

COMPREHENSIVE EXAM PROCESS (COMPS I AND II)
A Guide for Students
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1 Preface

This document is primarily intended to provide guidance for graduate students approaching their Comps II exam. Normally “approaching” means you are at the beginning of your third year of graduate school here at the University of Colorado. The exam consists of three parts. A formal paper demonstrates the ability to review and synthesize relevant published research on a selected topic in physics. An oral presentation demonstrates the ability to organize and present research at a scientific meeting. Finally, a question-and-answer session demonstrates the student’s broad understanding of physics.

1.1 Schedule requirements for Comps I and Comps II

Comps II is to be completed after Comps I (unsurprisingly). The Comps I requirements to be satisfied by the end of a student’s second year at CU include successfully completing five out of the six among the following classes of three credits each: Quantum Mechanics 1 and 2 (5250 and 5260); Electromagnetic Theory 1 and 2 (7310 and 7320); Theoretical Mechanics (5210), and Statistical Mechanics (7230). Students who have completed coursework equivalent to any of these courses at another university may petition the Physics Graduate Committee to waive Comps I courses. This is done by filling out a Comps I waiver form, attaching the course syllabus, and sending it to the Graduate Assistant. If the classes were not used to satisfy undergraduate requirements, they may be transferred and used toward the 30 course credits required by CU.

Comps II should ideally be undertaken by graduate students who have selected a research field and have an advisor.

Graduate students who are on track to not complete Comps II by the end of their sixth enrolled semester **MUST** petition the Associate Chair for Graduate Studies for an extension. In the absence of an extension, students who have not completed Comps II by the end of their sixth enrolled semester

are considered to have failed Comps II and therefore may not remain in the pro

Students must petition the department for any exceptions to this rule.

The typical student trajectory should have the student ready to address Comps II by the beginning of their fifth enrolled semester, typically the Fall beginning their third year. Early trajectories are welcomed and encouraged.

2 Comps II Exam Overview

The Comprehensive Exam itself takes place in a nominally two-hour period and has three oral parts: a presentation, a question period that specifically addresses the presented material, and a second question period covering general physics topics targeting a physics education up to second year graduate level.

The process begins with the submission of a “Topic Proposal” to the Chair of the Comprehensive Exam Committee (henceforth CEC). This is a brief description of a topic about which you propose to write a paper. Once approved, you are to write a professional level paper that will also serve as the basis of your oral presentation. The entire Comps II process, from start to finish, is designed to take about 3.5 – 4 months. It is expected be completed before the end of your sixth semester, and therefore it is wise to plan ahead, and not to wait till the last minute to submit your proposal.

3 The Comps II Process

The Comps II process is comprised of five action items for which you are responsible, plus an additional one if you do not pass all three parts of the exam. The following tasks and their timing are explained in further detail below:

1. Submit Topic Proposal to CEC Chair.
2. Coordinate schedules with oral exam committee to choose an exam date.
3. Notify CEC Chair of exam date.

4. Compose and submit Comps II Paper to oral exam committee and CEC Chair.
5. Take oral exam.
6. Retake/redo failed parts of exam if necessary.

4 Timing

A successful Comps II process nominally takes 3.5 - 4 months to complete, if there are no issues. Exams have to be completed by the end of the academic year, which is typically in mid-May. (This is because some faculty members whose salary is supported by external grants are not allowed to participate in non-research activities while they are paid by their grants.) The precise date will be included in a letter sent to all third year students early in the fall of the year that they must take Comps. Scheduling can be difficult even in early May because many faculty travel once classes are over. Working back, this means that it is very dangerous to send in a proposal to the CEC after early February: there will be no margin for issues such as having your proposal rejected. An early start is highly encouraged.

Submit the Topic Proposal in PDF form to the Chair of the CEC: that person will distribute it to the members of the CEC to evaluate. In the cover letter, tell us who is your advisor and in a general way what research you are doing. It usually takes a week or two to collect votes from the committee members. Once the votes are cast the Chair will write to you indicating whether the proposal is accepted or not, and if not, provide comments from the committee. If it is not accepted, you should then submit a new or revised proposal, taking the committee's comments into consideration. When approved the Chair will appoint an Oral Exam Committee to administer your comprehensive exam (to avoid confusion, we will refer to this as your "OEC", as opposed to the CEC which is a departmental committee). The CEC Chair will notify you of your committee membership, which will consist of three faculty members.

