

Course Syllabus for Underwater Optical Imaging for Marine Scientists

1. Course title/number, number of credit hours

Underwater Optical Imaging for Marine Scientists – OCE 6267 – 3 credit hours

2. Course prerequisites

- a. Permission of the instructor

3. Course logistics

- a. Term – Spring 2015
- b. Notation if online course – N/A
- c. Class location and time (if classroom-based course)
W/F – MC 209

4. Instructor contact information

- a. Instructor's name – Fraser Dalglish
- b. Office address – HBOI, Ed Link Bldg, Room 128
- c. Office hours – To be determined
- d. Contact telephone number – office 772 242-2591 (F. Dalglish)
- e. E-mail address – fdalglei@fau.edu

5. TA contact information (if applicable)

N/A

6. Course description

The use of imaging instrumentation and devices is of increasing importance in understanding the marine environment. This course introduces the key theoretical concepts in underwater optics and imaging, the alternate imaging technologies and related data formats and science products. An overview of imaging and visualization using conventional photography and videography, leads to more advanced techniques like laser line scan, range-gated line scanning lidar, fluorescence imagers, 3D and digital plankton imaging systems. The course emphasizes the use of these imaging sensors by marine scientists and engineers on controlled observation platforms and networks, advantages and limitations, and also includes a hands-on portion, which focuses on practical aspects of optical imager operation, calibration, deployment, image processing and visualization.

7. Course objectives/student learning outcomes

The students will be able to explain basic concepts of underwater optical imaging in natural waters, and how environmental characteristics can limit system performance. The students will also have first-hand lab experience to help them gain understanding of the relative performance trade-offs with both conventional and more sophisticated optical imaging technology, including the considerations in processing and interpretation of images for application to marine science.

8. Course evaluation method

There will be graded homework assignments accounting for 40% of the student's cumulative performance, a midterm exam, accounting for 30% of the student's cumulative performance, and a final exam that accounts for 30% of the cumulative performance. The overall grade in the course is derived from the cumulative performance according to the following table.

9. Course grading scale (optional)

Cumulative Performance	Grade
>94%	A
>90% - 94%	A-
>87% - 90%	B+
>83% - 87%	B
>80% - 83%	B-
>75% - 80%	C+
>65% - 75%	C
>60% - 65%	C-
>57% - 60%	D+
>53% - 57%	D
>50% - 53%	D-
<50%	F

10. Policy on makeup tests, late work, and incompletes

If a student cannot attend an exam or hand in a homework project on time due to circumstances beyond their control then the instructor may assign appropriate make-up work. Students will not be penalized for absences due to participation in University-approved activities, including athletic or scholastics teams, musical and theatrical performances, and debate activities. These students will be allowed to make up missed work without any reduction in the student's final course grade. Reasonable accommodation will also be made for students participating in a religious observance. Also, note that grades of Incomplete ("I") are reserved for students who are passing a course but have not completed all the required work because of exceptional circumstances. A grade of "I" will only be given under certain conditions and in accordance with the academic policies and regulations put forward in FAU's University Catalog. The student must show exceptional circumstances why requirements cannot be met. A request for an incomplete grade has to be made in writing with supporting documentation, where appropriate.

11. Special course requirements (if applicable)

Laboratory and field studies

12. Classroom etiquette policy (if applicable)

University policy on the use of electronic devices states: "In order to enhance and maintain a productive atmosphere for education, personal communication devices, such as cellular telephones and pagers, are to be disabled in class sessions."

13. Disability policy statement

In compliance with the Americans with Disabilities Act (ADA), students who require special accommodation due to a disability to properly execute coursework must register with the Office for Students with Disabilities (OSD) -- in Boca Raton, SU 133 (561-297-3880); in Davie, MOD 1 (954-236-1222); in Jupiter, SR 117 (561-799-8585); or at the Treasure Coast, CO 128 (772-873-3305) – and follow all OSD procedures.

