ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

# COLLEGE OF SCIENCE

**Imaging Science**

**NEW COURSE:** COS-IMGS-371-Imaging Systems Analysis

**1.0 Course Designations and Approvals**

| **Required course approvals:** | **Approval request date:** | **Approval granted date:** |
|---|---|---|
| Academic Unit Curriculum Committee | 11/12/14 | 11/19/14 |
| College Curriculum Committee | 3/16/15 | 3/16/2015 |

| **Optional designations:** | **Is designation desired?** | | ***Approval request date:** | ****Approval granted date:** |
|---|---|---|---|---|
| General Education: | | No | | |
| Writing Intensive: | | No | | |
| Honors | | No | | |

**2.0 Course information:**

| | |
|---|---|
| **Course title**: | Imaging Systems Analysis |
| **Credit hours:** | 4 |
| **Prerequisite(s):** | COS-IMGS-180 and COS-IMGS-261, or equivalent. |
| **Co-requisite(s)**: | |
| **Course proposed by:** | James Ferwerda |
| **Effective date:** | September 2015 |

| | **Contact hours** | **Maximum students/section** |
|---|---|---|
| Classroom | 4 | 30 |
| Lab | | |
| Studio | | |
| Other (specify) | | |

**2.a Course Conversion Designation*** (Please check which applies to this course).**
*For more information on Course Conversion Designations please see page four.

| | |
|---|---|
| | Semester Equivalent (SE) Please indicate which quarter course it is equivalent to: |
| | Semester Replacement (SR) Please indicate the quarter course(s) this course is replacing: |
| X | New |

**2.b Semester(s) offered** (check)

| | | | |
|---|---|---|---|
| Fall X | Spring | Summer | Other |

All courses must be offered at least once every 2 years. If course will be offered on a bi-annual basis, please indicate here:

**2.c Student Requirements**

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|---|
| **Students required to take this course**: (by program and year, as appropriate)<br>Imaging Science majors |
| **Students who might elect to take the course**:<br>Motion Picture Science majors, other students with appropriate backgrounds. |

*In the sections that follow, please use sub-numbering as appropriate (eg. 3.1, 3.2, etc.)*

**3.0 Goals of the course** (including rationale for the course, when appropriate):

3.1 Introduce students to the theory and practice of imaging systems analysis.
3.2 Teach students about the physical factors that affect the spatial and temporal response properties of optical, electronic, and biological imaging systems, and the mathematical methods that have been developed for describing these properties.
3.2 Expose students to practical methods for measuring, modeling, and controlling the spatial and temporal point spread functions (PSFs) and modulation transfer functions (MTFs) of imaging systems.

**4.0 Course description** (as it will appear in the RIT Catalog, including pre- and co-requisites, and quarters offered).

**COS-IMGS-371** **Imaging Systems Analysis**

This course will introduce students to the theory and practice of imaging systems analysis. Students will learn about the physical factors that affect the spatial and temporal response properties of optical, electronic, and biological imaging systems, and the mathematical methods that have been developed for describing these properties. Through hands-on projects, students will learn practical methods for measuring, modeling, and controlling the spatial and temporal point spread functions (PSFs) and modulation transfer functions (MTFs) of imaging systems. (COS-IMGS-180 and COS-IMGS-261, or equivalent) **Class 4, Credit 4 (Fall)**

**5.0 Possible resources (texts, references, computer packages, etc.)**

5.1 Boreman, *Modulation Transfer Function in Optical and Electro-Optical Systems, Tutorial Texts in Optical Engineering* (TT52), SPIE Press, Bellingham WA
5.2 Fiete, *Modeling the Imaging Chain of Digital Cameras* (SPIE Tutorial Text Vol. TT92) (Tutorial Texts in Optical Engineering), SPIE Press, Bellingham WA
5.3 Easton, *Fourier Methods in Imaging*, John Wiley & Sons, Hoboken, NJ
5.4 Readings assigned by the instructor.
5.5 MATLAB/Python programming environments

