D2L only. Students may not modify content or re-use content for any purpose other than personal educational reasons. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies are subject to suspension or civil action.
  - **Note:** look at [FERPA Privacy Protection guide](#) to know your rights and how to protect your personal information.