Once assigned an OEC, it becomes your responsibility to coordinate among their schedules to set an exam date. You should start scheduling soon after you learn the membership, because scheduling can be difficult, particularly at the last minute. Once you settle on a date, notify the CEC Chair of your exam date.

Your research advisor may attend the exam but does not vote.

At the same time, you should be composing your Comps II paper. It is due to your OEC members no later than two weeks before the oral exam.

It is wise to send email reminders to your OEC members a week before, two days before, one day before, and the morning of your oral exam. An excuse that “my committee member forgot” does not serve your interests.

5 The Topic Proposal

The Topic Proposal is a short, original to you, composition proposing to write and submit a paper on a contemporary topic of physics. Here, “physics” can be interpreted very broadly, going outside the core physics disciplines.

The proposed topic must be entirely outside your field of research. More topic proposals have been rejected by the CEC for reasons of topic overlap than any other reason. If you are doing thesis research on high-Tc superconductivity, for example, you should probably not propose to write about graphene, because both are topics belonging to condensed matter physics. On the other hand, your Proposal *might* convince the CEC that a paper on graphene-based lasers is acceptably far enough away from your research. Unfortunately, however, you cannot count on the CEC members to have the expertise to make a clear distinction of what is and what is not part of your subfield. Therefore it is a safest bet to keep a far distance for your own field. As a condensed matter physicist writing about X-ray laser physics you are probably safe.

The proposal should address a *contemporary* topic of physics. Contemporary means that it is of current or recent interest and activity, most likely as evidenced by literature, say, within the last ten or twenty years. In this we do not mean to discourage topics of continuing but slowly advancing fields, as long as there is progress to report.

Your topic description should be concrete, specific, and place clear limitations on the scope of the proposed paper. Recent fashionable topics such as “quantum computing” or “graphene” are terribly broad, for example. In the first case, you might limit the topic to “Quantum computing with neutral Rydberg atoms” and for the second, it might be: “Ultra high-speed optical modulation based on graphene.” Citations to specific literature should help you, in turn, to be specific and informative about your plans for the paper’s content.

While your topic should not be too broad, it should also not be too narrow. A single calculation or experiment will often lose the big picture of the topic. The core of the topic should be heavy on real physics; emphasis on engineering, applications, or societal issues should be avoided.

The Topic Proposal should include a small number of references and/or literature citations. In addition to giving credit where credit is due, providing references establishes credibility and helps to better define the proposed paper content. References/citations should not be exclusively of the Wikipedia ilk.

Here is a summary list of Topic Proposal characteristics:

- Physics topic outside of your physics research sub-discipline.
- Short, less than a page.
- Concrete, and specific, defining the scope of the future paper.
- Include a small number of citations to the literature.

5.1 Suggestions for Selecting a Topic

If you are having difficulty choosing a topic, try going through recent issues of Physics Today, Physical Review Letters, Science, Nature, and similar such journals covering physics and related fields. Journal publishers also often maintain web sites with the latest and greatest news in science. Attend colloquia and seminars. Pick something you may have never heard about but sounds interesting. One of the primary purposes of the Comps II paper-writing exercise is to help you maintain some breadth in physics, because much of the remainder of your time here focuses on one very tiny portion of physics (even if it is the most important in the world!)

5.2 Topic Proposal Format

As in nearly any professional composition, the Topic Proposal should list its title, authorship (that's your name as you like to have it appear in print) and date. The text follows, and the Proposal concludes with a short list of citations and/or references. It should be sent to the CEC Chair as a PDF document.

5.3 Topic Proposal Acceptance/Rejection

Once received by the CEC Chair the Topic Proposal is approved or disapproved by the CEC as a whole. The response is forwarded to you: comments are sometime provided even when the CEC approves the topic. These comments should be taken into account when writing your paper.

When rejected, the rationale is always provided. In this case you should revise your proposal or compose a new one as per the comments and suggestions from the CEC.

