



**ROCHESTER INSTITUTE OF TECHNOLOGY  
COURSE OUTLINE FORM**

**COLLEGE OF SCIENCE**

**Center for Imaging Science**

**NEW COURSE (COS-IMGS-789):** Special Topics: Introduction to Radiative Transfer in Media

**1.0 Course Designations and Approvals**

<b>Required course approvals:</b>	<b>Approval request date:</b>	<b>Approval granted date:</b>
Academic Unit Curriculum Committee	10/20/2015	10/28/2015
College Curriculum Committee		

<b>Optional designations:</b>	<b>Is designation desired?</b>		<b>*Approval request date:</b>	<b>**Approval granted date:</b>
General Education:	<input type="checkbox"/>	No		
Writing Intensive:	<input type="checkbox"/>	No		
Honors	<input type="checkbox"/>	No		

**2.0 Course information:**

<b>Course title:</b>	<u>Introduction to Radiative Transfer in Media</u>
<b>Credit hours:</b>	<u>3</u>
<b>Prerequisite(s):</b>	IMGS-619 and IMGS-633, or ASTP-615; or instructor permission
<b>Co-requisite(s):</b>	
<b>Course proposed by:</b>	<u>Charles Bachmann</u>
<b>Effective date:</b>	<u>January, 2016</u>

	<b>Contact hours</b>	<b>Maximum students/section</b>
Classroom	3	12
Lab		
Studio		
Other (specify)		

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

Fall	Spring <input checked="" type="checkbox"/>	Summer	Other
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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.b Student Requirements

**Students required to take this course:** (by program and year, as appropriate) None

**Students who might elect to take the course:**

Advanced CIS and AST Graduate Students

*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):

- The course should benefit both CIS students interested in remote sensing of sediment, as well as AST students interested, for example, in planetary astronomy. This is the first semester of a two-semester graduate-level course.
- By the end of the course, provide students with a solid foundation in and understanding of this material to prepare graduate students to do research in a related topic. Ensure that students understand where research opportunities exist in this area and the open research questions that could suggest dissertation topics in either CIS or AST.

### 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:

#### IMGS-789-01

#### Introduction to Radiative Transfer in Media

This course is the first half of a two-semester sequence, which covers the theory of radiative transfer in disordered media. The course begins with a brief review of basic electromagnetism and models for scattering and absorption by single particles and progresses to the theory of radiative transfer in semi-infinite media. Various approximations that allow closed-form solutions are presented, and related phenomenology such as the shadow-hiding opposition effect and coherent backscatter opposition effect are described in terms of these models. (Prerequisites: IMGS-619 & IMGS-633; or ASTP-615; or instructor permission) **Class 3, Credit 3 (S)**

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

Primary course textbook: B. Hapke, Theory of Reflectance and Emittance Spectroscopy, 2<sup>nd</sup> Edition, Cambridge University Press, 2012.

Various refereed journal papers by other authors in the field (e.g. Mishchenko, Nelson, and others)

### 6.0 Topics (outline):

- Review of Maxwell's Equations and EM Propagation (Hapke, 2<sup>nd</sup> ed., Ch2) and review of necessary mathematics (results from vector calculus and their relationship to Electromagnetism).
- Light Absorption, Dispersion, Band Shape (Hapke, 2<sup>nd</sup> ed., Ch3)
- Specular reflection: EM boundary conditions, Fresnel equations, Kramers-Kronig,

- absorption bands (Hapke, 2<sup>nd</sup> ed., Ch4)
- Single-particle scattering by perfect spheres/Mie Scattering theory, equivalent slab model (Hapke, 2<sup>nd</sup> ed., Ch 5)
- Single-particle scattering by irregularly shaped particles, generalized equivalent slab model (Hapke, 2<sup>nd</sup> ed., Ch 6)
- Radiative transfer equation and propagation in a non-uniform medium, threshold for coherent effects (Hapke, 2<sup>nd</sup> ed., Ch 7)
- First solutions to the radiative transfer equation for a semi-infinite medium and BRDF, the isotropic multiple-scattering approximation (IMSA), method of invariance and the Ambartsumian-Chandrasekhar H-function, modified IMSA (MIMSA), modeling density effects in the radiative transfer solution (Hapke, 2<sup>nd</sup> ed., Ch. 8)
- The opposition effect: shadow-hiding opposition effect (SHOE) and coherent backscatter opposition effect (CBOE) (Hapke, 2<sup>nd</sup> ed., Ch. 9)

**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
Develop familiarity with basic theory and approximate solutions to the radiative transfer models that are used to describe single particles and granular media	Homework
Develop an understanding of where open questions exist in the research literature	Student presentations on related journal articles
Develop proficiency in working with radiative transfer models in granular media and their applications	Extended take-home exam

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

- The course should benefit both CIS students interested in remote sensing of sediment, as well as AST students interested, for example, in planetary astronomy. This is the first semester of a two-semester graduate-level course.
- By the end of the course, provide students with a solid foundation in and understanding of this material to prepare graduate students to do research in a related topic. Ensure that students understand where research opportunities exist in this area and the open research questions that could suggest dissertation topics in either CIS or AST.

**9.0**

N/A	General Education Learning Outcome Supported by the Course, if appropriate	Assessment Method
<i>Communication</i>		
	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	
<i>Intellectual Inquiry</i>		
	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	
<i>Ethical, Social and Global Awareness</i>		
	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	
<i>Scientific, Mathematical and Technological Literacy</i>		
	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	
<i>Creativity, Innovation and Artistic Literacy</i>		
	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.)

**-Request smart/electronic white-board in classroom and computer projection equipment.**  
**-Request late morning class schedule if possible.**

**\*Optional course designation; approval request date:** This is the date that the college curriculum committee forwards this course to the appropriate optional course designation curriculum committee for review. The chair of the college curriculum committee is responsible to fill in this date.

**\*\*Optional course designation; approval granted date:** This is the date the optional course designation curriculum committee approves a course for the requested optional course designation. The chair of the appropriate optional course designation curriculum committee is responsible to fill in this date.

**\*\*\*Course Conversion Designations**

Please use the following definitions to complete table 2.a on page one.

- **Semester Equivalent (SE)** – Closely corresponds to an existing quarter course (e.g., a 4 quarter credit hour (qch) course which becomes a 3 semester credit hour (sch) course.) The semester course may develop material in greater depth or length.
- **Semester Replacement (SR)** – A semester course (or courses) taking the place of a previous quarter course(s) by rearranging or combining material from a previous quarter course(s) (e.g. a two semester sequence that replaces a three quarter sequence).
- **New (N)** - No corresponding quarter course(s).