

# Candidacy Exam Procedures (Updated in November 2017)

The CLaSP candidacy exam consists of two steps.

Step-1 is an oral exam primarily designed to test course knowledge. The objectives are (1) to assess the student's breadth of knowledge and quantitative skill sets and (2) to identify, if any, the weakness(es) in a student's knowledge base and quantitative skill sets and then to recommend a remedy for such weakness(es).

Step-2 includes a research-based written report and an oral presentation followed by an oral exam. The primary objective is to **assess the examinee's research potential and likelihood to successfully finish the Ph.D. program and to become an independent researcher. Passing the Step-2 exam marks advancement to PhD candidacy.**

Students are not allowed to take Step-2 until they pass Step-1.

Below are detailed procedures proposed for both steps. In addition to procedures outlined below, appropriate accommodations can be made for an examinee with a documented learning disability.

## Step-1

**1. Time: Students are supposed to take the Step-1 exam in May of their first academic year.** The following conditions need to be met before a student is eligible to take the exam: by the time of the exam, (1) the examinee should have taken core courses required by the department and (2) the examinee's cumulative GPA should be 3.3 (B+) or above.

Under special circumstances, if an examinee has not yet taken all required core courses but has taken at least one of them, he/she may be able to take the exam upon pre-approval from the Graduate Chair. Such approval will be on a case-by-case basis. *Under such circumstances, the examinee must take the remaining required course(s) before he/she can proceed to the Step-2 exam, and must obtain a grade of 3.0 (B) or above in such remaining required course(s).* Furthermore, the examinee should expect the course knowledge of such required courses to be examined in their Step-2 exam.

If a student cannot meet the above requirement, then he/she must defer the Step-1 exam to any time between May of his/her 1st year and the end of his/her 2nd year.

## **2. Coverage of the exam and selection of examinee committee members**

(1) **By the end of January** (when the winter-semester course registration deadline passes), the advisors of potential examinees and the Chair of Qualifying Exam Committee will decide the scope of exam. **The guiding principles are to select three courses and whatever math/physics/chemistry/biology knowledge that, by the time of exam, the advisors expect the examinees to be familiar with in the course of their research.** Normally two core courses plus one course related to the examinee's research major should be covered. For the aforementioned special circumstances, there could be one core course plus two courses related to the examinee's research major. If the timing of Step-1 is deferred, then this step should be completed at least 3 months prior to the expected date of the exam.

(2) Once the scope of exam is decided, **the oral exam committee of each examinee will be formed by the Qualifying Exam Committee.** The committee will consist of four members plus the examinee's advisor. One must be a cognate member, i.e. a climate faculty member serving on a space science exam or a space faculty member serving on a climate science exam. The other three faculty members should be familiar with the knowledge covered by the three courses selected for the examinee. One of the committee members will be designated by the Qualifying Exam Committee as the chair for the oral exam and will preside over the actual oral exam.

The examinee's advisor is required to sit in. **The advisor is not allowed to ask questions or give hints to the examinee during the exam. Should the advisor wish to comment on questions asked by the committee members, such comments will need to be deferred to the period of deliberation.**

Remarks: if the examinee plans to obtain a certificate, Master's, or dual PhD degree in programs such as Scientific Computing that require a question in the Qualifying Exam, the examinee should notify their committee members on this intention. Subsequently, such a question should be prepared for and asked during the Step-1 oral exam.

(3) The expected knowledge bases and skill sets for each course should be clearly stated and defined in a summary information sheet (see example in appendix 1). The expected skill sets from the advisor should be summarized in a similar way. In early February, the "skill-set" info sheets will be sent to potential examinees, together with the names of their exam committee members and general instructions about taking the exam. If the timing of this exam is deferred, then this step should be completed at least 2 months prior to the expected exam date. A sample skill-set info sheet is attached as Appendix 1.

(4) The potential examinees should then contact their exam committee members and schedule a time for the oral exam. Except in the cases of deferred exams, the exam date should be no later than May 31.

### 3. Procedure of the actual oral exam

(1) The oral exam will be presided over by the chair of the oral exam committee. The examinee is allowed to bring one letter-size front and back sheet of notes to the exam.

