

MIT-WHOI Joint Program
in
Physical Oceanography

The Guide To Procedures

Prepared by
The Joint Committee For Physical Oceanography
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1. About This Guide

The goal of the MIT—WHOI Joint Program in Physical Oceanography is to prepare students to carry out independent and creative research in Physical Oceanography and to demonstrate this ability by writing and defending a PhD dissertation. This Guide describes some of the roles and responsibilities of the students and the staff who make up the Program. It also discusses the procedures that are used to monitor the academic progress of students through the Program. This Guide was prepared by the Joint Committee for Physical Oceanography (JCPO, §2.4), which has the responsibility to oversee and administer all academic aspects of the Program.

Students enter this Program from diverse academic and social backgrounds. Moreover, scientific research is a highly individualistic endeavor whose progress cannot be preordained or tightly scheduled. Consequently, the procedures and schedules described in this Guide can be altered on a case-by-case basis by making a written petition (request) to JCPO. Appendix G has an example format for such a petition. All such petitions should be addressed to the Chair of JCPO and emailed to him/her directly.

For a much wider description of professional and academic policy, students and staff are referred to the MIT Graduate Policies and Procedures (<http://odg.mit.edu/gpp/>), which applies in full to this Program.

2. Roles and Responsibilities

2.1 Students

From the outset we want to emphasize that the primary responsibility for progress through this Program resides with the student. Consequently students need to be fully aware of the nominal progression through the Program, described in Section 3 of this Guide. Students should also be aware of the resources available to help them, described in the remainder of this section.

Advice and suggestions from the student's advisor and thesis committee are almost always required at certain key stages, e.g., selecting courses and developing a viable thesis problem. The latter, especially, requires judgment about the status of a research area and the availability of resources. If at any time a student feels that he or she is not being given appropriate guidance or support, then he/she is urged to take corrective steps. The first step is to consult with the principal advisor. However, the student may prefer to discuss the situation with the thesis committee, JCPO, the Education Coordinator, the Physical Oceanography Department Chair at WHOI, the Department Head of Earth, Atmospheric and Planetary Sciences at MIT, the Joint Program Director at MIT, or the Deans, all of whom have a professional commitment to insure that the Program functions in a fair and efficient way.

These advisory and supervisory committees can function well only when they are kept fully informed of a student's status. There are formal mechanisms for such reporting described below. However, these may not be appropriate or sufficiently timely for every circumstance. It is therefore the students' responsibility to keep their advisor and JCPO informed of significant events or circumstances that may affect their academic progress. Written notification is preferred.

Students with disabilities may be entitled to special accommodations, as described in Section 3.11.

2.2 Advisors

Each entering student is assigned two advisors, one from MIT and one from WHOI. One of these is the "principal advisor," with whom the student will begin his/her research work. The importance of a

strong working relationship between the student and the principal advisor cannot be overemphasized. The principal advisor will be the student's closest scientific contact and must have an active interest in helping and advising. The advisor's advocacy and assessment of the student's progress at the time of the general exam can be very important. A check-list of student/advisor responsibilities specific to JPPO is given in Appendix D. A longer description of advisor-student relations may be found at <http://mit.who.edu/responsibilities>, reproduced in Appendix E.

The initial assignment of advisors is made by JCPO before students arrive for their first term. Assignment is based upon indications of scientific interests in the admissions application and, to some degree, upon availability of financial support. It is natural that students' scientific interests may change as they learn more about the field of Physical Oceanography. The initial principal advisor may then not be the most suitable and each student should seek out the best advisor for his/her thesis research, subject to personal and financial considerations. A change of principal advisor for this reason is not uncommon. Students can best choose a new advisor when they have made an effort to discover what research opportunities are available within the Program. The student is encouraged to discuss potential advisor changes with one or more JCPO members prior to the change, but it is the student's duty to identify one or more faculty members willing to serve as advisor(s). The student must notify JCPO in writing of the proposed change of principal advisor and receive JCPO's approval (with the Joint Program Administrator at MIT and the Academic Programs Office at WHOI notified of the approval).

2.3 Advisory Committee (Thesis Committee)

The Advisory Committee is intended to serve as a resource for the student in planning courses and research. Prior to submission of a student's thesis proposal, in consultation with the advisor(s), he/she needs to form a four to five, or more, person Advisory Committee at least two months prior to the thesis proposal defense. The principal advisor serves as chair of this committee, which must have MIT and WHOI representation (two from each institution are strongly encouraged) and include at least one current member of JCPO. If the latter person steps off of JCPO, the student may petition that the person continue to fulfill the requirement of JCPO representation on the advisory committee. JCPO must be notified, in writing, of the composition of the proposed Advisory Committee; JCPO may recommend changes and must approve the final composition. It may be appropriate and indeed desirable to change the membership of this committee as the research develops; approval of the advisor and JCPO is also required for such changes. The Committee, together with the principal advisor, should be the student's primary resource for information and advice; close contact with the members of the Committee is important and two formal meetings per year with the Committee are required. One or two of the Committee members can be external (not from WHOI or MIT), depending on the focus of the research. Some travel funds for one external committee member are available through the WHOI Academic Programs Office.

2.4 Joint Committee for Physical Oceanography

The Joint Committee for Physical Oceanography (JCPO), composed of members of the faculty at MIT and the staff at WHOI, oversees the graduate educational program in Physical Oceanography. It is responsible for development of the curriculum and course scheduling, overseeing student admissions and the initial assignment of advisors, setting examination policy, reviewing student progress, and maintaining acceptable academic standards for doctoral theses. Upon recommendation of the advisor and the student's Advisory Committee, JCPO approves continued registration in the program and accepts the final Ph.D. Thesis. In addition, it serves as the first level grievance board for student concerns.

The Education Coordinator of the Physical Oceanography Department at WHOI is a member of JCPO. His/her responsibilities include liaison with the Academic Programs Office for allocation of financial support to students and other educational activities at WHOI. Advisor(s) and students should feel free to discuss problems with the Education Coordinator or any other member of JCPO. At MIT, the

Department of Earth, Atmospheric and Planetary Sciences and the Institute as a whole have Committees on Graduate Students who can respond to concerns.

JCPO can best serve the educational needs of the students if fully informed of their status. Thus it requests notification of changes that may affect a student's academic status and has the final authority for approving them. A written note (email) to JCPO will best assure careful consideration and a clear response to students' concerns. Please address correspondence to the Chair of JCPO and cc other members. A list of JCPO members may be found here: <http://mit.whoi.edu/page.do?pid=34583>.

2.5 WHOI Dean of Graduate Studies and MIT Dean for Graduate Education

The Deans set the overall policy of the Graduate Program. They generally do not have a direct role in the day-to-day academic operation of the Joint Program. They are, however, very experienced educators and administrators who have a keen interest in the welfare of the students and of the Program overall. They are available to students and staff for personal consultation, and are essentially the last stop in the chain of academic governance at both Institutions. The rare problem, which cannot be resolved by JCPO, will be referred to the Deans.

The WHOI Academic Programs Office, which is run by the WHOI Dean of Graduate Studies, and the Joint Program Administrator's Office at MIT administer services to Joint Program students (registration, admissions, housing, payroll, etc.; see the webpage for current students: <http://mit.whoi.edu/current-students>). They also maintain official records. The Earth, Atmospheric, and Planetary Sciences Department Office can also provide help with student services.

3. The Academic Program

The completion of a PhD requires ~five years of sustained effort (Appendix A). For most students the first two years are devoted mainly to course work, though with some important opportunity for research. The remaining years in the program are devoted mainly to dissertation research and writing. Extension beyond the fifth year requires a petition by the student and principal advisor to JCPO. To be approved, this petition must provide supporting evidence that good progress is being made toward the completion of the thesis. Extensions beyond the seventh year will not be granted. In rare instances, unsatisfactory progress or unacceptable behavior can lead to a student being denied permission to continue (see Official Graduate Policies and Procedures <http://odg.mit.edu/gpp/>).

