ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

COLLEGE OF SCIENCE

Chester F. Carlson Center for Imaging Science

REVISED COURSE: COS-IMGS-613-Probability, Noise, and System Modeling

1.0 Course Approvals

Required course approvals:	**Approval Requested Date:**	**Approval Granted Date:**
Academic Unit Curriculum Committee	9/1/2010	9/27/2010
College Curriculum Committee	9/28/2010	10/14/2010
Optional course designation approvals:		
General Education Committee		
Writing Intensive Committee		
Honors		

2.0 Course information:

Course title:	Probability, Noise, and System Modeling
Credit hours:	3
Prerequisite(s):	COS-IMGS-616 and IMGS-619; or permission of instructor
Co-requisite(s):	None
Course proposed by:	Harvey Rhody
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: 1051-713 Noise and Random Processes
	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) Ph.D. Students in Imaging Science
Students who might elect to take the course: M.S. Students in Imaging Science; 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 provide students with a foundation that enables him/her to describe signals and noise in imaging systems, and to apply this knowledge to the optimization of S/N in imaging systems.

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-613 **Probability, Noise, and System Modeling**

This course develops models of noise and random processes within the context of imaging systems. The focus will be on stationary random processes in both one dimension (time) and two dimensions (spatial). Power spectrum estimation will be developed and applied to signal characterization in the frequency domain. The effect of linear filtering will be modeled and applied to signal detection and maximization of SNR. The matched filter and the Wiener filter will be developed. Signal detection and amplification will be modeled, using noise figure and SNR as measures of system quality. At completion of the course, the student should have the ability to model signals and noise within imaging systems. (COS-IMGS-616 and IMGS-619; or permission of instructor) **Class 3, Credit 3 (F)**

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

5.1 Peebles, *Probability, Random Processes, and Random Signals*, McGraw-Hill, Columbus OH.

5.2 Papoulis and Pillai, *Probability, Random Variables and Stochastic Processes*, McGraw-Hill, Columbus OH.

6.0 Topics (outline):

- 6.1 Probability
  - 6.1.1. Introduction to probability
  - 6.1.2. Joint and conditional probability
  - 6.1.3. Independent events
  - 6.1.4. Combined experiments
  - 6.1.5. Bernoulli trials
- 6.2. Random Variables
  - 6.2.1. Random variable (RV) concept
  - 6.2.2. Distribution function
  - 6.2.3. Density function
  - 6.2.4. Gaussian RV
  - 6.2.5. Density and distribution examples
  - 6.2.6. Conditional distribution and density functions
- 6.3. Operations on One RV – Expectation and Moments
  - 6.3.1. Expectation
  - 6.3.2. Moments
  - 6.3.3. Functions that give moments
- 6.4. Multiple RV**s**
  - 6.4.1. Vector RVs
  - 6.4.2. Joint distribution and its properties
  - 6.4.3. Joint density and its properties
  - 6.4.4. Conditional distribution and density
  - 6.4.5. Statistical independence
  - 6.4.6. Distribution and density of a sum of RVs
  - 6.4.7. Central limit theorem
- 6.5. Operations on Multiple RVs
  - 6.5.1. Expected value of a function of RVs
  - 6.5.2. Conditional expectation
  - 6.5.3. Jointly Gaussian RVs
  - 6.5.4. Sampling and limit theorems
- 6.6. Random Processes – Spatial/Temporal Characteristics
  - 6.6.1. Random process (RP) concept
  - 6.6.2. Stationarity and ergodicity
  - 6.6.3. Correlation and covariance functions
  - 6.6.4. Discrete RPs and sequences
  - 6.6.5. Cyclostationary RPs
  - 6.6.6. Image noise and its analysis
- 6.7. Random processes – spectral Characteristics
  - 6.7.1. Power density spectrum and its properties
  - 6.7.2. Relationship between power spectrum and autocorrelation function
  - 6.7.3. Power spectrums for discrete RPs
  - 6.7.4. White noise
  - 6.7.5. Photon noise
  - 6.7.6. Response of linear systems to random signals
  - 6.7.7. Zero-frequency value of noise power spectrum

- 6.7.8. Noise correlation
- 6.8. Zero-Frequency Analysis of Signal and Noise
  - 6.8.1. Photon noise and signal-to-noise ratio
  - 6.8.2. Noise sources in digital imaging
  - 6.8.3. Detector performance metrics
  - 6.8.4. Example: System radiometric performance analysis
  - 6.8.5. Example: Photon amplifier modeling
- 6.9. Fourier Analysis of Signal and Noise
  - 6.9.1. System performance metrics
  - 6.9.2. Signal and noise transfer
  - 6.9.3. Cascaded systems
  - 6.9.4. Example: Electro-optical system
  - 6.9.5. Example: Radiographic screen-detector system
- 6.10. Fourier Analysis of Signal and Noise in Digital Systems
  - 6.10.1. Detector-element size and aperture modulation transfer function (MTF)
  - 6.10.2. Digital MTF: presampling MTF and aliasing
  - 6.10.3. Digital Wiener spectrum: presampling and noise aliasing
  - 6.10.4. Digital Detector Quantum Efficiency (DQE)
  - 6.10.5. Example: digital detector array performance analysis

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

Learning Outcome	In class attendance and evaluation	Homework Assignments
7.1 Apply basic probability theory to solving problems	X	X
7.2 Use the random process concept to solve problems	X	X
7.3 Analyze signal and noise in imaging systems	X	X
7.4 Optimize signal/noise in imaging systems	X	X

8.0 Program outcomes and/or goals supported by this course

Prepares graduate students in science and engineering for careers in imaging science.

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.)

Classroom with computer projection system, internet access and conference access for online participation

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.

None

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
H. Rhody	9/18	1	Document originator