(2) Before the exam starts, the committee members will be provided with the examinee's transcript at UM, the "skill sets" information sheets sent to the examinee, and a one-page general reminder of the oral exam procedure.

(3) At the beginning of the exam, the chair should ask the examinee to make a 2-minute self-introduction, covering topics such as their academic background, current research direction, etc. This self introduction serves two purposes: (1) it lets committee members further familiarize themselves with the examinee and his/her background; and (2) it starts the exam with "small" talk to calm the examinee and reduce any nervousness that he/she might have.

(4) The oral exam will be divided into a first half (~1-1.5hour) and a second half (~1-1.5hour), with a 10-minute break in between. **The exam should be scheduled for 2.5 hours and an early finish is allowed.** The 10-minute break is strategically important; this is the time that the committee members should go over the examinee's performance and decide how to refocus questions in the second half. **Please keep in mind one of the objectives is to determine whether the examinee has certain weaknesses in his/her knowledge base and to assess the extent of such weaknesses.**

It is expected that problems should be worked out on the board in front of the committee. However, examinees can take a minute or two to think through the problem before going to the board or even work first on scratch paper before presenting on the blackboard. If the examinee chooses to do so, he/she is responsible for bringing his/her own pencil and scratch paper.

(5) After the exam, the committee members will discuss on the spot and reach a consensus for the outcome of the exam. There are **three potential outcomes for first-time examinees:**

- (a) Pass
- (b) Conditional Pass with further course work required
- (c) Fail with retake

For (b) and (c), the chair of the committee should summarize the findings from the exam and provide the summary to the Graduate Chair, who will then integrate it into the official letter to the examinee. For (b), the summary should also specify which courses the committee recommends the examinee to take. The availability of such recommended courses and the timing for the Step-2 exam should be considered when such recommendations are made.

For (b), the examinee is supposed to take the recommended courses and obtain a grade of B (3.0) or above for the courses before his/her Step-2 exam. He/she will be reminded that he/she should expect questions related to the recommended courses in the Step-2 exam.

The examinee's advisor will participate in the deliberation process. In the case that a consensus cannot be reached after the deliberation, the chair will need to preside over a vote: four committee members and advisor will cast their votes and the outcome with most votes will be deemed as the outcome for the exam.

(6) After the graduate chair receives the report from the oral exam committee, the graduate chair will compose an official letter to communicate the outcome of the exam to the examinee.

#### **4. Retake of the Step-1 exam**

Students who fail the Step-1 exam are allowed to retake it once in the following academic year. If the student fails the exam again, under normal circumstances there will be no further retake opportunity and he/she will be asked to leave the program. (Presumably by then the examinee will have met the requirement for an M.S. degree and can exit the program with this degree).

#### **5. Feedback from individual exam committee members**

In the two weeks after the exam, regardless of the outcome, the examinees are encouraged to make an appointment to meet briefly with each member of his/her exam committee and receive their individual feedback and comments.

### **Step-2**

#### **1. Scope of the exam**

The exam will primarily focus on the research that the examinee has conducted by the time they take the exam. After entering the Ph.D. program, the examinee is supposed to carry out research under the supervision of their advisor(s). The **Step-2 exam will focus on the research progress made prior to taking the exam.** Please note that the written report and oral presentation are based on the research progress made by the examinee. This document could be a nearly finalized manuscript ready for submission, or a research proposal with preliminary results, or something in between.

Students should expect knowledge-based questions closely related to their research project. In addition, students that conditionally pass the Step-1 exam should also expect questions on topics identified in the official notification letter provided after the Step-1 exam.

#### **2. Determination of the committee members for the Step-2 exam**

In order to take the Step-2 exam, the examinee needs to maintain a cumulative GPA of 3.3 (B+) or above. Once the student passes the Step-1 exam, the committee for their Step-2 exam will be formed. The guiding principles for this committee are:

- (1) For students with conditional pass of the Step-1 exam, 1-2 members of their Step-1 committee should be selected for the sake of re-examining the weakness(es) identified in the Step-1 exam.
- (2) One cognate member is required (i.e. a climate faculty member serving on a space science exam or a space faculty member serving on a climate science exam).
- (3) The examinee's advisor is required to sit in.
- (4) Preferably, the remaining members should be familiar with the research presented by the examinee.

