CREOL, The College of Optics and Photonics

OSE4720 VISUAL OPTICS

Semester: Spring 2023
Location: A214, CREOL
Prerequisites: OSE 3052 Introduction to Photonics
Credit Hours: 3

Course Description: Optics of the human eye and color vision. Optical and neural processing of spatial, temporal, and color information. Detection, discrimination, and recognition. Color science.

Instructor: Bahaa Saleh
Email/Contact Info: besaleh@creol.ucf.edu
Office Hours: Rm A331, CREOL

Course Materials: No textbook is required.
Class notes and reading material will be made available on Webcourses@UCF
Recommended references:
Visual Perception, T. Cornsweet, Academic, 1970
Color Science, G. Wyszecki, W. Stiles, Wiley, 2005

Deadlines, Holidays, and Significant Semester Events:

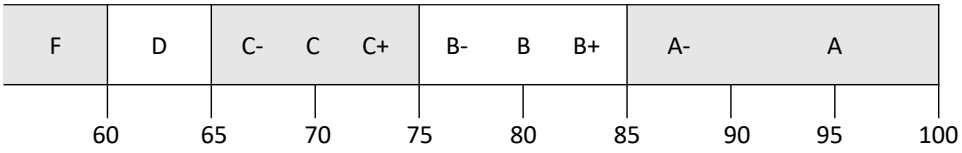
First Day of Class	January 10
Last Day to Drop Classes	January 13
Last Day to Add Classes	January 13
Spring Break	March 13-19
Withdrawal Deadline	March 24, 11:59 pm
Final Exam	April 27, 1:00-3:00 pm

Please refer to the UCF Academic Calendar and the UCF Exam Schedule for more information such as Exam Dates, Add/Drop, Withdrawal, and Grade Forgiveness Deadlines.

Course Grading and Requirements for Success:

Criteria	Grade Weighting
Homework	20%
Term Paper	10%
Midterm Exam	30%
Final Exam	40%
Total	100%

Grade	Rubric Description
A	Excellent, has a strong understanding of all concepts and is able to apply the concepts in all and novel situations. Has full mastery of the content of the course.
B	Good, has a strong understanding of most or all of the concepts and is able to apply them to stated and defined situations.
C	Average, has a basic understanding of the major concepts of the course and is able to apply to basic situations.
D	Below average, has a basic understanding of only the simple concepts and is able to apply to only a limited number of the most basic situations.
F	Demonstrates no understanding of the course content.



Grade Dissemination: To comply with the Family Educational Rights and Privacy Act (FERPA), grades must not be released to third parties, which includes posting grades by name, SSN, or UCFID. To ensure students have prompt feedback, and knowledge of their progress, all grades will be recorded in Webcourses@UCF following student data classification and security standards.

Make Up Policy: If an emergency arises and a student cannot submit assigned work on or before the scheduled due date or cannot take an exam on the scheduled date, the student **must** give notification to the instructor **no less than 24 hours before** the scheduled date and **no more than 48 hours after the** scheduled date. Per university policy, students must be allowed to turn in make-up work (or an equivalent, alternate assignment) for university-sponsored events, religious observances, or legal obligations (such as jury duty). In these instances, students must also be excused from class without penalty. The Undergraduate Catalog states, "Reasons for acceptable absences may include illness, serious family emergencies, special curricular requirements (e.g., judging trips, field trips, professional conferences), military obligations, severe weather conditions, and religious holidays."

Grade Objections: All objections to grades should be made **in writing within one week** of the work in question. Objections made after this period has elapsed will **not** be considered – NO EXCEPTIONS.

Financial Aid and Attendance: As of Fall 2014, all faculty members are required to document students' academic activity at the beginning of each course. In order to document that you began this course, please complete the following academic activity by the end of the first week of classes, or as soon as possible after adding the course, but no later than January 31, 2023. Failure to do so will result in a delay in the disbursement of your financial aid.

Detailed Course Outline

This course is an introduction to optics of the human eye and physiology of the visual system. It covers optical and neural processing of temporal, spatial, and color information from an engineering viewpoint. The performance of the visual system in carrying out tasks such as change detection, brightness and texture discrimination, and recognition, will be introduced using measures such as detectability, receiver operating characteristic (ROC), modulation transfer function (MTF), contrast sensitivity function, and acuity. Various theories of depth perception will be introduced along with cues for 3D display. Mechanisms for human color perception will be reviewed and the relation between the perceived color (hue, saturation, and brightness) and the physical stimulus will be highlighted. Spectral colors and color reproduction in the printing and display industry (TV and Web), colorimetry and color image processing using MatLab tools will be included.