3.1 Financial Support

Students are eligible for fellowships, scholarships and research assistantships for the first five years. As stated at the time of admission, the Joint Program commits to financial support for a nominal term of five years towards a Ph.D., assuming satisfactory progress towards the degree is achieved. Extension of aid into the sixth year requires a petition to JCPO by spring of the fifth year. No financial support is available beyond the sixth year. Guidelines for the obligations and benefits for students supported by Research and Teaching Assistantships (e.g., vacation policy) can be found on the ODGE website <<http://odg.mit.edu>>; information about RA/TA appointments can be found at <http://odg.mit.edu/gpp/assistance/rata/> and <http://odg.mit.edu/gpp/assistance/rata/terms-of-appointment/>.

3.2 Curricula in Physical Oceanography

Students are expected to take about 9-12 (see appendix I) courses during their first two years in the Joint Program. Typically these will include 4 core courses, 1 math course, and 4-7 electives. This number is a recommendation and not a requirement – there are no formal physical oceanography course

requirements in the Joint Program. Courses should be selected in a way that is consistent with a student's preparation, and with their research interests (in consultation with their advisor). JCPO will contact first-year students and their advisors in order to offer advice in curriculum planning prior to the first semester.

Each student's general exam (see §3.4 below) will be tailored to reflect their individual course of study. Performance in the coursework, including the actual grades, is taken into account at the Annual Review and in the General Exam Assessment. It is generally expected that students receive a mix of A and B grades in their coursework.

Curricula may vary considerably depending on the focus chosen by the student and advisor. Here, we present suggested curricula for four main areas of interest of students in Physical Oceanography:

1. General Physical Oceanography
2. Physical Oceanography and Climate
3. Physical-biological-chemical Interactions
4. Coastal/Nearshore Physical Oceanography and Engineering

The curricula consist of:

A. Core Courses.

Four area-specific core courses are highly recommended, with possible exceptions for students who have already completed similar courses. They are intended to provide the minimum, essential foundation needed by students pursuing research with a strong physical oceanography component. They can be completed within the first year.

Two core courses are recommended to all students within Physical Oceanography

12.800 Rotating Stratified Fluids (F)

12.808 Introduction to Observational Physical Oceanography (F)

Plus two area-relevant core courses that may vary depending on the focus

General Physical Oceanography

12.801 Large-scale Ocean Dynamics (S)

12.802 Small Scale Ocean Dynamics (S)

Physical Oceanography and Climate

12.812 General Circulation of the Atmosphere (F)

12.801 Large-scale Ocean Dynamics (S)

Physical-biological-chemical Interactions

12.742 Marine Chemistry (F)

7.47 Biological Oceanography (S)

Coastal/Nearshore Physical Oceanography and Engineering

1.69 Coastal Engineering (F)

12.862 Coastal Physical Oceanography (F)

12.802 Small Scale Ocean Dynamics (S)

B. Applied Mathematics Courses.

An understanding of the methods of applied mathematics is essential for nearly all research topics. The choice of applied mathematics course is dictated by the student's preparation and

interests and made in consultation with the advisor. Amongst the possible courses, we recommend one of the following two part series:

18.085 Computational Science and Engineering I

18.086 Computational Science and Engineering II

-or-

18.305 Advanced Analytic Methods in Science and Engineering

18.306 Advanced Partial Differential Equations with Applications

As an alternative to one of the courses within a series, students may consider taking:

18.075 Advanced Calculus for Engineers

C. Electives Courses.

The core curricula have been kept to a minimum in order to allow each student the time to define a program of elective courses that are tailored to their research interest. Some of the most common and relevant electives are indicated within the different curricula by an asterisk (*). In addition, to help prepare for research on these diverse topics, Joint Program students may choose elective courses from the offerings of any MIT or WHOI department and cross-registration is available with Harvard. The list of possible elective is thus very extensive. Students are encouraged to consult the sample curricula as well as the appropriate course catalogues. Students are expected to define their own, personal paths through an elective course program, with advice from their major advisor and other academic staff members.

Focus: General Physical Oceanography

12.805* Data Analysis in Physical Oceanography (S)

12.809 Hydraulic Phenomena in Geophysical Fluid Flows (F)

12.862 Coastal Physical Oceanography

12.758 Classic Papers PO (S)

12.820 Turbulence in the Atmosphere and Oceans

12.824 Instability Theory

12.831 Dynamics and Transport in the Stratosphere (S)

12.843* Large-scale Atmosphere and Ocean Dynamics

12.850 Computational Ocean Modeling

12.853 Advanced Geophysical Fluid Dynamics

12.870 Air-Sea Interaction (S)

12.950 Computational Ocean Modeling (S)

Focus: Physical Oceanography and Climate

12.842* Physics and Chemistry of Climate (F)

12.756* Climate Variability and Diagnostics (S, odd)

12.740* Paleoceanography (S, even)

12.802* Small Scale Ocean Dynamics (S)

12.864* Inference from data and models (starting in 2015-2016).

12.708 Advanced Seminar in Paleoceanography

12.707 The history of the Earth's Climate (S, odd)

12.757 Climate Change Science and Communication (S)

12.860 Climate Variability and Diagnostics (S)

12.831 Dynamics and Transport in the Stratosphere (S)

12.848 Global Climate Change: Economics, Science and Policy (S)

12.885 Environmental Science and Society (F)

EPS208 Physics of Climate (Harvard, F)

EPS231 Climate Dynamics (Harvard, S)

Focus: Physical-Bio-Chemical Interactions

7.410* Applied Statistics (F)
12.702 Elements of Modern Oceanography (F)
12.823* Modeling the Biology and Physics of the Ocean (S)
12.802* Small Scale Ocean Dynamics (S)
7.430 Genetics of Marine Organisms
7.431 Topics in Marine Ecology
7.440 Intro to Mathematical Ecology
7.437 Topics in Molecular Biological Oceanography
7.436 Topics in Phytoplankton Biology
7.434 Topics in Zooplankton Biology connectivity
7.435 Topics in Benthic Biology
7.439 Topics in Marine Microbiology
12.746 Marine Organic Geochemistry
2.29 Numerical Fluid Mechanics
12.864 Inference from Data and Models
7.440 An Introduction to Mathematical Ecology
1.715 Environmental Data Analysis
12.714 Computational Data Analysis

Focus: Coastal/Nearshore Physical oceanography and Engineering

2.29* Numerical Fluid Mechanics
12.805* Data Analysis Physical Oceanography
12.820* Turbulence in the Ocean and Atmosphere
or
2.27* Turbulent and separated flows
1.64* Physical Limnology
1.723 Numerical Modeling
1.72 Groundwater
1.67 Sediment transport and coastal processes
12.754 Coastal geomorphology
12.864 Inference from data and models

Comprehensive sample curricula for these four areas are presented in the Appendix together with a list of electives and core courses divided by topic.

3.3 Annual Review

Each winter, JCPO conducts a general review in order to monitor student progress and to make sure that the student/advisor relationship is functioning well. Students are asked to meet with their advisors and, together, fill out a form (see Appendix H) requesting information on past and future checkpoints, the advisor-student relationship, and other types of professional training. This meeting provides a formal opportunity for the student and advisor to discuss progress. The completed form should be signed by the advisor and returned by the student to JCPO in preparation for the annual review meeting. Forms are typically sent out in mid December and the review meeting typically takes place in mid January. JCPO will provide written feedback to the student and the advisor following their meeting.