**6.0 Topics (outline):**

6.1. Resolution of imaging systems
- 6.1.1. Brief review of geometrical optics
- 6.1.2. Effects of diffraction and aberrations
- 6.1.3. Addressability vs. resolution in sampled systems
- 6.1.4. Measuring resolution

6.2. Modeling imaging systems in the spatial domain
- 6.2.1. Brief review of linear systems theory
- 6.2.2. The point spread function (PSF)
- 6.2.3. Measuring the PSFs of imaging systems

6.3. Modeling imaging systems in the frequency domain
- 6.3.1. Brief review of Fourier methods in imaging
- 6.3.2. The optical transfer function (OTF)
- 6.3.3. The modulation transfer function (MTF)
- 6.3.4. Measuring the MTFs of imaging systems

6.4. MTFs of optical imaging systems
- 6.4.1. Analytical models of diffraction-limited MTF
- 6.4.2. Effects of optical aberrations and defocus on MTF
- 6.4.3. Contributions of other factors to MTF: motion, atmospherics, …
- 6.4.4. Measuring and modeling the MTFs of optical imaging systems
- 6.4.5. Summary measures of spatial response (MTFA, Strehl ratios)

6.5. MTFs of digital camera systems
- 6.5.1. Components of digital camera systems
- 6.5.2. Optical prefiltering MTF
- 6.5.3. Detector footprint, sampling, and crosstalk MTF
- 6.5.4. Demosaicing, sharpening, and compression MTFs
- 6.5.5. Measuring and modeling the MTFs of digital image capture systems

6.6. MTFs of display systems
- 6.6.1. Components of display systems
- 6.6.2. Characterizing the display reconstruction process
- 6.6.3. The transfer response and spurious response functions
- 6.6.4. Measuring and modeling the MTFs of display systems

6.7. Chromatic and temporal MTFs of imaging systems
- 6.7.1. Color processing in digital cameras and displays
- 6.7.2. Demosaicing, color aliasing and other chromatic artifacts
- 6.7.3. Measuring and modeling chromatic MTFs
- 6.7.4. Temporal processing in digital cameras and displays
- 6.7.5. Motion blur, temporal aliasing and other temporal artifacts
- 6.7.6. Measuring and modeling temporal MTFs
- 6.7.7. MTFs of color sequential systems

6.8. Image quality and human vision
- 6.8.1. The eye as an imaging system
- 6.8.2. PSF, MTF of the eye's optics
- 6.8.3. The visual contrast sensitivity function (CSF)
- 6.8.4. Chromatic and temporal CSFs in vision
- 6.8.5. Modeling vision and imaging within the MTF/CSF framework

6.9. Perceptually-based image capture, coding, and display
- 6.9.1. Projects
- 6.9.2. Measure and model the point spread functions (PSFs) of optical and electronic imaging systems
- 6.9.3. Measure and model the PSF of the human eye
- 6.9.4. Measure and model the modulation transfer functions (MTFs) of optical and electronic imaging systems
- 6.9.5. Measure and model the CSF of the human visual system
- 6.9.6. Characterize the spatial response properties of a digital camera/display system
- 6.9.7. Characterize the temporal response properties of a digital video system

**7.0 Intended course learning outcomes and associated assessment methods of those outcomes** (please include as many Course Learning Outcomes as appropriate, one outcome and assessment method per row).

| Course Learning Outcome | Assessment Method |
|---|---|
| Explain the theory and practice of imaging systems analysis | Homeworks, Exams |
| Describe the factors governing the spatial and temporal response properties of imaging systems | Homeworks, Exams |
| Measure and model the point spread functions (PSFs) and modulation transfer functions (MTFs) of imaging systems | Project reports |
| Characterize the end-to-end spatial and temporal response properties of an imaging system | Project reports |

**8.0 Program outcomes and/or goals supported by this course**

8.1 To gain knowledge of the concepts and terminology of imaging systems analysis
8.2 To gain hands-on experience with imaging systems
8.3 To gain fluency in computational problems solving
8.4 To apply knowledge of physics, mathematics, computing, and vision to address practical problems in imaging science

**9.0 N/A**

**10.0 Other relevant information**

Smart classroom. Dedicated project room for out-of-class access to measurement equipment.