List of Topics: (A detailed schedule with dates follows at the end of this document.)

- Introduction & overview of the visual system
- Geometric optics of the human eye.
- Imaging in the human eye using optometric measures.
- Ophthalmic instruments
- Physical optics of the human eye: MTF and effect of aberrations, imaging quality
- Retina-brain processing
- Visual sensitivity. Detectability and ROC characteristics. Role of photon noise and neural noise
- Spatial vision. Brightness vs intensity. Contrast sensitivity and modulation transfer function.
- Image quality. Acuity and hyperacuity, discrimination, and masking.
- Temporal vision. Role of eye movement. Detection of moving objects
- Binocular vision. Depth perception.
- Color vision.
- Color science and technology. Colorimetry and the CIE system. Color reproduction in the printing and display industry
- Visual adaptation

Learning Outcomes:

Upon completing this course, the students will be able to:

- describe the optics of the human eye as an image formation system and compare its features to a camera
- explain how the ophthalmoscope functions
- use a linear system model of the eye and the retina to explain the contrast sensitivity function and its measurement using psychophysical experiments
- use a photon model of light to explain the results of psychophysical experiments regarding the detectability of weak flashes of light
- describe the physical and physiological factors that limit visual acuity.
- use the principal theories of depth perception to design 3D display systems using visual cues
- describe the various representations of color (RGB, CMYK, YIQ) and convert one to another
- explain the significance of the color gamut of a display device

Relationship of Course to ABET Criteria

ABET Criteria	Level of Emphasis
(a) An ability to apply knowledge of mathematics, science, and engineering.	High
(b) An ability to design and conduct experiments, as well as to analyze and interpret data	Low
(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	Low
(d) An ability to function on multidisciplinary teams.	Low
(e) An ability to identify, formulate, and solve engineering problems.	Medium
(f) An understanding of professional and ethical responsibility.	Low
(g) An ability to communicate effectively.	Low
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	Medium
(i) A recognition of the need for, and an ability to engage in life-long learning.	Medium
(j) A knowledge of contemporary issues.	Medium
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	High

Student learning outcomes and measures relevant to OSE4721

Outcome	Measure
1 Graduates have an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	1.1 A passing student must be able to formulate and solve a complex or multistep problem based on relevant parameters.
1 Graduates have an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	1.2 A passing student must be able to identify a photonics engineering problem out of a complex, context-rich statement or scenario.
1 Graduates have an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	1.1 A passing student must be able to formulate and solve a complex or multistep problem based on relevant parameters.
1 Graduates have an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	1.2 A passing student must be able to identify a photonics engineering problem out of a complex, context-rich statement or scenario.
3 Graduates have an ability to communicate effectively with a range of audiences.	3.1 A passing student must be able to demonstrate effective written communication for specified audiences using technical written communication modes, such as reports, publication, patents, or proposals.
3 Graduates have an ability to communicate effectively with a range of audiences.	3.2 A passing student must be able to demonstrate effective oral communication techniques for specified audiences, using conference presentations, posters, seminars, “elevator speeches”, or presentations without visual aids.
7 Graduates have an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	7.2 A passing student must be able to demonstrate the ability to self-learn content beyond that taught in classroom instruction.

Weekly Schedule (subject to change)

Week	Date	Course material:
1	T 1/10	Introduction & overview of the visual system
	R 1/12	Geometric optics of the human eye using optometric units
2	T 1/17	Imaging in the human eye
	R 1/19	Ray tracing in the human eye
3	T 1/24	Vision correction
	R 1/26	Ophthalmic instruments
4	T 1/31	Physical optics of the human eye
	R 2/2	Midterm Exam I
5	T 2/7	MTF and effect of aberrations. Imaging quality
	R 2/9	Retina-brain processing
6	T 2/14	Retina-brain processing
	R 2/16	Visual sensitivity. Detectability and ROC characteristics
7	T 2/21	Role of photon noise and neural noise
	R 2/23	Spatial vision. Brightness vs intensity
8	T 2/28	Contrast sensitivity and modulation transfer function
	R 3/2	Visual acuity
9	T 3/7	Midterm Exam II
	R 3/9	Temporal vision. MTF
10	T 3/14	Spring Break
	R 3/17	Spring Break
11	T 3/21	Temporal vision. Detection of dynamic objects
	R 3/23	Binocular vision. Depth perception
12	T 3/28	Binocular vision. Depth perception
	R 3/30	Applications to 3D display
13	T 4/4	Color vision
	R 4/6	Color vision
14	T 4/11	Colorimetry and the CIE system
	R 4/13	Color reproduction in the printing and display industry
15	T 4/18	Visual adaptation
	R 4/20	Term paper presentations
16		
	R 4/27	FINAL EXAM