If a student does not feel comfortable sharing information with their advisor, the student should fill out the form and return it to the Chair of JCPO with a description of the problems that have arisen with the advisor. The Chair and JCPO will then work with the student on a one-by-one basis in order to

address the problems and complete the review. If the advisor is a JCPO member the student should send the completed form and explanation to the JCPO Chair or to another member. Any student may request to meet with JCPO at any time.

3.4 Pre-generals Research Project

Students are strongly encouraged to start research as soon as possible to build expertise in identifying a field of interest, developing a firm understanding of the state of knowledge within the field, and singling out possible research/thesis topics. It is expected that students focus on research during the summer and IAP (Independent Activities Period, January of each year). In the semester before the general exam, normally the spring semester of the second year, students are strongly encouraged to take a reading course with their principal advisor. This course should help prepare the students for the brief research presentation required as part of the oral portion of the general exam (see below) and for later development of a formal thesis proposal.

3.5 General Exam in Physical Oceanography

The general exam qualifies the student for Ph.D. research in the Joint Program. The purpose of the exam is to test the ability of the student to function as an independent research scientist. The first portion consists of a written research report, a more general 2-day written exam, and an oral presentation of research/ oral exam. Usually the general exam will be taken after two years in the program. Taking the exam at an earlier time may be requested via petition to JCPO; this is most often done by students entering with a related MS who wish to take the exam after one year in the program. If these exams are satisfactory, the student must then prepare and defend a thesis proposal within 4-5 months.

The purpose of the exam is to test:

- the student's grasp of material covered in the core curriculum and other courses. The exam emphasizes not only understanding of the basic ideas and concepts presented in the courses but also the ability to draw together and synthesize material from different courses, readings, seminars, etc. For all students the general exam will recognize the individualized aspects of their course of study.
- the student's ability to approach a new problem in ways appropriate for an independent scientist. This ability is central to the notion that passing the general exams qualifies one to prepare the Ph.D. dissertation.

The research report will be due in early May, and the written and oral exams will usually be given in early June each year. The General Exam is administered by a General Exam Committee (GEC), comprised of the principal advisors of the students taking the exam that year plus possible additional members appointed by JCPO. Two JCPO members, one from MIT and one from WHOI, will chair the GEC and be responsible for the logistics.

Application to take the General Exam should be made to the chair of the GEC one month prior to the exam. (See Appendix B for Application Form.) The form requires that the students list all graduate courses taken. In addition, students are asked to indicate the 4-6 courses they feel are most relevant to their sub-discipline. The GEC will meet with the students taking the general exam in February of their second year. The purpose of the meeting is to provide clarification regarding the format and administration, and complete scheduling of the general exam.

3.5.1 Research Report

The research report is intended to demonstrate the ability to document and communicate research in a paper format. The paper should be 15 pages or less (single spaced and including figures, but not including references), a minimum font of 12 points, and have the nature of a paper draft. (If the student has encountered difficulties such as intractability or negative results, it should still be possible to tell an interesting story.) The advisor can give advice on the outline and general organization, but the primary writing and research must be the student's. The degree of input from the advisor will be discussed at the oral exam.

3.5.2 Written Exam

The written exam consists of two open-book/open-note written exam, administered over consecutive days. Each exam is four hours in duration and students are typically asked to select three out of five questions to answer. The questions are solicited from the advisors and course instructors. The GEC will gather and select the questions to be included and will ensure that individualized courses of study are respected and that grading standards are maintained. Graded answers will be returned and students are encouraged to discuss them with their advisors, the question writers, or other members of the GEC prior to the oral.

3.5.2 Oral Exam

The oral exam is administered about a week after the written examinations, to allow the Committee and the student to review the performance on the written part. The oral exam gives the students an opportunity to describe their research, to clarify questions raised by the research report and the written exam, and to further demonstrate their ability to organize and utilize scientific concepts and information. At the beginning of the oral exam, students will make a short presentation, lasting approximately 20-30 minutes, describing research that they have carried out. This portion of the exam is an opportunity to demonstrate the ability to master an area of interest, to show progress on a reasonable research problem, and to argue for its relevance and tractability. If in doubt about the content of the presentation, the student should consult with the advisor(s). Again, the advisor can make suggestions, but needs to keep in mind that the preparation and presentation work must be done by the student – advice should be pedagogical. Giving the presentation to and soliciting feedback from other students is encouraged. After the presentation, the examining committee will ask questions pertinent to the research and may also ask questions concerning the written exam, the course work, and other areas.

The GEC will be in charge of the oral exams, but may delegate responsibility to a smaller group or choose to invite participation from other faculty members who may share a special scientific interest with the student and who can aid in formulating an appropriate oral exam. Students may suggest such faculty members. Students will be informed of the membership of the GEC.

The GEC will recommend to JCPO (and cc the student) whether or not this portion of the general exam has been passed, with a fairly full discussion of the strong and weak points. If the student has passed, he/she then either proceeds to the final part of the exam, which involves preparing a thesis proposal or, if recommended by the GEC, prepares a Master's thesis before continuing to the thesis proposal stage. If the decision is that the student has not passed the oral or written exam, the GEC normally recommends that the student (1) immediately withdraw (which would be extraordinary), (2) prepare a Master's thesis and then withdraw, or (3) prepare a Master's project and retake all or part of the general exam. Although it is possible to take the exam a second time, the student must withdraw if the exam is failed again.

3.5.3 Thesis Proposal

The purpose of the thesis proposal is to demonstrate the ability to formulate a tractable, interesting research problem. The proposal is a written document (typically 10-15 pages of text, 20-30 pages with figures and references) that should outline

1. the scope of the problem
2. its significance
3. previous work done by others
4. the methods of research to be used
5. a timeline with a detailed plan for the immediate 6-12 months

Preliminary results can be presented mainly to indicate the direction the work will take, but are not a necessary component of a successful proposal. The proposal is not in itself expected to be a completed piece of research. Given the nature of research, thesis work may evolve away from the path originally outlined in the thesis proposal; guidance in this evolving process is one of the roles of the advisor and the Advisory Committee [see §2.3]. It may occur that after acceptance of the proposal, the student wishes to change thesis problems (and perhaps advisor) completely. This can be done with approval of the Advisory Committee and JCPO; it will sometimes involve defending a new thesis proposal.

The thesis proposal document is normally to be submitted to the Advisory Committee within about four months after the successful completion of the written and oral exams, or in the cases described below, within about four months after the acceptance of a required Master's thesis. A modest extension of the preparation period may be approved by JCPO in cases when the proposal topic is sufficiently different than the pre-generals research. Two weeks after submission, the thesis proposal is to be defended before the Advisory Committee, potentially supplemented by representation from the General Exam Committee depending on the outcome of the General Exam. The length of the presentation should be discussed with the principal advisor. An essential first step is for the student to review the proposal with his or her advisor before submission. Students are also urged to solicit the response of individual committee members to the proposal before the thesis proposal oral presentation.

Upon acceptance of the thesis proposal by the Advisory Committee, a student has completed the general exam and can continue on to prepare a Ph.D. thesis. The chair of the Advisory Committee will advise JCPO (and cc the student) in writing. An electronic copy of the accepted thesis proposal should be submitted to the WHOI Academic Programs Office. The student should expect to receive a letter with feedback from the committee at this point, as with all committee meetings.

3.6 Ph.D. Progress

Progress towards a PhD may suffer short interruptions and periods of slow progress. However, prolonged delays (a month) are a cause for concern. The timely recognition of a research dead end, and the selection of a new research direction are best done in consultation between the student, the principal advisor and the Advisory Committee. It is important that students maintain close, informal contact with their Advisory Committee and, of course, with their principal advisor to avoid excessive delays.

