UCF CREOL, THE COLLEGE OF OPTICS AND PHOTONICS

## Course Syllabus 2022

## OSE4720 VISUAL OPTICS, 3 Cr

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|---|---|---|---|
| **Instructor:** | MJ Soileau (Swallow) | **Term:** | Spring 2022 |
| **Email:** | mj@ucf.edu | **Class Meeting Days:** | Tuesday, Thursday |
| **Phone:** | 407-823-5539 | **Class Meeting Time:** | 12-1:15 pm |
| **Office:** | CREOL Rm A219 | **Class Location** | CREOL A214 |
| **Office Hours:** | M,W 4:15-5:30 pm | **Website:** | Webcourse |

+ I will be in my office at these times, but of course I will be happy to discuss the material with you anytime. I often get questions via e-mail that can be quickly answered.

**Course Catalog 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.

**Prerequisites:** OSE 3052 Introduction to Photonics

**What majors require or recommend this course for graduation?**
This course is one of several technical electives offered by the College of Optics and Photonics for the BS degree in Photonic Science and Engineering. The course may be taken by science and engineering and biomedical sciences students as a technical elective.

**Detailed Course Description and Learning Outcomes:**
**Detailed Description:**
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), and colorimetry and color image processing 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 (Low, Medium, High) |
|---|---|
| (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 |

**Textbook:**

None (Class notes will be provided)

**Recommended Reference:**

Visual Perception, T. Cornsweet, Academic, 1970 (recommended)

Color Science, G. Wyszecki, W. Stiles, Wiley, 2005 (recommended)

**Other required course material**

None

**Course Grading:**
Homework (15%), weekly quiz (15%), 2 midterm exams (15% each), final exam (30%), participation (including a special assignment at the end) (10%)

**Make up Exam 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
**Weekly Quizzes**: You can drop the lowest two quiz grades. If you miss a quiz then that is one of your dropped grades. No makeup for missed quizzes.

**Financial Aid and Attendance:** All faculty members are required to document students' academic activity at the beginning of each course. To document that you began this course, please complete the following academic activity by the end of the first week of classes. In this case a five minute quiz will be given next class period, Th Jan 13, 2022. Failure to take the quiz will result in a delay in the disbursement of your financial aid.

| 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. |

Grades will be assigned according to 100 total points possible, with letter grades, including + or – grades, according to UCF policy.
**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.
**Class Website:**
Materials used for classes will be available on UCF Webcourses for download before each class.
**Professionalism and Ethics:**
Per university policy and plain classroom etiquette, mobile phones, etc. must be silenced during all classroom lectures, unless you are specifically asked to make use of such devices for certain activities. Academic dishonesty in any form will not be tolerated! If you are uncertain as to what constitutes academic dishonesty, please consult The Golden Rule in the UCF Student Handbook (www.goldenrule.sdes.ucf.edu) for further details. As in all University courses, The Golden Rule Rules of Conduct will be applied. Violations of these rules will result in a record of the infraction being placed in your file and the student receiving a zero on the work in question AT A MINIMUM. At the instructor's discretion, you may also receive a failing grade for the course. Confirmation of such incidents can also result in expulsion from the University. **ALL HOMEWORK MUST BE NEATLY PREPAIRED, WITH THE PROBLEM CLEARLY STATED AND THE SOLUTION CLEARLY MARKED (BOX OR HIGH ARE ACCEPTABLE, OTHERWISE IT WILL BE RETURNED UNGRADED AND ASSIGNED A GRADE OF ZERO.**
**Students with Special Testing/Learning Needs:**

Students with special needs and require special accommodations must be registered with UCF Student Disability Services prior to receiving those accommodations. Students must have documented disabilities requiring the special accommodations and must meet with the instructor to discuss the special needs as early as possible in the first week of classes. UCF Student Disability Services can be contacted at www.sds.sdes.ucf.edu or at (407) 823-2371.

**Note that details of the schedule and exact topics are subject to change as the course progresses**.

**Dates:**

| | |
|---|---|
| First Day of Class | January 10, 2022 |
| Last Day to Drop Classes | |
| Last Day to Add Classes | |
| Spring Break | March 6-13, 2022 |
| Last Day of Class | April 21, 2022 |
| Final Exam: | TBD April 26 is a study day, no classes |

**Grades:**

WEEKLY QUIZZES (DROP LOWEST 2) 15%
MID TERMS (2@ 15% EACH) 30%
HOMEWORKS (DROP LOWEST 2) 15%
FINAL 30%
**PARTICIPATION and special projects 10%**

**Daily Schedule** (subject to change):

| Week | Course material: |
|---|---|
| 1 | Introduction & overview of the visual system |
| | Geometric optics of the human eye. Optometric units; zmax ray tracing in the human eye |
| 2 | Imaging in the human eye |
| | Vision correction; Ophthalmic instruments |
| 3 | MARTIN LUTHER KING DAY NO CLASS<br>Review of optics of the eye |
| 4 | Physical optics of the human eye |
| | Retina-brain processing |
| 5 | PHOTONICS WEST: CLASS MAY BE RE-SCHEDULED |
| | MIDTERM #1: (SUCJECT TO CHANGE) |
| 6 | MTF and effect of aberrations. Imaging quality |
| | Retina-brain processing |
| 7 | Visual sensitivity. Detectability and ROC characteristics |
| | Role of photon noise and neural noise |
| 8 | Spatial vision. Brightness vs intensity |
| | Contrast sensitivity and modulation transfer function |
| 9 | Visual acuity |
| | Midterm Exam II (SUBJECT TO CHANGE) |
| 10 | Spring Break |

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|---|---|
| | Spring Break |
| 11 | Temporal vision. MTF |
| | Temporal vision. Detection of dynamic objects |
| 12 | Binocular vision. Depth perception |
| | Binocular vision. Depth perception |
| 13 | Applications to 3D display |
| | Color vision |
| 14 | Color vision |
| | DRAFT PARTICIPATION PROJECTS DUE |
| | Colorimetry and the CIE system |
| 15 | Color reproduction in the printing and display industry |
| | Visual adaptation |
| 16 | Term paper presentations April 19 and 21 |