Guidelines for term paper

The paper and presentation should be a technical review of a specific topic related to the material presented in the course.

Paper: 4-5 pages single-space 11-pt font, including 3-5 figures to explain the key concepts with captions, and an extra page for bibliography.

Presentation: Please submit an mp4 video recording (< 5 minutes), uploaded to Zoom with a link shared with the class.

Assessment: The paper and presentation will be graded based on the following criteria:

1. Whether the concept, operation principles, or methods are clearly explained?
2. Whether the key parameters, figure of merits, and limitations are adequately discussed?
3. Whether appropriate references are included?
4. Whether the paper is consistently formatted?

Samples of topics chosen by students in previous classes:

- Aberration in the human eye
- Astigmatism
- The ophthalmoscope
- Optics of LASIK
- Vision after cataract removal
- Entoptic phenomena
- Application of adaptive optics to examine the retina
- Amazing eyes of animalya
- Vision in insect vision
- Marine animal eyes
- Color vision in other species
- Interspecies comparison of pupil shape
- Hyperacuity
- How many photons can the eye see?
- Role of spatial summation and lateral inhibition in perceived brightness
- Virtual reality and binocular vision (Oculus)
- Role of eye movement in vision
- Color constancy
- Color blindness
- Stereopsis
- Dark adaptation and after images
- Optical illusions

Policy Statements

Academic Integrity

Students should familiarize themselves with UCF's Rules of Conduct at <https://scai.sdes.ucf.edu/student-rules-of-conduct/>. According to Section 1, "Academic Misconduct," students are prohibited from engaging in

1. Unauthorized assistance: Using or attempting to use unauthorized materials, information or study aids in any academic exercise unless specifically authorized by the instructor of record. The unauthorized possession of examination or course-related material also constitutes cheating.
2. Communication to another through written, visual, electronic, or oral means: The presentation of material which has not been studied or learned, but rather was obtained through someone else's efforts and used as part of an examination, course assignment, or project.
3. Commercial Use of Academic Material: Selling of course material to another person, student, and/or uploading course material to a third-party vendor without authorization or without the express written permission of the university and the instructor. Course materials include but are not limited to class notes, Instructor's PowerPoints, course syllabi, tests, quizzes, labs, instruction sheets, homework, study guides, handouts, etc.
4. Falsifying or misrepresenting the student's own academic work.
5. Plagiarism: Using or appropriating another's work without any indication of the source, thereby attempting to convey the impression that such work is the student's own.
6. Multiple Submissions: Submitting the same academic work for credit more than once without the express written permission of the instructor.
7. Helping another violate academic behavior standards.
8. Soliciting assistance with academic coursework and/or degree requirements.

Responses to Academic Dishonesty, Plagiarism, or Cheating

Students should familiarize themselves with the procedures for academic misconduct in UCF's student handbook, *The Golden Rule* <https://goldenrule.sdes.ucf.edu/>. UCF faculty members have a responsibility for students' education and the value of a UCF degree, and so seek to prevent unethical behavior and respond to academic misconduct when necessary. Penalties for violating rules, policies, and instructions within this course can range from a zero on the exercise to an "F" letter grade in the course. In addition, an Academic Misconduct report could be filed with the Office of Student Conduct, which could lead to disciplinary warning, disciplinary probation, or deferred suspension or separation from the University through suspension, dismissal, or expulsion with the addition of a "Z" designation on one's transcript.

Being found in violation of academic conduct standards could result in a student having to disclose such behavior on a graduate school application, being removed from a leadership position within a student organization, the recipient of scholarships, participation in University activities such as study abroad, internships, etc.

Let's avoid all of this by demonstrating values of honesty, trust, and integrity. No grade is worth compromising your integrity and moving your moral compass. Stay true to doing the right thing: take the zero, not a shortcut.