Students are expected to arrange meetings with their Advisory Committee at least twice a year in order to review progress and discuss plans. The advisor is expected to write up an assessment of the student's progress and communicate that to the Advisory Committee, JCPO and to the student, after each committee meeting. JCPO will request written progress reports from each student and his/her advisor annually. It is the principal advisor's responsibility to give an objective and candid assessment of the student's performance at fairly frequent intervals. The student and advisor should discuss the annual progress report in detail, especially when problems are identified. It is the principal advisor's responsibility to insure that these written evaluations are transmitted to JCPO, which will use them to

evaluate the student's progress toward a degree. These reports will be filed with the MIT Joint Program Office and WHOI Academic Programs Office.

3.7 Ph.D. Thesis

In general, a thesis consists of four parts:

- a) an introductory chapter with a historical review and setting of the problem,
- b) chapters developing the original contribution toward the solution of the problem,
- c) a final section summarizing the work and its significance,
- d) a bibliography.

A student may incorporate as part of the main chapters, (b), manuscripts that have been prepared for publication, submitted for publication, or already published, if most of the work is his/her own original contribution. Inclusion in a thesis of multiple-authored sections is possible but requires the student to establish his/her own contribution; the student should notify the Thesis Committee and the Chair of the Thesis Defense (see §3.7) in writing of his/her intent to incorporate such material at least one month before submission of a thesis.

3.8 Thesis Defense

The thesis defense provides an open forum for presentation of the results of the research and final decision on the acceptability of the work. It is essential that an adequate period of time be available for review of the thesis between the time the dissertation is submitted to the thesis committee and the date of the defense. Therefore, the oral defense of the doctoral dissertation can be held not sooner than three weeks after the submission of the defendable thesis draft. Every effort should be made to submit the thesis at least one week prior to the defendable draft submission deadline. Submission entails giving copies to the Committee members and the Department Office at MIT and the Academic Programs Office at WHOI and arranging for announcements of the thesis defense to be posted at both institutions. In order to be on a particular semester's degree list, the student must also meet the thesis submission deadline dates given in the Joint Program Academic Calendar and your MIT Department; keep these deadlines in mind. (These are the official MIT deadlines; students should check with their MIT department for the actual due date -it may vary).

Each Thesis Defense consists of two parts:

- A public seminar in which either the whole thesis or some significant and coherent subsection is presented. A seminar of normal length (i.e., 50 minutes) is expected. The seminar should precede the defense by at least four months. It should be given at the institution at which the student is not resident. Arrangements may be made to broadcast the talk to the institution of residency. Students are encouraged to make this early in the process since comments from people attending the seminar can be helpful in the final drafting of the dissertation.
- A formal defense, chaired by someone not a member of the Advisory Committee; this person, the Chair of the thesis defense, is selected by the student in consultation with the advisor and committee, subject to JCPO approval. The defense is a public presentation of the thesis, including a period for detailed questions. At this time, the student is presenting the work to the scientific public and must be ready to explain and defend it. Private discussions with the Advisory Committee and other faculty focused on the written document will follow.

The responsibility to accept the thesis rests with the Advisory Committee. They may recommend that the thesis be accepted as it is or they may accept it subject to minor revisions that the Thesis Defense

Chair must relay in writing to the student. In exceptional circumstances, the Committee may request further work before the thesis can be accepted. In such cases, another defense may be required. The Thesis Defense Chair will notify JCPO and the student in writing of the decision of the Advisory Committee.

3.9 Masters Project in Physical Oceanography

A Master's Project is an opportunity for a student to demonstrate the capacity to master a particular subject area in Physical Oceanography and to make a useful contribution to the field. Generally speaking, the degree of independence and originality is not as demanding for the S.M. as for the Ph.D. and there is no requirement that the research problem reach the same stage of resolution as in the Ph.D. It is expected that the student will complete the Master of Science (S.M.) within a year of the General Exam.

There are a number of reasons why a student may choose or be required to defend a S.M. project and, potentially, complete an S.M. thesis. These generally fall into one of two categories:

- i) Terminal Master's – The GEC may request that a student who has failed the general exam complete a Master's Thesis and not continue to the Ph.D. Alternatively, a student may choose to complete a Master's project and leave. In either case the student needs to write up a Master's Thesis, subject to the principal advisor's approval, in order to receive an S.M. degree. There is also a requirement that the student complete 24 credit hours of graduate thesis research, normally 12.ThG.
- ii) Required Master's – For some students, the GEC may decide that the student's performance in the general exam is not conclusive and may request the student to complete a S.M. project as part of the general exam's assessment, or prior to submitting a thesis proposal. In this case the student will need to successfully defend the research in an oral presentation to a committee composed of the then standing GEC plus the principal advisor and possibly one or more other members of the faculty. (A public defense is not required). This committee will then recommend whether or not the student continue to the thesis proposal stage. If the student is continuing on to do a Ph.D. then he/she will choose, in consultation with their advisor, whether to complete a S.M. Thesis and hence obtain an S.M. degree. If a Thesis is completed, and signed off by the advisor, then the material in that thesis may not be used as a principal chapter of the Ph.D. thesis.

3.10 Navy Master of Science in Physical Oceanography

The Navy Master of Science program is designed to be completed in 27 months (two years and a summer) and there is typically very little flexibility since timing is dictated by the U.S. Navy. The first year is spent taking courses and beginning research with an advisor. In the second year, the student conducts research, culminating in a Master's thesis.

Residency and Summer Math Class

All incoming JP Navy students are strongly encouraged to spend their first summer at WHOI, prior to the official start of the first academic year. A math refresher class is normally offered to all incoming students. This class can help prepare Navy officers, who may have been out of school for a number of years, for the upcoming semester of classes at MIT.

Advisors

Each Navy Master's student in physical oceanography is assigned two advisors, one from MIT and one from WHOI. One of these is designated as *research advisor*; the other is designated as *academic*

advisor. The research advisor helps the student develop a thesis topic, supervises the thesis research, and ensures that the student takes all of the classes necessary to support the research. The academic advisor provides an additional perspective on curriculum and research ideas and helps the student to ensure that he or she meets the requirements to receive a Master's Degree in Physical Oceanography from MIT/WHOI. Although the research advisor is normally the principle source of input and direction, each students should meet with his or her academic advisor at the beginning each semester for registration and is encouraged to have a broader discussion with the academic advisor.

Any MIT faculty member in any MIT department participating in the MIT/WHOI Joint Program, or any member of the WHOI Scientific Staff, may serve as research or academic advisor for a Navy Master student in PO. Many incoming JP Navy Master's students have already been matched with research advisors prior to their arrival in the Joint Program. However, some students may spend the initial portion of the first summer in the program identifying a research advisor. Students must notify the Chair of JCPO, the WHOI Academic Program Office and the MIT Department of Earth and Planetary Sciences Graduate Office of their thesis advisor within six weeks of arrival.

Master's Thesis

Unlike JP Doctoral students, JP Navy Master's students do not form a thesis committee, do not take the general examinations, and do not publicly defend a thesis. The Master's thesis is signed off by the research advisor and by the chair of JCPO.

Navy Master of Science Course Requirements

Students must obtain at least 72 credit units of coursework, corresponding to six 12-unit subjects, not including credit received for thesis work. Graduate subjects at MIT are classified as one of two types: G-level and U-level. A G-level subject indicates a subject approved for graduate credit. An U-level subject is an undergraduate subject. Of the 72 units of required coursework, at least 48 must be G-level graduate subjects. The remaining 24 units may be for U-level subjects. Students must maintain a minimum grade point average of 3.5 (A=5, B=4, C=3, D=2, F=0).