One committee member will be designated as the chair to preside over the exam.

The roles of the advisor are (1) to answer any questions that other committee members might have directly for the advisor, especially clarification-type questions; and (2) observe the exam and take part in the deliberation after the exam. **Therefore, the advisor is not supposed to actively ask questions to the examinee during the exam. Should the advisor wish to comment on questions asked by the committee members, such comments will need to be deferred to the period of deliberation.**

### 3. Timing of the exam

**After passing Step-1, the examinee should take Step-2 within the following academic year.** The examinee is responsible for scheduling the date for the Step-2 exam with their committee members. It is recommended that the Step-2 exam be scheduled in the first two weeks of the fall or winter semester, a period during which faculty members are usually more available than the rest of the semester. But any other time convenient for the examinee and the committee members is acceptable. **Please note if Step-2 is scheduled in the spring or summer semester, the examinee is required by Rackham to register for the semester, as passing of the Step-2 exam marks advancement to candidacy.**

Once the exam date is set, the examinee should notify the Graduate Coordinator, Qualifying Exam Committee Chair, and the Graduate Chair. A classroom will be reserved by the Graduate Coordinator for the exam.

### 4. Written report

The written report is due 2 weeks before the actual exam date. The examinees should submit the written report electronically to their committee members and also provide a hard copy to each committee member.

The written report should contain a title, abstract, context, references, and if applicable, figures, tables, and their captions. Excluding references and figures/tables, the body of the report should be 6-10 single-spaced pages. The written report should be based on the research progress made by the examinee. It could be a nearly finalized manuscript ready for submission, or a research proposal with preliminary results, or something in between. The examinee is expected to demonstrate their capability of formulating scientific questions and strategies to address such scientific questions in the written report, as well as their scientific writing skills.

The examinee should adopt a style requirement used in a mainstream journal (e.g. AMS or AGU or IEEE journal author style guide) and prepare the written report in accordance with such style requirements. This will give the examinee a chance to gain familiarity with the discipline-specific formats of scientific writing.

**The examinees must prepare and proofread the actual written report independently.** Please note that scientific writing is also a key factor in the assessment of the likelihood of becoming a successful independent researcher. Discussions with advisors and colleagues on the general outline of the report are acceptable. For native English speakers, the actual writing and proofreading must be done by the examinees themselves without any assistance from others. Non-native English speakers are allowed to seek help with English editing and proofreading from the staff in the English Language Teaching Unit (or similar English editing units) in the University. **If a non-native English examinee chooses to seek such help, a signed statement from the helper(s) who does the actual English editing must be submitted together with the written report.** The helper(s) must clearly state in the statement that his/her help has been limited only to English editing and that no effort has been made to improve other aspects of the report.

## 5. Procedures of the oral exam

The oral exam is expected to be 1-1.5 hours long, presided over by the chair of the exam committee.

(1) Before the actual exam starts, the exam committee members should have a brief discussion on their impression of the written report, and go over the examinee's transcript and the evaluation of the Step-1 exam. Such practice will serve as a reminder if course-related questions still need to be examined in this exam. Also an evaluation sheet (see Appendix 2 for a sample) will be given to each committee member.

(2) As in Step-1, the examinee will start with a 2-5 minute self introduction, describing, in general, himself/herself and the research project.

(3) **The examinee should then give an uninterrupted presentation of 20-30 minutes about his/her research based on the written report.** The chair can stop

the examinee if the presentation is over 30 minutes. Except for questions pertaining to clarification, no other questions should be asked during this stage. This is intended to allow the examinee to present his/her entire talk coherently before being dragged into loops of questions.

(4) After the presentation, the committee members begin to ask questions.

## **6. Outcome of the exam**

The chair will ask the examinee to leave the examination room, and then the committee, including advisor, will deliberate on the spot to reach a consensus. Before the deliberation begins, each committee member should finish their evaluation sheet independently. Three possible outcomes of the exam are:

- (1) Pass
- (2) Fail with retake
- (3) Fail with no retake

For cases (2) and (3), the committee should provide sufficient observations and justifications in the report summary page. Both the summary page and individual evaluation sheets will be returned to the Graduate Coordinator.