Unauthorized Use of Websites and Internet Resources

There are many websites claiming to offer study aids to students, but in using such websites, students could find themselves in violation of academic conduct guidelines. These websites include (but are not

limited to) Quizlet, Course Hero, Chegg Study, and Clutch Prep. UCF does not endorse the use of these products in an unethical manner, which could lead to a violation of our University's Rules of Conduct.

They encourage students to upload course materials, such as test questions, individual assignments, and examples of graded material. Such materials are the intellectual property of instructors, the university, or publishers and may not be distributed without prior authorization. Students who engage in such activity could be found in violation of academic conduct standards and could face course and/or University penalties. Please let me know if you are uncertain about the use of a website so I can determine its legitimacy.

Unauthorized Distribution of Class Notes
Third parties may attempt to connect with you to sell your notes and other course information from this class. Distributing course materials to a third party without the my authorization is a violation of our University's Rules of Conduct. Please be aware that such class materials that may have already been given to such third parties may contain errors, which could affect your performance or grade.

Recommendations for success in this course include coming to class on a routine basis, visiting me during my office hours, connecting with the Teaching Assistant (TA), and making use of the Student Academic Resource Center (SARC), the University Writing Center (UWC), the Math Lab, etc. If a third party should contact you regarding such an offer, I would appreciate your bringing this to my attention. We all play a part in creating a course climate of integrity.

In-Class Recording
Students may, without prior notice, record video or audio of a class lecture for a class in which the student is enrolled for their own personal educational use. A class lecture is defined as a formal or methodical oral presentation as part of a university course intended to present information or teach enrolled students about a particular subject.

Recording class activities other than class lectures, including but not limited to lab sessions, student presentations (whether individually or part of a group), class discussion (except when incidental to and incorporated within a class lecture), clinical presentations such as patient history, academic exercises involving student participation, test or examination administrations, field trips, private conversations between students in the class or between a student and the faculty member, and invited guest speakers is prohibited.

Recordings may not be used as a substitute for class participation and class attendance and may not be published or shared without the written consent of the faculty member. Failure to adhere to these requirements may constitute a violation of the University's Student Code of Conduct as described in the Golden Rule.

Course Accessibility Statement
The University of Central Florida is committed to providing access and inclusion for all persons with disabilities. Students with disabilities who need access to course content due to course design limitations should contact the professor as soon as possible. Students should also connect with Student Accessibility Services (SAS) http://sas.sdes.ucf.edu/ (Ferrell Commons 185, sas@ucf.edu, phone 407-823-2371).

For students connected with SAS, a Course Accessibility Letter may be created and sent to professors, which informs faculty of potential course access and accommodations that might be necessary and reasonable. Determining reasonable access and accommodations requires consideration of the course

design, course learning objectives and the individual academic and course barriers experienced by the student. Further conversation with SAS, faculty and the student may be warranted to ensure an accessible course experience.

Deployed Active Duty Military Students
If you are a deployed active duty military student and feel that you may need a special accommodation due to that unique status, please contact your instructor to discuss your circumstances.

Campus Safety Statement
Emergencies on campus are rare, but if one should arise during class, everyone needs to work together. Students should be aware of their surroundings and familiar with some basic safety and security concepts.

- In case of an emergency, dial 911 for assistance.
- Every UCF classroom contains an emergency procedure guide posted on a wall near the door. Students should make a note of the guide's physical location and review the online version at https://centralflorida-prod.modolabs.net/student/safety/index.
- Students should know the evacuation routes from each of their classrooms and have a plan for finding safety in case of an emergency.
- If there is a medical emergency during class, students may need to access a first-aid kit or AED (Automated External Defibrillator). To learn where those are located, see https://ehs.ucf.edu/automated-external-defibrillator-aed-locations.
- To stay informed about emergency situations, students can sign up to receive UCF text alerts by going to https://my.ucf.edu and logging in. Click on "Student Self Service" located on the left side of the screen in the toolbar, scroll down to the blue "Personal Information" heading on the Student Center screen, click on "UCF Alert", fill out the information, including e-mail address, cell phone number, and cell phone provider, click "Apply" to save the changes, and then click "OK."
- Students with special needs related to emergency situations should speak with their instructors outside of class.
- To learn about how to manage an active-shooter situation on campus or elsewhere, consider viewing this video https://youtu.be/NIKYajEx4pk.