Credit Transfer

Students are allowed to transfer credit toward their Master's degree from graduate subjects taken previously at MIT or another accredited institution, and not used as part of the credits required for an undergraduate or graduate degree. The limit is 24 credit units if the subjects were taken outside MIT. Transferred subjects must have a grade of B or higher. No thesis units may be transferred.

Navy Educational Skill Requirements (ESRs)

The Navy requires that students understand the fundamental concepts and be familiar with certain basic functional areas within the Department of Navy and the DoD and be able to apply them in future meteorology and oceanography billets. As of the writing of this guide, these areas include mathematics, sensing, dynamics, acoustics, prediction and problem solving. The student should consult with his or her advisors in designing an education plan that insure that all such ESRs are covered in the coursework. Appendix J includes a list of courses that have been used by past students to fulfill ESRs.

Navy Approval of Education Plan

It is the student's responsibility to fulfill all Navy requirements for the Master's degree. These include reporting to and gaining approval from the Navy for the Education Plan, put together under consultation with the advisors. This plan must be submitted to the Navy at least 30 days prior to the beginning of the first-year fall semester. This plan lists the courses that the student expects to take in each of the four semesters. As time progresses, unexpected changes in class or cruise schedules and/or research directions may require alterations to the original plan. It is the student's responsibility to obtain written Navy approval for any such changes.

Thesis Requirements

The Master's thesis is considered to be the centerpiece of a student's graduate experience. The thesis is an original work of research, design, or development. The research advisor and the Chair of JCPO sign and accept the thesis upon completion.

3.11 Procedures for Students with Disabilities

Students with disabilities can receive assistance from the MIT Student Disability Services (SDS) (<http://studentlife.mit.edu/sds>). SDS has identified an individual within each academic department who serves as a logistical coordinator/Disability Services liaison, assisting students and faculty with the implementation of accommodations. The Logistical Coordinator for EAPS is the department Academic Administrator, presently Megan Jordan.

A student with a disability may be entitled to receive an accommodation for course exams or the general exam, based upon the functional impact of the disability. Some examples of test accommodations include: having someone write down a student's dictated answers (using a "scribe"), accessing a written test through auditory means (using a reader, assistive technology, or a taped version of the exam), or completing the exam with an additional time allotment. To qualify for an accommodation, the student must first make a request through SDS and follow the SDS procedure:

<http://studentlife.mit.edu/sds/students/procedures-requesting-academic-accommodations>

If the student qualifies, he or she will be provided with a letter specifying the accommodation(s). The student must make an appointment with each faculty member/instructor during office hours to provide them with the accommodation letter and discuss their accommodation needs. This is typically done at the beginning of the semester, but at a minimum, should be done two weeks in advance of the first test. Thereafter, students are expected to remind their faculty member and Departmental Logistical Coordinator of their accommodation needs at least two weeks before each exam date. Students are strongly encouraged to interact directly with faculty/instructor regarding their accommodation needs. Additionally, the student must deliver an accommodation letter to the Department Logistical Coordinator.

The knowledge of a student's disability is confidential. Information is provided at the student's request or with a signed consent on a "need to know" basis only. This typically means that SDS will share information related to the student's accommodations requests for reasons directly related to the request or for personal safety.

A student seeking an accommodation as part of the General Exam (GE) should be prepared to describe the format of the exam to SDS as laid out in Section 3.5 of this Guide. Once an accommodation is approved, the student should present the SDS-authored letter to the two Chairs of the GE Committee and the Departmental Logistical Coordinator. In addition, students are strongly encouraged to inform their advisors of their approved accommodations. We strongly recommend that the student initiate the accommodation request process several months in advance of the GE, as the approval process takes some time. Further, students are strongly encouraged to share their approval decision/accommodation letter with the GE Committee Chairs six weeks in advance of the date of the Written Exam, to allow sufficient time for implementation. (The GE committee is appointed approximately four months prior to the written portion of the exam – typically in early February for a June exam.) Once notified, the two Chairs will consult with the student in order to develop a procedure by which the accommodation can be implemented and confidentiality can be safeguarded. The Departmental Logistical Coordinator is

available to assist the faculty member and student with implementation logistics. The Chairs are instructed to disclose the accommodation to other committee members only on a need-to-know basis.

Appendix A - Timeline to Degree

	Summer	Summer Research and introductory courses at WHOI Participate in SEA cruise or other organized trip
Year 1	Fall	JCPO meets with first years in September Courses: 2 Core Courses (typically 12.800 and 12.808), Applied math course, 1 elective (~3-4 courses total)
	Spring	Courses: 2 Core Courses, 2 electivea (~3-4 courses total)
	Summer	Work on research
Year 2	Fall	Coursework and research (~3-4 courses total)
	Spring	Jan: SLUSSPO (Student Lunch Seminar Series in Physical Oceanography) Feb: Meet with General Exam Committee to discuss dates and procedures Mar-Apr: Dates for General Exam are announced Submit general exam petition at least 1 month before exam Coursework and research (~1-2 courses)
	Summer	Early May: SLUSSPO – General exam practice presentations First week of May: Research paper due. June First week: Written Exam June Second Week: Oral Exam
Year 3	Fall & Spring	Aug-Sep: Form thesis committee (2 months before thesis proposal defense) and request approval from JCPO SLUSSPO – Thesis proposal practice presentations Oct-Nov - Defend thesis proposal (4 months after general exam) If presenting a masters’ project, complete it by June.
Year 4	Fall & Spring	Meet with thesis committee twice a year minimum
Year 5	Fall & Spring	Meet with thesis committee twice a year minimum
Year 5 or potentially 6		Find chair for thesis defense Do public seminar at MIT / WHOI (whichever is applicable) Thesis defense

Appendix B - General Exam Application Form - page 1

MIT/WHOI Joint Program in Oceanography
Application Form for General Examination in Physical Oceanography

Name: _____ Today's Date: _____

When did you enter the Joint Program? _____ (month/year)

Have you taken any part of the General Examination before? _____

Please provide the following information:

Undergraduate major: _____ Degree: _____ Date: _____

Institution: _____

Graduate major: _____ Degree: _____ Date: _____

Institution: _____

Is there some general subfield of physical oceanography in which you have special expertise?

What have been your primary sources of financial support while enrolled in the Joint Program?

General Exam Application Form - page 2

List all the graduate courses you have taken, giving dates, names of institutions, instructors, and grades achieved. Use reverse side if necessary. In addition, identify a subset of 4-6 courses that are most relevant to your sub-discipline.

Subject Title	Subject #	Institution	Instructor	Date	Grade

Signature of Applicant: _____ **Date:** _____

I recommend that the applicant be placed on the list of candidates for the General Examination to be held in the Fall Term _____, Spring Term _____, 20____.

Who is your principal advisor? _____

Signature of Academic Advisor at MIT: _____

Signature of Academic Advisor at WHOI: _____

If you are unable to obtain your advisor's signature, please explain why.

