ROCHESTER INSTITUTE OF TECHNOLOGY

COLLEGE OF SCIENCE
CENTER FOR IMAGING SCIENCE

COS-IMGS-789*
Special Topics: Modern Astronomical Imaging

1.0 Course Information

a) Catalog Listing (click HERE for credit hour assignment guidance)

Course title (100 characters)	Special Topics: Modern Astronomical Imaging
Transcript title (30 Characters)	Modern Astronomical Imaging
Credit hours	3
Prerequisite(s)**	IMGS-633, Optics for Imaging; IMGS-616, Fourier Methods for Imaging; IMGS-682, Image Processing and Computer Vision; or permission from the instructor.
Co-requisite(s)	

b) Terms(s) offered (check at least one)

	Fall
X	Spring
	Summer
	Other
	Offered biennially

If "Other" is checked, explain:

c) Instructional Modes (click HERE for credit hour assignment guidance)

	Contact hours	Maximum students/section
Classroom	3	10
Lab		
Studio		
Other (specify, i.e. online, workshop seminar, etc.)		

2.0 Course Description (as it will appear in the bulletin)

Modern astronomical imaging makes use of advanced telescopes such as segmented apertures, sparse apertures, coronagraphs, as well as interferometric and computational methods. This course will review the underlying physical optics principles of astronomical image formation that form a basis for understanding advanced systems.

The course will then explore basic principles of complex aperture systems that provide a means of achieve high resolution images. Students will be guided by a textbook and other published literature on modern imaging topics. All students must participate in round table discussions, presenting material in a journal club like setting. Project reports will be assigned which have both an analytical and numerical component. A computer programming language is needed to complete the numerical component (e.g., MatLab, Mathematica, Fortran, C, or Python).

3.0 Goal(s) of the Course

1. To understand the basic principles of telescopes.
2. To understand analytical and numerical methods needed to form high-resolution images with segmented and sparse aperture systems.
3. To develop computational expertise in modeling advanced imaging systems.

4.0 Intended course learning outcomes and associated assessment methods

Include as many course-specific outcomes as appropriate, one outcome and assessment method per row. Click HERE for guidance on developing course learning outcomes and associated assessment techniques.

Course Learning Outcome	Assessment Method
Describe advanced astronomical imaging systems	Roundtable Discussions
Calculate imaging metrics	Projects
Assimilate theory and numerical models	Computer Programs

5.0 Topics

1. Astronomical Optics
    a. Geometric optics
    b. Wave optics
    c. Radiometry
    d. Quantum theory
2. First-Order Paraxial Optics
    a. Ray tracing
    b. ABCD matrix method
3. Aberration Theory
    a. Tip/Tilt, Defocus
    b. Zernike Polynomials
4. Transmittance, Throughput
    a. Etendue
    b. Scattered Light
    c. Image Constrast
    d. Signal-to-noise ratio
    e. Strehl ratio
5. Scalar Diffraction Theory and Image Formation
    a. Fraunhofer diffraction
    b. Fresnel diffraction

c. Rayleigh criterion
d. Fourier optics
e. Optical Transfer Function

6. Image Processing
    a. Autocorrelation function
    b. Wiener filter
7. Interferometry
    a. Young's Double Slit
    b. Michelson stellar interferometer
    c. Contrast and coherence
    d. Heterodyne interferometry
8. Phase Retrieval
    a. Iterative methods
    b. Gerchberg-Saxton algorithm
    c. Phase diversity
    d. Wavefront control
    e. Laser guide star
9. Segmented Aperture Telescopes
    a. Image Quality
    b. Wavefront errors
    c. James Webb space telescope
10. Sparse Aperture Telescopes
    a. Redundant and nonredundant apertures
    b. Angular resolution
    c. Image reconstruction
    d. Modulation transfer function
    e. Signal-to-noise ratio

6.0 Possible Resources (should be in an enumerated list or outline format)

1. Textbook: Basic Optics for the Astronomical Sciences, James. B. Breckinridge, SPIE Press 2012

2. Research papers, conferences proceedings, and technology reports (e.g., JOSA-A, Applied Optics, SPIE Proceedings, Astronomy & Astrophysics, Astronomical Society of the Pacific, Optical Engineering).

7.0 Program outcomes and/or goals supported by this course

1. To provide students with a depth and breadth of modern astronomical imaging.
2. Prepare students with a physics, mathematical, and numerical foundation to participate in research and career paths that make use of modern imaging techniques.
3. To develop the students' skills in assimilating theoretical principles with computation models.

8.0 Administrative Information

a) Proposal and Approval

Course proposed by	
Effective term	
Required approval	Approval granted date
Academic Unit Curriculum Committee	
Department Chair/Director/Head	
College Curriculum Committee	
College Dean	

b) Special designations for undergraduate courses

The appropriate Appendix (A, B and/or C) must be completed for each designation requested. IF YOU ARE NOT SEEKING SPECIAL COURSE DESIGNATION, DELETE THE ATTACHED APPENDICES BEFORE PROCEEDING WITH REVIEW AND APPROVAL PROCESSES.

Check	Optional Designations	*** Approval date (by GEC, IWC or Honors)
	General Education	
	Writing Intensive	
	Honors	

c) This outline is for a…

	New course
	Revised course
	Deactivated course

If revised course, check all that have changed

	Course title		Mode of Delivery
	Credit hour		Course Description
	Prerequisites		Special Designation
	Contact hour		
	Other (explain briefly):		

d) Additional course information (check all that apply)

	Schedule Final Exam
	Repeatable for Credit | How many times:
	Allow Multiple Enrollments in a Term
	Required course | For which programs:
	Program elective course | For which programs:

e) Other relevant scheduling information

(e.g., special classroom, studio, or lab needs, special scheduling, media requirements)

9.0 Colleges may add additional information here if necessary
(e.g., information required by accrediting bodies)

Endnotes:

*** College-Alpha-Number-Name:** As in the file name in the Further Instructions below. Note: the suffix '-X' is used for cross-listed courses only and, if appropriate, must appear in this place on the form, but only in this place. The '-X' must be included in the course outline forms for both courses in such cases.

**** Prerequisites:** These may be: major, year within major, and/or completion of specific courses. Note that these are system-enforceable prerequisites, and a student will not be able to register for the course without meeting this exact prerequisite course or an equivalent that can be detected by the system. To list course prerequisites, use CourseAlpha-Number (as in ISTE-101). If more general skill-based prerequisites are needed, they should be listed at the end of section 2, such as, "Note: One year of programming is helpful" or "Note: One semester of descriptive Statistics is recommended"

***** 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.

Further Instructions:
The file that contains this form should be named using the following convention:

COLLEGE-ALPHA-NUM-NAME

- College is the Alpha College Designation (e.g., GCCIS)
- NUM is the course number including the 4 letter text code and course number (e.g., HCIN-744)
- NAME is the course name, no spaces, each word beginning with an upper case letter
- EXT is the extension (doc or docx). These are the only acceptable extensions

APPENDIX A: GENERAL EDUCATION

Preliminary Notes:

According to NYSED, "The liberal arts and sciences comprise the disciplines of the humanities, natural sciences and mathematics, and social sciences." Although decisions about the general education status of RIT courses are guided by this categorization and the details provided at the NYSED web site (click HERE), RIT recognizes that a general education course might not fit neatly into any one of these categories. Course authors from all areas are encouraged to read not only the NYSED web site, but also the mission statement at RIT's General Education web site (click HERE).

This appendix is meant to highlight those facets of a course that are directly relevant to its General Education status, and if applicable, to provide course authors with an opportunity to elaborate on aspects of the course that locate it in one or more of the Perspective categories. The course description, course goals, and course learning outcomes (sections 2, 3, and 4 of the course outline) should clearly reflect the content of this appendix.

Information provided here will also be used to identify appropriate courses for inclusion in RIT's General Education Outcomes assessment cycle.

I. Nature of the Course:

After reviewing the NYSED web site (click HERE) and the RIT description of general education (click HERE) describe how this course fits the definition of general education.

II. General Education Essential Outcomes:

The Academic Senate approved the following proposal at the meeting of 16 April, 2015.

Communication and critical thinking are essential to the general education of every student at RIT. Going forward, every course designated as general education by GEC will provide learning experiences designed to achieve at least one student learning outcome from each of these domains (Communication and Critical Thinking).

The approved student learning outcomes are listed below.

a. Communication

a.1 Check at least one of the following student learning outcomes:

	Express oneself effectively in common college-level written forms using standard American English
	Revise and improve written products
	Express oneself effectively in presentations, either in American English or American Sign language
	Demonstrate comprehension of information and ideas accessed through reading

a.2 In the space below, explain which aspects of this course lend themselves to the Communication outcome(s) indicated above, and how student achievement will be assessed.

b. Critical Thinking

b.1 Check at least one of the following student learning outcomes:

	Use relevant evidence gathered through accepted scholarly methods and properly acknowledge sources of information
	Analyze or construct arguments considering their premises, assumptions, contexts, and conclusions, and anticipating counterarguments
	Reach sound conclusions based on logical analysis of evidence
	Demonstrate creative and/or innovative approaches to assignments or projects

b.2 In the space below, explain which aspects of this course lend themselves to the Critical Thinking outcome(s) indicated above, and how student achievement will be assessed.

III. Additional Student Learning Outcomes

Indicate which (if any) of the following student learning outcomes will be supported by and assessed in this course.

Table A.1: Student Learning Outcomes	
(Check)	**Student Learning Outcomes**
	1. Interpret and evaluate artistic expression considering the cultural context in which it was created
	2. Identify contemporary ethical questions and relevant positions
	3. Examine connections among the world's populations
	4. Analyze similarities and differences in human experiences and consequent perspectives
	5. Demonstrate knowledge of basic principles and concepts of one of the natural sciences
	6. Apply methods of scientific inquiry and problem solving to contemporary issues or scientific questions
	7. Comprehend and evaluate mathematical or statistical information
	8. Perform college-level mathematical operations or apply statistical techniques

a. Explanation: In the space below, explain how this course supports the student learning outcomes indicated above.

b. Assessment: In the space below, explain how student achievement in the specified student learning outcomes will be assessed.

IV. Perspectives

Indicate which Perspectives (if any) this course is intended to fulfill.

Keep in mind that perspectives courses are meant to be introductory in nature. Click HERE for descriptions of the General Education Perspectives and their associated student learning outcomes.

Table A.2: Request for Perspective Status			
Date Requested	**GE Perspectives**	**Required Outcomes (see Table A.1)**	**Date Granted**
	Artistic	#1	
	Ethical	#2	
	Global	#3	
	Social	#4	
	Natural Science Inquiry	#5 and #6	
	Scientific Principles	#5 or #6	
	Mathematical	#7 and #8	

APPENDIX B: WRITING INTENSIVE

Preliminary Notes:

This appendix is meant to highlight those facets of a course that are directly relevant to its Writing Intensive (WI) status. The course outline, including course goals and course learning outcomes (sections 3 and 4 of the course outline), should clearly reflect the content of this appendix.

Information provided here will also be used to identify appropriate courses for inclusion in RIT's Writing Outcomes assessment cycle.

I. Course Category: *Check one*

First Year Writing	
General Education (WI-GE)	
Program (WI-GE)	

A course can be both WI-GE and WI-PR.

II. Nature of the Course:

Criteria that define Writing Intensive courses at RIT can be found at the Institute Writing Committee web site (click HERE).

a. Writing-Related Learning Outcomes

List the writing-related course learning outcomes.

b. Informal and Formal Writing Assignments

1. Informal writing (commonly described as "writing to learn") is distributed throughout the course as appropriate to its learning outcomes. Use the space below to describe briefly the informal writing assignments in the course and the distribution of those activities throughout the course.
   Informal writing includes activities such as free/quick-writing, lab notebooks, response/reading journals, and online discussions. For other examples, (click HERE). (Shift/Enter to continue)

2. Formal writing assignments (commonly described as "writing in the discipline") engage students in the work of the discipline/s represented by the course. Use the space below to describe briefly the formal writing assignments taught in the course, and what students will learn by completing the assignment(s).
   Formal writing assignments include genres such as a research/project report, case study, and clinical observation. For more examples, (click HERE). (Shift/Enter to continue)

c. Revision Policy

Students must receive feedback from instructors and have an opportunity to incorporate that feedback into a revision of the written work. Use the space below to describe briefly the kinds of feedback students are provided, and what opportunities students have to improve their writing based on that feedback.

Feedback can be given in many forms, including margin comments, summative end-comments, a 1-on-1 conference, scoring guides, and rubrics. For more information, (click HERE).

d. Class Discussion

Class topics include lessons on specific writing strategies. Check which writing strategies are discussed in the course. Use the space below to describe briefly the writing strategies discussed in the course.

In-class lessons of writing strategies can include discussions of revision strategies, genre conventions, copyediting, concision, and clarity. For more information, (click HERE).

e. Writing Portion of Grade

At least 20% of the overall course grade must be based on writing assignments. What portion of the course grade is based on the writing students submit?

	<20%
	20% or more

Use the space below to describe briefly how the writing is evaluated in the course.

APPENDIX C: HONORS

Honors core curriculum course development

1. First Year Honors Seminar: Explorations of Space and Place (3 credits)
Specific sections of the First-Year Honors Seminar can be developed by faculty in any college, pending approval by chair/department and HCC. If the course "Shell" or course template has already been approved by the college, then a section can be customized by faculty wishing to teach a section relevant to their area(s) of expertise. The proposal process requires faculty to complete an "Honors First Year Seminar Subtopic Proposal Form" and a course description that will, upon approval, be entered into SIS.

All iterations of FY Honors Seminar include Year-One curriculum, and therefore are only offered in fall semester. They also must fulfill Foundational Elective and General Education course requirements, and cannot be considered "Perspective" courses.

