This course covers the analysis, synthesis, and application of systems that use coherent or incoherent light.

Topics include:

- Scalar diffraction theory
- Diffraction from planar objects; light propagation (exact and approximate)
- Coherent and incoherent light (mathematical and physical descriptions)
- Imaging systems (including diffraction effects; incoherent and coherent systems)
- Optical Fourier transforming systems
- Introduction to information processing and computing systems using optics
- Introduction to holography

Sample applications will be selected from these and other topics, and will depend on student interest:

- Computing, including optical memory and interconnections
- Biomedical, including optical coherence tomography for 3-D imaging of human tissue
- Optical metamaterials, negative index of refraction, and superlenses
- 2-D and 3-D displays
- Optical imaging and sensing using compressive sampling
- Noninvasive testing and measurement
- Diffractive optical concentrators for solar cells

Prerequisite: Knowledge of Fourier transforms and linear systems (at the level of EE 401)

Time & Location: Monday and Wednesday 12:30 - 1:50 PM, OHE 100B; and DEN@Viterbi locations.


Instructor: Prof. B. Keith Jenkins, EEB 404A, jenkins@sipi.usc.edu, (213) 740-4149
Class days and time: MW 12:30 - 1:50 PM PT
Class location: OHE 100B and DEN@Viterbi

Course prerequisites

Required: Knowledge of signals, linear systems, and Fourier transforms at the level of EE 301 or EE 401. Graduate standing in engineering or physics.

Relevant but not required: Familiarity with basic electromagnetics.

Course text (required)


Course Materials (daily lecture notes, handouts, and homeworks)

These materials will be available for downloading from the web. (Daily lecture notes will be posted after each class.) The web site for EE 401 materials is reachable from your DEN@Viterbi login page:

www.uscden.net

Your DEN account is automatically set up for you if you are registered for this class. You will need Adobe Reader to view the files.

Course Contact Information

Instructor: Prof. B. K. Jenkins
Office: EEB 404A
Phone: 213-740-4149
Fax: 213-740-6618
Email: jenkins@sipi.usc.edu [Please include “EE 566” in the subject line]
Office hours: Tuesday and Thursday, 3:30 – 5:00 PM

Grader.: TBA
Office: 
Phone: 
Fax: 
Email: 
Grading

**Homework**  Approximately 1 per week, to be solved with pen or pencil and paper; some optional or extra credit problems may use applets or a small amount of coding  20%

**Midterm**  TBA; most likely Mon. 3/2 or Mon. 3/9, during 12:30 – 1:50 PM PDT  40%

**Final exam**  Friday, May 8, 2015, 11:00 AM – 1:00 PM PDT  40%

**Statement for Students with Disabilities**
Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. Website and contact information for DSP: [http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html](http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html), (213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) [ability@usc.edu](mailto:ability@usc.edu).

**Statement on Academic Integrity**
USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one’s own academic work from misuse by others as well as to avoid using another’s work as one’s own. All students are expected to understand and abide by these principles. [SCampus, the Student Guidebook](http://scampus.usc.edu) contains the University Student Conduct Code (see University Governance, Section 11.00), while the recommended sanctions are located in Appendix A.

**Emergency Preparedness/Course Continuity in a Crisis**
In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies.
1. Course introduction
   – Course logistics and requirements
   – Overview of course material and applications

2. Background material and review
   – Delta functions
   – Linear systems
   – Fourier transforms (2-D)
   – Space-bandwidth product and local spatial frequency

3. Scalar diffraction theory and wavefront propagation
   – Preliminaries (representation, scalar diffraction theory assumptions)
   – Wave and Helmholtz equations
   – Formulation of optical waves
   – Diffraction formulas
     (Monochromatic and nonmonochromatic cases)
   – Angular spectrum of plane waves interpretation
     (Spatial-frequency domain)
   – *Evanescent waves and negative index materials (metamaterials)