Appendix C - List of Useful Seminar Series

Title	Location	Time
PAOC Colloquium	MIT 54-911	Mon, 12pm – 1pm
WHOI PO Seminar	Clark 507	Tue, 3pm – 4pm
SACK Lunch Seminar	MIT 54-911	Wed, 12pm – 1pm
Climate and Paleo Lunch seminar series	WHOI, Clark 237	Thursdays 12:15
COFDL – Coastal Ocean Fluid Dynamics Laboratory Seminar	Bigelow 114	Fri, 12:15-1:15 pm
SLUSSPO – Student Lunch Seminar Series in Physical Oceanography	MIT / WHOI (videoconferenced)	Tue, 12pm – 1pm

Appendix D - Student / Advisor Checklist

The following are recommended issues to discuss at different stages in our program:

- Year 1, 2:
 - Coursework and grades
 - External funding options; generally, applications are due Nov-Jan
 - Research project and expectations for its progress before the general exam
 - Annual review (January)

- Years 3, 4, 5:
 - Thesis committee makeup and thesis proposal
 - Scheduling committee meetings. The advisor will submit a memo to the student, copying JCPO, after each meeting summarizing what was discussed and recommended.
 - Publication and conference presentation of research (including the general exam project). Soliciting feedback from the thesis committee prior to journal submission is strongly recommended. Publication of a manuscript does not guarantee approval of material as a thesis chapter.
 - Relevant summer schools
 - TA opportunities; there are few TA opportunities in the PO program so early discussion is advised
 - Fieldwork; if this is not a part of proposed research, volunteering to assist others may be advisable
 - Opportunities to mentor undergraduates or K-12 students
 - Co-writing a grant proposal
 - Thesis defense date and progress toward completion
 - Post-doctoral positions and non-academic job prospects
 - 6th year petition if required (Spring of 5th year)
 - Annual review (January each year)

Appendix E - Faculty/Student Responsibilities

This list is available at www.mit.whoie.edu/responsibilities and was provided by the Academic Programs Office.

- Advisors and students should be familiar with appropriate discipline handbook(s) <http://mit.whoie.edu/handbooks> and with the Joint Program housing policy <http://mit.whoie.edu/housing>.
- When a student first arrives, the advisor and student should discuss what courses the student should take, and when. Advice is also available from the education coordinator and the student's academic advisory committee.
- When a student first arrives, the advisor and student should discuss what research project(s) the student should undertake, including expectations of when and how that research will be carried out (e.g., during first summer, semesters when classes are in session, during IAP, during subsequent summers), and balance between coursework and research. They should also discuss any upcoming fieldwork (timing and duration), and whether it is optional or required.
- Advisors should make expectations clear to the student, including how frequently the advisor and student should meet. The advisor should make him/herself available to provide advice to the student, and clarify with the student how best to set up meetings – e.g., regular weekly meetings, or meetings as needed with some amount of lead time so that the advisor can set aside time, etc. Likewise the student should feel comfortable communicating with the advisor regarding the frequency of meetings.
- Full-time Graduate Research and Teaching Assistants (and students on Fellowships and Scholarships as well) are expected to devote at least 50 hours per week on average to academic activities, including time devoted to classes, research activities, and any activities specific to Research or Teaching Assistant duties. If supported as a Graduate Research Assistant, 20 hours per week on average should be devoted to work on the grant/contract. Specifics of how the 20-hour per week obligation is to be satisfied should be agreed upon by the advisor and the student (e.g., less time devoted to grant/contract activities when classes are in session, more time during IAP and summer). It is good to have an understanding between the student and advisor about this balance (the education coordinator is another resource to provide advice about balance). If supported as a Teaching Assistant, the student is expected to devote 20 hours per week to Teaching Assistantship activities (10 hours/wk for half-time TA).
- Students are entitled to two weeks of vacation per year and should clear vacation schedules in advance with advisor(s). It is useful for students and advisors to discuss expectations given that many oceanography students spend considerable time in the field. Information about terms of appointments is at <http://odg.mit.edu/gpp/assistance/rata/terms-of-appointment/>
- Advisors and students should discuss authorship protocol (e.g., when is someone an author vs. acknowledged; when is someone first author; etc.), and scientific conduct. Training in scientific conduct is now required by some funding agencies. Ethics training is available, and advisors should encourage students to take advantage of such training.
- Advisors should make best efforts to fund students fully, and encourage (and assist as needed) students to submit fellowship applications. If the student has his/her own funding through a fellowship, and wishes to pursue research not covered by existing grants, the student needs to have the advisor's permission and support. The student and the advisor then need to openly discuss possibilities and how other costs (e.g., lab supplies and analyses) will be covered. The burden of funding the student and his/her research costs falls on the advisor, thus the need for the advisor being in agreement that the student should pursue this research.
- Regular feedback should be provided to the student about progress, and if the student is not fulfilling the advisor's expectations, the advisor should bring that to the student's attention in a

timely manner so that the student can address the concern (rather than waiting until the semester's end or as part of the annual review).

- Advisors and students should discuss progress at annual review time and go over any issues or concerns. On all submitted memos/paperwork, copy Ronni and Lea (who will print the correspondence and place it in the student's file).
- As the student's research progresses, the advisor(s) should encourage participation in scientific meetings and assist with writing and submitting abstracts, choice of sessions and travel costs, and encourage and assist with networking at meetings. Both MIT and WHOI offer funding to help with student travel to conferences when they are presenting. See <http://mit.who.edu/policies>. Advisors should introduce students to colleagues and program managers from funding agencies at meetings, as well as when colleagues or program managers visit the home institution.
- Each year students and advisors should discuss career goals (which may evolve). Advisors should offer advice to students on postdoc and job opportunities, and encourage the student to think broadly about his/her career.
- Advisors should encourage and assist with publication of results including advice on appropriate journals; structure, length and content of articles; appropriate analyses and graphics; and guidance in responding to reviewers.
- Advisors should provide timely feedback (e.g., within a week or two, with an idea of the timing provided by the advisor) as students write up results for their theses.
- In addition to the Educational Coordinator, Associate Dean, Dean, MIT Director of the Joint Program, and Joint Committee members, the Department Chair at WHOI and Department Head at MIT are go-to people for graduate students who need advice or assistance on important professional matters such as resolving conflicts or other issues with their advisors or others in the department. MIT also has an Omnibus Office <http://web.mit.edu/ombud/>.

Appendix F - Defense Timeline - Times Referenced to Defense Date

Start of semester: Submit online degree application.

-3-4 months: Schedule your seminar at the institution where you will not defend (slots fill up). Also, begin talking to your committee about scheduling a defense date when they are all available.

-2 months: Seminar at institution where you will not defend

-1-2 months: Final committee meeting. Make sure everyone is onboard. “Clearly prior to this, the thesis committee should have seen completed drafts of all the main chapters of your thesis with sufficient time to read them.”

- contact APO (or someone at MIT) to reserve rooms for your public and private defense

-1 month: Make sure you have identified a defense chair; get JCPO approval of choice

-1 month: notify the Thesis Committee and the Chair of the Thesis Defense in writing of intent to incorporate published material.

-3 weeks: turn in defendable draft. Hard copy to EAPS. Digital copies to APO, advisor, committee and defense chair. Doctoral defense notice form to APO, signed by advisor (<http://mit.who.edu/fileserver.do?id=60343&pt=10&p=37282>)

-1 week: arrange with APO for travel reimbursement for 1 outside committee member
t=0: defense

+1 weeks: make appointments at EAPS and APO to submit your thesis. You will have to travel between MIT and WHOI and submit to both places on the same day.

+ (2 wks - 1 day): print thesis. make sure all formatting requirements are met; get advisor’s signature on title pages (BLACK INK)

+2(to 4) weeks: Submit final thesis, printed on special paper (all copies). Your stipend will stop on this day. Also, make sure MIT library processing fee has been paid.

- thesis reproduction form to APO
- pdf thesis copy to APO
- 200-word abstract in .doc file to APO
- unsigned title page to APO
- submit 2 printed copies to APO (1 for APO and 1 for your thesis copy)
- submit 2 printed copies to MIT
 - submit UMI/ProQuest form (<http://libraries.mit.edu/archives/thesis-specs/images/umi-proquest-form.pdf>) stapled to extra copy of title page and 350 word abstract to MIT

useful link: <http://mit.who.edu/page.do?pid=36075>

Appendix G - JCPO Petition

To request assistance or special accommodations, the following information should be sent to the Chair and/or Education Coordinator of JCPO, who will respond as quickly as possible.