2. Honors Electives
Honors electives can be either new courses or honors versions of existing non-honors courses. They can be either general education or discipline specific, and are part of a two 3-credit course requirement that Honors students must complete by the end of their third year. They can be developed and taught by faculty in any college as part of course load or as an overload. New courses require approval by chair, department, college curriculum committee, HCC review and recommendation, and then GEC approval if the general education designation is desired (see below). Honors courses created as a section of an existing non-honors course should follow each college's approval procedures; with the chair of the college curriculum committee submitting the course to the HCC for review (see below). Honors electives can be offered either semester or Summer term.

3. Research Seminar (3 credits)
- Requirement for third-year Honors students.
- Honors research seminars can be developed by faculty in any college, pending approval by chair, department, and/or college unit.
- Honors research seminars can be taught by faculty in any college as part of course load or overload, pending approval by chair, department, and/or college unit.
- Honors research seminars can be Honors or non-Honors seminar (if non-honors, students complete additional components approved by faculty instructor).

4. Senior thesis/capstone experience (1 credit)
Requirement for fourth/fifth-year students

5. Contract Course Arrangements
Contract course arrangements involve a student agreeing to complete additional academic course components by contract agreement with faculty teaching the course in

order for the student to earn Honors points. Such arrangements can be made with any non-honors course open to select honors students by faculty instructor's approval.

Honors Course Approval Process:

Proposals for Section Versions of First Year Honors Seminar: Explorations of Space and Place

Faculty proposing to offer a new version of the First Year Honors Seminar course template will first complete an "Honors First Year Seminar Proposal Form" and provide a course description. After completing this form, the faculty member secures the approval and signature of the Administrative Chair and department approval. The next step is HCC review and recommendation, which will be conveyed to the Chair. If approval is granted, the registrar can then enter the course section into SIS.

If the template or 'shell' of the First Year Honors Seminar has not yet been approved in a specific college, the course 'shell'/template needs to be submitted as any other new course to the chair/department, then the College Curriculum Committee. Since the course 'shell' has already been approved by GEC for general education designation, the chair of the college curriculum committee, upon approval, can send the course template to the registrar to be listed in SIS.

Proposals for New Honors Courses

Proposals for **new** honors courses require review and approval by the following entities in this order:

1. Faculty member's home department chair and curriculum committee
2. College Curriculum Committee
3. RIT Honors Curriculum Committee
4. RIT General Education Committee (if general education designation is desired)

Upon gaining the approvals above, the chair of the CCC or GEC notifies the Registrar for listing in SIS.

Honors Sections of Existing Non-Honors Courses

Faculty may redesign an existing course as an honors course. The process for gaining approval of such courses is as follows:

Such courses require review and approval by the following entities in this order:

1. Faculty member's home department chair and curriculum committee
2. College Curriculum Committee (if college requires it)
3. RIT Honors Curriculum Committee
4. RIT General Education Committee, for information purposes only (if existing course is general education, so that course can be designated as GE)

Upon gaining the approvals above, the chair of the CCC or GEC notifies the Registrar for listing in SIS.

Honors Course Development Guidelines:

Honors courses are distinguished from non-honors courses by the mode of content delivery, based on innovative and creative teaching methods. Courses designated to meet honors requirements include the following characteristics on this Honors Course Content Checklist:

- Are capped at 20 students
- Are discussion-based; content delivery in seminar style
- Promote active student learning through focus on exploration, innovation and creativity
- Integrate experiential learning components (conferences, study abroad, field trips, off-campus events, lecture series, etc.)
- Include student independent research/creative work
- Include student presentation of research project/creative work
- Integrate interdisciplinary components

Please use the matrix below to map your course content to Honors Curricular requirements.

Criterion	**Guideline**	**How requirement will be met**
1. Honors Courses have experiential learning outcomes.	Honors courses will include an experiential learning outcome related to at least one of RIT's general education outcomes.	
2. Honors Courses have individual research outcomes.	Research project can integrate field based research, site visits and course readings.	
3. Honors Courses have research presentation outcomes.	Oral presentation of research at the end of the semester.	
4. Classroom Discussion	Honors courses emphasize discussion in a seminar learning environment. Final course grade should include assessment of discussion of critical course readings and student research.	
5. Research portion of the grade	At least 20% of the final course grade should be based on research project.	

6. Interdisciplinary teaching	Team-teaching, guest speakers from other disciplines, assignments that include other disciplinary approaches.	
7. Global education	Study abroad.	

Honors form effective Fall, 2014; Drafted April 25, 2014
Revised May 5, 2014
Updated March 4, 2016