14. Honor Code policy statement

Students at Florida Atlantic University are expected to maintain the highest ethical standards. Academic dishonesty, including cheating and plagiarism, is considered a serious breach of these ethical standards, because it interferes with the University mission to provide a high quality education in which no student enjoys an unfair advantage over any other. Academic dishonesty is also destructive of the University community, which is grounded in a system of mutual trust and places high value on personal integrity and individual responsibility. Harsh penalties are associated with academic dishonesty. For more information, see University Regulation 4.001 at http://www.fau.edu/regulations/chapter4/Reg_4.001_5-26-10_FINAL.pdf

15. Required texts/readings

Handbook of Underwater Imaging System Design. C. J. Funk, S. B. Bryant, P. J. Heckman, Naval Undersea Center. Ocean Technology Dept., Ocean Technology Department, Naval Undersea Center, 1972

16. Supplementary/recommended readings (optional)

J. Watson and O. Zielinski. *Subsea Optics and Imaging*, Woodhead Publishing, London, 2013.

E. P. Zege, A. P. Ivanov, and I. L. Katsev, *Image Transfer through a Scattering Medium*, Springer-Verlag, Berlin, 1991.

17. Course topical outline

1. Introduction and course objectives

Homework assignment: evaluate (1) significance of *underwater optical imaging* to various marine science disciplines and (2) the application of *underwater optical imaging* to environmental studies and its societal benefits

2. Fundamentals of Marine Optics - Basics

Homework assignment: classify transmissometer data snippets into standard optical water types or classes

3. Overview of Underwater Imaging Techniques and Instrumentation

Homework assignment: complete essay describing timeline for the main technology developments, current status and possible future trends

4. Imaging Optics – Basics

Homework assignment: demonstrate understanding of key system parameters such as depth of field (DOF) and Modulation Transfer Function (MTF) for camera based systems

5. Sensors and Illumination Sources

Homework assignment: completing a specification sheet outlining key optical, electronic and noise parameters for several hypothetical and real imagers based on datasheets of key components

6. Imaging in Scattering Media - Basics

Homework assignment: power budget calculation for various hypothetical and real underwater imaging scenarios, system and environmental parameters

7. Laboratory: Underwater Photography and Videography

Introduction to commonly used image quality metrics and technical imaging targets. Experiments with alternate camera-light configurations through a range of artificially generated turbidities in 13 m underwater test facility.

Homework assignment: analyze the acquired images to evaluate the advantages and limitations of alternate configurations.

8. Laser Line Scan (LLS) Systems

Homework assignment: application of EODES-3 LLS performance prediction tool to various hypothetical and real underwater imaging scenarios, system and environmental parameters

9. Laser Range Gated (LRG) Camera Systems

Homework assignment: LRG instrument operation and data acquisition.

10. Laboratory: LRG experiments

Experiments with both conventional camera/lamp system and LRG system using both natural and technical targets.

Homework assignment: Analysis and presentation of image quality results and findings.

11. Range Gated Laser Line Scan Lidar (RGLLSL) Systems

Homework assignment: given a scientific survey rate and resolution requirements, derive the main system and operational parameters for an AUV-based RGLLSL system. Use of advanced simulation tool to verify system and operational choices.

12. Fluorescence Imaging Systems

Homework assignment: describe and define an array of science studies where fluorescence imagery would be important.

13. Three-dimensional Imaging Systems

Homework assignment: describe and define an array of science studies where 3D imagery would be important.

14. Underwater Plankton Imaging Systems

Homework assignment: Select appropriate off-the-shelf technologies for a range of microscopic imaging science studies.

15. Image quality assurance and control

Homework assignment: geodetic error evaluation for hypothetical image survey.

16. Image Visualization Tools

Homework assignment: use of off-the-shelf image visualization software with previously test tank datasets. Presentation and evaluation of quality of final image products.