What is the nature of your complaint?

Do you have a proposed course of action? If so, please explain.

How can we help?

Would you like to meet with any or all members of JCPO? If so, please list them.

Please list any other comments.

Appendix H - Annual Review Questions

1) Where are you in the program? (year, engaged in thesis research, etc). What are your most recent and next major milestones? (exams, thesis committee meetings, thesis defense, start of research project, etc.)

2) Advising:

2a) Who is your principal advisor and, for pre-generals students, who is your secondary advisor?

2b) How often do you meet with your advisor?

2c) Is your advisor generally helpful in answering questions? Do you get the support that you want?

2d) If in your first or second year, does your advisor respect that you have other responsibilities other than research such as assignments, exams etc.?

2e) Name one thing that could be improved in your student/advisor relationship and one thing that you would like continued? (e.g. frequency of meeting, type of feedback, expectations)

3) Courses:

3a) If you took, or are taking, courses either this spring or fall, what were they and how did you do?

3b) What classes are you planning to take in the coming year?

3c) Have you been a TA or do you plan to TA in the future?

3d) What topics would you like to see for a course or to be covered better in existing courses?

4) Research:

4a) If you are working on a thesis what is its title or topic and please briefly describe it. Who is on your thesis committee?

4b) If you are a pre-generals student working on a research project, please briefly describe it. Do you feel this is a good topic for you?

4c) Do you have any publications (in preparation, submitted, or out)? If you are a post-generals student, have you and your advisor spoken about publications?

5) Future:

5a) Are you on track to finish in 5 years?

5b) If applicable: Do you feel you are getting prepared well for a career as a scientist viz., publishing papers / preparing conferences etc.? If not, what would help?

5c) If applicable: If you are thinking of a career in academia, do you feel you are getting prepared well for that? If not, what would help?

We also want to remind you that any member of JCPO will be glad to talk with you at any time. Let us know if you would like to speak to any of us privately. In addition, the Education Coordinator, the JP staff at MIT and WHOI and the EAPS 9th floor staff, as well as other resources (c.f. <http://mit.whoiedu/page.do?pid=81276>) are there to help you. MIT Mental Health Services: (617)253-2916. Walk-in hours M-F 2-4pm.

Appendix I - Curricula and List of Core Courses and Electives by Topic

Here we present a general list of courses of interest, divided into general areas, followed by sample curricula for several main tracks. Note that courses are subject to change in time.

List of courses within their relevant areas and sample curricula.

Physical Oceanography

- 12.800 Rotating Stratified Fluids
- 12.808 Introduction to Physical Oceanography
- 12.801 Large-scale Ocean Dynamics (S)
- 12.802 Small Scale Ocean Dynamics (S)
- 12.805 Data Analysis Physical Oceanography
- 12.843 Large-scale Atmosphere and Ocean Dynamics
- 12.853 Advanced Geophysical Fluid Dynamics
- 12.862 Coastal Physical Oceanography
- 12.758 Classic Papers PO
- 12.809 Hydraulic Flows
- 12.820 Turbulence in the atmosphere and ocean
- 12.824 Instability Theory
- 12.870 Air-Sea Interaction

Data Analysis/Modeling

- 12.747 Modeling and data analysis for Geochemistry
- 7.410 Applied Statistics
- 12.950 Computational Ocean Modeling
- 12.823 Modeling Bio and Physics
- 12.805 Data Analysis Physical Oceanography
- 12.864 Inference from data and models (starting in 2015-2016).
- 2.29 Numerical Fluid Mechanics
- 1.715 Environmental Data Analysis
- 12.714 Computational Data Analysis

Atmosphere

- 12.831 Dynamics and transport in the stratosphere
- 12.818 Introduction to Atmospheric Data and Synoptic Meteorology
- 12.811 Tropical Meteorology
- 12.810 Atmospheric Dynamics
- 12.812 General Circulation of the Atmosphere

Biology

- 7.47 Biological Oceanography
- 7.431 Topics in Marine Ecology
- 7.440 Intro to Mathematical Ecology
- 7.437 Topics in Molecular Biological Oceanography
- 7.436 Topics in Phytoplankton Biology
- 7.434 Topics in Zooplankton Biology connectivity
- 7.435 Topics in Benthic Biology
- 7.439 Topics in Marine Microbiology

Chemistry

- 12.746 Marine Organic Geochemistry
- 12.849 Mechanisms and Models of the Global Carbon Cycle
- 12.491 Organic Geochemistry - Summons
- 12.742 Marine Chemistry
- 12.744 Marine Isotope Chemistry

Climate

- 12.842 Physics and Chemistry of Climate
- 12.860 Climate Variability and Diagnostics
- 12.757 Climate Change Science and Communication
- 12.848 Global Climate Change: Economics, Science and Policy
- 12.885 Environmental Science and Society
- EPS208 Physics of Climate (Harvard, F)
- EPS231 Climate Dynamics (Harvard, S)

PaleoClimate

- 12.740 Paleoceanography
- 12.708 Advanced Seminar in Paleoceanography
- 12.707 The history of the Earth's Climate

Data Analysis/Modeling

- 12.747 Modeling and data analysis for Geochemistry
- 7.410 Applied Statistics
- 12.950 Computational Ocean Modeling (F, odd)
- 12.823 Modeling Bio and Physics

Atmosphere

- 12.831 Dynamics and transport in the stratosphere (F)
- 12.818 Introduction to Atmospheric Data and Synoptic Meteorology (F)
- 12.811 Tropical Meteorology
- 12.810 Atmospheric Dynamics (S)
- 12.812 General Circulation of the Atmosphere (F)

General Physical Oceanography Curriculum

Students are normally required to complete 4 core courses, 2 maths courses, and approximately 6 electives. Substitutions are allowed with the relevant JC approval.

Electives indicated with * are strongly recommended.

Core Courses

- 12.800 Rotating Stratified Fluids (F)
- 12.808 Introduction to Physical Oceanography (F)
- 12.801 Large-scale Ocean Dynamics (S)
- 12.802 Small Scale Ocean Dynamics (S)

Maths Courses – we recommend taking 2 of

- 18.085 Mathematical Methods for Engineers I
- 18.086 Mathematical Methods for Engineers II
- or-
- 18.305 Advanced Analytic Methods in Science and Engineering
- 18.306 Advanced Partial Differential Equations with Applications

Strongly Recommended

- 12.805* Data Analysis Physical Oceanography (F)
- 12.843* Large-scale Atmosphere and Ocean Dynamics (F)
- 12.853* Advanced Geophysical Fluid Dynamics (F)

Physical Oceanography

- 12.862 Coastal Physical Oceanography (F)
- 12.758 Classic Papers PO (S)
- 12.809 Hydraulic Phenomena in the Ocean and Atmosphere (F)
- 12.820 Turbulence (S, even)
- 12.824 Instability Theory (F)
- 12.870 Air-Sea Interaction

(for additional electives refer to list above).

Coastal/Nearshore Physical Oceanography and Engineering Track

Students are normally required to complete 4 core courses, 2 maths courses, and approximately 6 electives. Substitutions are allowed with the relevant JC approval.

Electives indicated with * are strongly recommended.