## **7. Communicating the outcome to the examinee**

The committee can notify the examinee about the outcome on the spot. After the graduate chair receives the report summary from the oral exam committee, the graduate chair will compose an official letter to communicate the outcome of the exam to the examinee. Similar to Step-1, the examinee is encouraged to schedule brief meetings with committee members to get their individual feedback.

## **Appendix 1 Skill-set information sheet for AOSS 551 and 532 (Draft Version)**

### **Sample: Expectations for the qualifying exam**

#### **Skills that are related to course 551: Fluid dynamics**

1. Be able to express and relate the units of density, flux, and fluence of physical quantities and their spectral equivalents.
2. Be able to write and analyze conservation (partial differential) equations
3. Be able to write down the momentum equation in a rotating frame of reference
4. Be able to do scale analysis to find key dimensionless parameters and to select ignorable terms
5. Be able to solve simple differential equations for structure
6. Be able to linearize partial differential equations and obtain dispersion relations including instability thresholds
7. Be able to derive the vorticity transport equation and the wave equations for acoustic waves, gravity waves, and Rossby waves.
8. Be able to explain the connection between convective instability, Rayleigh Taylor instability, and gravity waves.
9. Be able to explain conceptually potential flow, self-similar systems, Kelvin-Helmholtz instability, shock waves, Ekman layers, Rayleigh-Bernard cells, the transition to turbulence.

#### **Skills that are related to course 532: Radiative Transfer**

- Be able to express and related the units of fundamental radiometric quantities (spectral intensity, spectral flux, broadband flux, etc.) and radiative quantities (absorptivity, emissivity, transmissivity, optical depth, extinction coefficient, single scattering albedo, phase function)
- Be able to physically interpret spectroscopy parameters (e.g. line strength, line width) and optical parameters (e.g. scattering matrix, effective size parameters) and relate them with radiative quantities
- Be able to summarize the fundamental physical laws (Planck function, Beer-Lambert-Bouguer Law, Kirchhoff Law), definition/assumption/limitation.
- Be able to write down the radiative transfer equation and solve it analytically for one-layer atmosphere in the absence of scattering
- Know the fundamentals of molecular spectroscopy (electronic/vibrational/rotational transition, selection rules)
- Know the numerical procedures of performing line-by-line calculation for inhomogenous atmosphere, know the essence of band model and correlated-K methods
- Be able to use two-stream approximation/argument to qualitatively explain various multiple-scattering phenomena
- Be able to explain the principles of different numerical methods used in computing particles' optical properties: applicability and limitation
- Be able to explain major advantage and weakness of “mainstream” numerical methods used in solving multiple-scattering problems (two-streams, doubling-adding, discrete ordinate, etc)
- Be able to conceptually “integrate” everything together. E.g. facing a brand-new planetary atmosphere, which quantities can be measured, step-by-step which quantities can be computed in which manners, with ultimate goal of obtaining radiative heating rate to be used in dynamical model.

## Appendix 2: Step-2 Exam Evaluation Sheet

Examinee's Name

Committee member's Name

	<b>Strongly Agree</b>	<b>Agree</b>	<b>Neutral</b>	<b>Disagree</b>	<b>Strongly Disagree</b>	<b>No Basis to Judge</b>
Written report is well organized, well referenced, and well written in English						
The research progress is sufficiently described in the written report in a coherent and logical way						
The oral presentation is well organized, well delivered, and correctly referenced (if applicable)						
The examinee has good understanding of the motivation and background of the research project						
The examinee can justify the scientific methods employed in the research project						
The examinee can explain any results obtained so far in the context of overarching research question and the "big picture"						
The examinee has a well-thought-out plan for the follow-up work						
The examinee is aware of the frontier research topics related to his/her project						
The examinee can handle impromptu questions with logical thinking and scientific reasoning						
The examinee exhibits effective communication skills in both the presentation and Q&A session						

Remarks: