ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

COLLEGE OF SCIENCE

Chester F. Carlson Center for Imaging Science

REVISED COURSE: COS-IMGS-619- Radiometry

1.0 Course Approvals

Required course approvals:	**Approval Requested Date:**	**Approval Granted Date:**
Academic Unit Curriculum Committee	9/1/2010	9/15/2010
College Curriculum Committee	9/27/2010	10/14/2010
Optional course designation approvals:		
General Education Committee		
Writing Intensive Committee		
Honors		

2.0 Course information:

Course title:	Radiometry
Credit hours:	3
Prerequisite(s):	Graduate standing or permission of instructor
Co-requisite(s):	
Course proposed by:	John Schott
Effective date:	September 2013

	Contact hours	**Maximum students/section**
Classroom	3	50
Lab		
Studio		
Other (specify)		

2.1 Course Conversion Designation (Please check which applies to this course)

X	Semester Equivalent (SE) Please indicate which quarter course it is equivalent to: SIMG 719
	Semester Replacement (SR) Please indicate the quarter course(s) this course is replacing:
	New

2.2 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:

2.3 Student Requirements

Students required to take this course: (by program and year, as appropriate) Graduate students in Imaging Science graduate program
Students who might elect to take the course: Non-matriculated students with undergraduate degrees in the Physical Science or Engineering. Graduate students in the College of Science or College of Engineering.

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

To give the students the tools needed to solve the radiometric propagation problems they will encounter in working with imaging systems and an initial experience with using them to solve a range of common radiometry problems.

4.0 Course description (as it will appear in the RIT Catalog, including pre- and co-requisites, and quarters offered). Please use the following format:

COS-IMGS-619 **Radiometry**

This course is focused on the fundamentals of radiation propagation as it relates to making quantitative measurements with imaging systems. The course includes an introduction to common radiometric terms and derivation of governing equations with an emphasis on radiation propagation in both non-intervening and turbid media. The course also includes an introduction to detector figures of merit and noise concepts**.** (Graduate standing or permission of instructor) **Class 3, Credit 3 (F)**

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

5.1 Grum, F., & Becherer, R.J., *Optical Radiation Measurements:* in *Vol. 1,Radiometry*. Academic Press, New York.
5.2 Wolfe, William L., *Introduction to Radiometry*, Vol. TT29, SPIE Optical Engineering Press, Bellingham.
5.3 Ientillucci, E., and Schott, J.R., *Introduction to Radiometry*; Oxford University Press, Oxford.

6.0 Topics (outline):

6.1 Review of electromagnetic energy and relevant modern physics
- 6.1.1 Definition of radiometric terms

6.2 Sources power, intensity, coherent, polarization, stability
- 6.2.1 Blackbody, Graybody radiators
  - 6.2.1.1 Planck equation
  - 6.2.1.2 Stefan Boltzmann law
  - 6.2.1.3 Wien displacement law
  - 6.2.1.4 Simpson’s rule
    - 6.2.1.4.1 Integration over a spectral window
    - 6.2.1.4.2 Use of blackbody tables
- 6.2.2 Sun
  - 6.2.2.1 Thermionic emission
  - 6.2.2.2 Apparent blackbody temperature
  - 6.2.2.3 Fraunhofer lines
- 6.2.3 Tungsten and tungsten-halogen sources
  - 6.2.3.1 Halogen regeneration cycle
- 6.2.4 Gas discharge and fluorescent illumination
  - 6.2.4.1 Pressure broadening
  - 6.2.4.2 Doppler broadening
- 6.2.5 Lasers
  - 6.2.5.1 Coherence
  - 6.2.5.2 Beam characteristics

6.3 Radiometric terms and principles
- 6.3.1 Irradiance
- 6.3.2 Cosine law for irradiance
  - 6.3.2.1 Projected area
  - 6.3.2.2 Vector concept
- 6.3.3 Inverse square law
  - 6.3.3.1 For point source of known flux
  - 6.3.3.2 Relation to irradiance
- 6.3.4 Point source, line source, broad source
  - 6.3.4.1 How irradiance varies with respect to distance
  - 6.3.4.2 How to approximate

6.4 Radiance, constancy of radiance during propagation
- 6.4.1 Lambertian surfaces

6.5 Detectors
- 6.5.1 Thermal (bolometer)
  - 6.5.1.1 Bimetallic single element
  - 6.5.1.2 Silicon bolometer array
  - 6.5.1.3 Broadband response
- 6.5.2 Photon
  - 6.5.2.1 Quantum concept
  - 6.5.2.2 External photo effect (photoemission)
  - 6.5.2.3 Hertz
  - 6.5.2.4 work function