4. Approximations to diffraction formulas
   – Rayleigh-Sommerfeld formula; initial approximations
   – Fresnel (near to far field, paraxial)
   – Fraunhofer (far field, paraxial)
   – Regions of validity
   – *Far-field, large angle
   – *Limited spatial frequency
   – Examples 1: absorption and phase gratings; diffraction efficiency
   – *Examples 2: diffractive optical elements – computer designed to synthesize arbitrary
diffraction patterns

5. Optical Fourier transforming and imaging using thin-lens systems
   => Assume monochromatic illumination
   – Thin lenses
   – Fourier transforming
   – Imaging
   – *Research example: superlenses to exceed the diffraction limit
   – General optical system analysis

6. Coherence
   – Spatial and temporal coherence
   – Coherent and incoherent illumination
   – *Biomedical application example: Optical coherence tomography for 3-D imaging
7. Analysis of optical imaging systems
   – Frequency-domain analysis of generalized imaging systems
   – Coherent illumination
   – Incoherent illumination
   – *Application example: diffraction effects in the eye

8. Information processing: optical/photonic devices and systems
   – *Wavefront modulation (fixed materials, real-time devices, diffractive optical elements)
   – *Early information processing work
   – *Incoherent processing systems
   – *Incoherent processing application: compressive sensing of images
   – Coherent processing systems (including frequency domain processing)
   – *Application examples: Optics in computing systems - memory and interconnections

9. Introduction to holography
   – Wavefront recording and reconstruction
   – Planar holography (for 3-D reconstruction and general wavefront reconstruction)
   – *Application example: noninvasive evaluation of surface topography
   – *Computer-generated holography
   – *Volume holography
   – *Application example: diffractive optical concentrators for solar cells

10. *Other topics and applications of interest
    – *Application to other realms, such as RF or radar

Notes:
*Degree of inclusion and emphasis of indicated topics will depend on class interest and available time.
1. Optics and diffraction effects in the eye
   - What is actually incident on the retina
   - Effects of coherence, pupil size and shape

2. Signal processing and computing
   - Special-purpose parallel signal processing
   - Optical interconnections
     - Board-to-board, chip-to-chip, within-chip
   - Large-scale artificial neural network processing
   - Quantum computing and communication

3. Optical memory
   - Optical disc: CD, DVD, Blue-Ray
   - 3-D holographic memory

4. Optical metamaterials
   - Index of refraction $n < 1$ and $n < 0$
   - Superlenses
   - Cloaking devices

5. Biomedical applications
   - Optical coherence tomography
     - 3-D imaging of human tissue
   - Infrared optical techniques for brain imaging
   - Optical tweezers for control of tiny particles in fluids
   - Probing of micro-array-experiment data

6. Displays
   - 3-D displays based on integral imaging
   - True 3-D displays based on holography
   - Multiplane displays based on computer holography
   - True 3-D displays based on filled volume techniques
   - Head-mounted displays for virtual reality and augmented reality

7. Image acquisition
   - Camera optics (e.g., in smartphones)
   - 3D image acquisition
8. Diffractive optical components and systems
   – Diffractive optical elements (DOE's) for generation of arbitrary output intensity or phase patterns
   – Holographic optical elements for generation of arbitrary point-spread functions
   – Examples
     – CD or DVD pickup heads
     – Diffractive optical concentrators for solar cells
     – Free-space or substrate-mode optical interconnections

9. Smart cameras using photonic multichip modules
   – Vision in robots
   – Autonomous smart cameras
     – For autonomous visual recognition in adverse environments
   – Head-mounted smart cameras
     – For location and recognition of objects for augmenting or annotating a real scene

10. Non-invasive inspection, test, and measurement
   – Holographic-interferometric measurement of distances and surface shape variations
   – Inspection of integrated circuits after fabrication
   – Measurement of surface warping due to stress and strain
     – Mechanical systems in automobiles and aircraft
     – Optimize strength, durability, weight
   – Test of VLSI circuit function using optical access (input and output of test signals)

11. Optical imaging and sensing using compressive sampling
   – High quality image acquisition using a lot fewer sampling pixels
   – Remove human from loop (acquired images fed directly to subsequent processing stages)