Core Courses

- 12.800 Rotating Stratified Fluids (F)
- 12.808 Introduction to Physical Oceanography (F)
- 1.69 Coastal Engineering (F)
- and one of
- 12.862 Coastal Physical Oceanography (F)
- 12.802 Small Scale Ocean Dynamics (S)

Maths Courses – we recommend taking 2 of

- 18.085 Mathematical Methods for Engineers I
- 18.086 Mathematical Methods for Engineers II
- 18.075 Advanced Calculus for Engineers
- or-
- 18.305 Advanced Analytic Methods in Science and Engineering
- 18.306 Advanced Partial Differential Equations with Applications

Recommended Electives

- 2.29* Numerical Fluid Mechanics (F)
- 1.723 Numerical Modeling
- 1.72 Groundwater (also includes numerical modeling)
- 12.805* Data Analysis Physical Oceanography (F)
- 12.809 Hydraulic Phenomena in the Ocean and Atmosphere
- 1.67 Sediment transport and coastal processes (S)
- 12.820* Turbulence (S, even) or
- 2.27* Turbulent and separated flows
- 1.64* Physical Limnology
- 12.754 Coastal geomorphology
- 12.864 *Inference from data and models (starting 2015-2016).*

Physical-biological-chemical interactions Curriculum

Interconnection between physics, biology, and chemistry of the ocean arises from three basic sources: (1) hydrodynamic flows continually redistribute material in the ocean; (2) environmental fluctuations impact biological and chemical rates; and (3) organisms are capable of directed motion through the water.

Research in physical-biological-chemical interactions requires an interdisciplinary curriculum with depth in the native disciplines, as well as coursework at their interfaces.

Students are normally required to complete 4 core courses, 2 math courses, and approximately 6 electives. Substitutions are allowed with the relevant JC approval.

Electives indicated with * are strongly recommended.

Core Courses

- 12.800 Rotating Stratified Fluids (F)
- 12.742 Marine Chemistry (F)
- 7.47 Biological Oceanography (S)
- 12.808 Introduction to Physical Oceanography (F)

Math Courses – we recommend taking 2 of

- 18.085 Mathematical Methods for Engineers I
- 18.086 Mathematical Methods for Engineers II
- or-
- 18.305 Advanced Analytic Methods in Science and Engineering
- 18.306 Advanced Partial Differential Equations with Applications

Recommended

- 7.410* Applied Statistics (F)
- 12.823* Modeling Bio and Physics (S, odd)
- 12.802* Small Scale Ocean Dynamics (S)
- 12.820 Turbulence (S, even)
- 12.860 Laboratory in Physical Oceanography (F)
- 12.801 Large-scale Ocean Dynamics
- 12.862 Coastal Oceanography (F, even)
- 7.430 Genetics of Marine Organisms
- 7.431 Topics in Marine Ecology
- 7.440 Intro to Mathematical Ecology
- 7.437 Topics in Molecular Biological Oceanography
- 7.436 Topics in Phytoplankton Biology
- 7.434 Topics in Zooplankton Biology connectivity
- 7.435 Topics in Benthic Biology
- 7.439 Topics in Marine Microbiology
- 12.746 Marine Organic Geochemistry
- 2.29 Numerical Fluid Mechanics
- 12.864 Inference from Data and Models
- 7.440 An Introduction to Mathematical Ecology
- 1.715 Environmental Data Analysis
- 12.714 Computational Data Analysis

(for additional electives see list above)

Climate and Physical Oceanography Track

For students interested in climate, including climate change, paleo climate.

Students are normally required to complete 4 core courses, 2 maths courses, and approximately 6 electives. Substitutions are allowed with the relevant JC approval.

Electives indicated with * are strongly recommended.

Core Courses

- 12.800 Rotating Stratified Fluids (F)
- 12.808 Introduction to Physical Oceanography (F)
- 12.801 Large-scale Ocean Dynamics (S)
- 12.812 General Circulation of the Atmosphere (F)

Maths Courses – we recommend taking 2 of

- 18.085 Mathematical Methods for Engineers I
- 18.086 Mathematical Methods for Engineers II
- or-
- 18.305 Advanced Analytic Methods in Science and Engineering
- 18.306 Advanced Partial Differential Equations with Applications

Recommended Electives

- 12.842*Physics and Chemistry of Climate (F)
- 12.756*Climate Variability and Diagnostics (S, odd)
- 12.740*Paleoceanography (S, even)
- 12.802* Small Scale Ocean Dynamics (S)
- 12.864*Inference from data and models (starting in 2015-2016).

Physical Oceanography

- 12.843 Large-scale Atmosphere and Ocean Dynamics (F)
- 12.853 Advanced Geophysical Fluid Dynamics (F)
- 12.805 Data Analysis Physical Oceanography (F)

Atmosphere

- 12.831 Dynamics and transport in the stratosphere (F)
- 12.818 Introduction to Atmospheric Data and Synoptic Meteorology (F)
- 12.811 Tropical Meteorology
- 12.810 Atmospheric Dynamics (S)

PaleoClimate

- 12.708 Advanced Seminar in Paleoceanography
- 12.707 The history of the Earth's Climate (S, odd)

General Climate

- 12.757 Climate Change Science and Communication (S)
- 12.848 Global Climate Change: Economics, Science and Policy (S)
- 12.885 Environmental Science and Society (F)

Chemistry

- 12.491 Organic Geochemistry - Summons (F)
- 12.742 Marine Chemistry (F)

- 12.744 Marine Isotope Chemistry
- 12.746 Marine Organic Geochemistry
- 12.849 Mechanisms and Models of the Global Carbon Cycle

Data Analysis/Modeling

- 12.747 Modeling and data analysis for Geochemistry
- 12.950 Computational Ocean Modeling (F, even)

Appendix J - Courses Satisfying Navy ESR Requirements

Below are courses previous Navy Master's students have scheduled to satisfy ESR requirements. This list is provided to assist in Education Plan development and is not meant to limit the courses available to attain an ESR. Note that one class may contribute towards the fulfillment of multiple ESRs. At the same time, more than one class may be necessary to fulfill a particular ESR. Appendix I contains a list of other classes that could potentially be used to satisfy these requirements

ESR-1: Mathematics

12.800 Rotating Stratified Fluids
12.805 Data Analysis in Physical Oceanography
12.842 Climate Science
12.843 Large-Scale Atmosphere and Ocean Dynamics
12.850 Computational Ocean Modeling
18.085 Computational Science and Engineering I

ESR-2: Sensing

2.066 Acoustics and Sensing
2.681 Environmental Ocean Acoustics
2.688 Principles of Ocean Instrument Systems
12.805 Data Analysis in Physical Oceanography

ESR-3: Dynamics

12.800 Rotating Stratified Fluids
12.801 Large-scale Ocean Dynamics
12.805 Data Analysis in Physical Oceanography
12.808 Introduction to Physical Oceanography
12.810 Dynamics of the Atmosphere
12.811 Tropical Meteorology
12.818 Introduction to Atmospheric Data and Synoptic Meteorology
12.842 Climate Science
12.843 Large-Scale Atmosphere and Ocean Dynamics
12.850 Computational Ocean Modeling

ESR-4: Acoustics

2.066 Acoustics and Sensing
2.681 Environmental Ocean Acoustics
2.688 Principles of Ocean Instrument Systems

ESR-5: Prediction

12.805 Data Analysis in Physical Oceanography
12.810 Dynamics of the Atmosphere
12.818 Introduction to Atmospheric Data and Synoptic Meteorology
12.843 Large-Scale Atmosphere and Ocean Dynamics
12.842 Climate Science
12.850 Computational Ocean Modeling

ESR-6: Problem Solving and Practical Applicability

2.688 Principles of Ocean Instrument Systems

12.805 Data Analysis in Physical Oceanography

12.810 Dynamics of the Atmosphere

12.818 Introduction to Atmospheric Data and Synoptic Meteorology

ESR-7: Physical Oceanography

12.800 Rotating Stratified Fluids

12.801 Large-Scale Ocean Dynamics

12.805 Data Analysis in Physical Oceanography

12.808 Introduction to Physical Oceanography

12.850 Computational Ocean Modeling