- 6.5.2.5 Phototube
- 6.5.2.6 Photomultiplier tube (PMT)
- 6.5.2.7 Microchannel plate
- 6.5.2.8 Internal photo effect (photoconductive, photovoltaic)
- 6.5.2.9 Semiconductor concepts
- 6.5.2.10 Forward and reverse bias
- 6.5.2.11 Linear and two-dimensional arrays
- 6.5.2.12 Read out concepts
- 6.5.2.13 Linear-interline
- 6.5.2.14 Multiple tap

6.6 Photometry
- 6.6.1 Photopic response
- 6.6.2 Scotopic response
- 6.6.3 Tristimulus functions
- 6.6.4 Chromatics coordinates
- 6.6.5 Color temperature vs. color distribution temperature

6.7 Detector figures of merit
- 6.7.1 Responsivity
  - 6.7.1.1 Spectral shape issues
  - 6.7.1.2 Materials:
    - 6.7.1.2.1 Indium antimonide (InSb)
    - 6.7.1.2.2 Mercury-cadmium-telluride (HgCdTe)
    - 6.7.1.2.3 Silicon (Si)
  - 6.7.1.3 temperature
- 6.7.2 Noise, Noise sources
  - 6.7.2.1 Read noise
  - 6.7.2.2 Dark current
  - 6.7.2.3 Photon noise
  - 6.7.2.4 Other noise sources
- 6.7.3 Signal-to-noise ratio (SNR)
  - 6.7.3.1 Signal processing and control vs. image SNR
  - 6.7.3.2 Noise reduction by averaging
- 6.7.4 Temporal frequency response (bandwidth)
  - 6.7.4.1 Rise time
  - 6.7.4.2 Fall time
  - 6.7.4.3 Bandwidth
- 6.7.5 Noise equivalent power (NEP)
- 6.7.6 Detectivity, Specific detectivity
- 6.7.7 Quantum efficiency
  - 6.7.7.1 Relationship to responsivity

6.8 Measurement Examples (Macro and quantum)
- 6.8.1 Source, propagation, detection, output

6.9 Spectroradiometry
- 6.9.1 Monochromators
- 6.9.2 Reflection gratings
- 6.9.3 Interferometers

6.16.2 Radiometric analysis along the image chain 6.16.3 Specific sensor/detector example

7.0 Intended course learning outcomes and associated assessment methods of those outcomes

Course Learning Outcome	Homework	Exams
7.1 Solve simple propagation problems	X	X
7.2 Solve spectral propagation problems with noise	X	X
7.3 Solve spectral propagation problems in turbid media	X	X
7.4 Solve extended source propagation problems including noise	X	X

8.0 Program outcomes and/or goals supported by this course

Prepares graduate students in science and engineering for careers in the field of imaging systems

9.0

	General Education Learning Outcome Supported by the Course	Assessment Method
Communication		
	Express themselves effectively in common college-level written forms using standard American English	
	Revise and improve written and visual content	
	Express themselves effectively in presentations, either in spoken standard American English or sign language (American Sign Language or English-based Signing)	
	Comprehend information accessed through reading and discussion	
Intellectual Inquiry		
	Review, assess, and draw conclusions about hypotheses and theories	
	Analyze arguments, in relation to their premises, assumptions, contexts, and conclusions	
	Construct logical and reasonable arguments that include anticipation of counterarguments	
	Use relevant evidence gathered through accepted scholarly methods and properly acknowledge sources of information	
Ethical, Social and Global Awareness		
	Analyze similarities and differences in human experiences and consequent perspectives	
	Examine connections among the world's populations	
	Identify contemporary ethical questions and relevant stakeholder positions	
Scientific, Mathematical and Technological Literacy		
	Explain basic principles and concepts of one of the natural sciences	
	Apply methods of scientific inquiry and problem solving to contemporary issues	
	Comprehend and evaluate mathematical and statistical information	
	Perform college-level mathematical operations on quantitative data	
	Describe the potential and the limitations of technology	
	Use appropriate technology to achieve desired outcomes	
Creativity, Innovation and Artistic Literacy		
	Demonstrate creative/innovative approaches to course-based assignments or projects	
	Interpret and evaluate artistic expression considering the cultural context in which it was created	

10.0 Other relevant information (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

Smart Classroom

11.0 Supplemental information for Optional Course Designations: If the course is to be considered as writing intensive or as a general education or honors course, include the sections of the course syllabus that would support this designation.

Programform.doc

NYSED Documentation Form

Audience

This document is intended for all department chairs and program directors.

Summary

This document includes the information and required forms for submission of program to NYSED for semester conversion.

Change Log

Responsible	Date	Version	Short description
<your name here>	<date>	1	Document originator