6 Writing the Paper

The Comps II paper is to be written as an overview of a research topic including its history, importance, ongoing efforts, outstanding issues, and likely future directions. The paper should be a formal, publication-quality document of 2500-3000 words (12 - 15 pages). It should contain an abstract, figures and/or tables properly referenced, and citations. The paper's writing quality, organization, typesetting, and figures should be up to professional standards. The general level of the paper should be that of a serious review article, such as a feature article in *Physics Today* on current research or a contribution to *Annual Reviews*. The paper must draw on many original sources; a "book report" or a paper that relies largely on a single source will be rejected. The paper should be **your** writing, but it is not expected and not appropriate to originate any new science in the work. The paper should be typeset in 12-point font, and double-spaced.

For style guidance, go to the website of one of the physics journal publishers (preferably one that you might actually use to submit manuscripts for publication). You may use the style format for paper submissions to that Journal, except figures and tables should be included with the text near their first mention rather than at the end as expected by some publishers.

6.1 Writing Assistance

The Physics Department has courses about technical writing. The person teaching those classes is available to provide technical writing assistance. We urge you to seek this person's advice and help. Whether English is your second language, or you are simply concerned about your technical writing ability, outside expertise can be of enormous value.

We also encourage you to seek advice from your research advisor about form and content of your paper. It is in everyone's interest that you are able to compose a competent work.

6.2 Paper Submission

The paper should be turned in (in final form) to the committee at least two weeks before the oral exam. Also provide a PDF copy of the paper by email to the CEC Chair.

7 Scheduling the Exam

The exam must be completed within three months after the exam committee is appointed. The candidate is responsible for organizing the time and place of the oral examination (with assistance from program assistants to find a room, if necessary) and obtaining any necessary presentation equipment such as a projector or screen. The candidate must ensure that all members of the exam committee are available *for a full two hours*, in order that adequate time is available for the exam and discussion afterwards.

These days, all forms are electronic and it is useful to include the URL in any communication you have with your committee reminding the members of the exam's time and place.

8 The Exam Format

The exam will consist of the student's 20-minute oral presentation, followed by 60 minutes of questions. At least 40 minutes of questions will be on physics topics unrelated to the talk or paper.

8.1 Public Attendance

By default the Comps II oral exam is *not* open to the public (or your guests, colleagues, etc.).

8.2 The Oral Presentation

The examination begins with you giving a 20-minute talk on the paper topic. You are expected to use a projector, and it is your responsibility to stay within the time limit. The time limit will be enforced by your OEC, with allowances made if there are delays due to questioning. The presentation should be at the same level as a review talk at a major conference. A rule of thumb for gauging the level is that a physicist in the same general research field but outside the particular topic should learn something new from the talk, but shouldn't feel that it is too specialized to understand. The talk should have good slide organization, use figures and data plots well, and be presented clearly with good diction and no rambling. You should be comfortable enough with the material and the slides that you do not need to read from a script.

The committee members are requested not to ask too many questions during the presentation, saving them for the end. In reality this proves not to be practical for most presentations. Thus, be prepared to handle questions about the talk as you progress, and to the extent that these questions extend the presentation time, you will not be penalized.

8.3 The Question-and-Answer session

After the talk concludes, the exam committee will ask the candidate a series of questions. This part of the exam will last approximately one hour. Some of the questions will be about the topic of the talk: these questions may clarify the material presented, as well as probe further the student's understanding of the research field and how it relates to other fields. The committee may also ask questions about the paper.

The majority of the question session will be about general physics. This section of the Comps II exam is the key moment in your graduate career when you must demonstrate the skills and knowledge of all fields of physics to qualify for PhD candidacy. You are expected to demonstrate in the exam a mastery of undergraduate physics, defined broadly. The exam will test both conceptual understanding and problem-solving. Questions may be drawn from the full range of basic physics fields: classical mechanics including fluids, wave motion, and Lagrangian and Hamiltonian dynamics; electromagnetism including circuits and EM waves; special relativity; nonrelativistic quantum mechanics including perturbation theory and scattering; optics; statistical

physics and thermodynamics. You are expected to be able to use basic mathematical techniques such as series expansions and solving differential equations. Special topics such as solid-state, nuclear, particle, atomic, or plasma physics can appear, but specialized knowledge is not expected of you.

8.4 Concluding the exam

After the oral exam ends, you will be excused from the room: remove your belongings as well as the projector, computer, etc., from the exam room. You should leave the exam area as you will not be given the results of the exam orally. You will be informed of the outcome of the exam by electronic mail.

9 Exam Scoring and Results

Each Oral Exam Committee member will assign points to the three parts of the examination as follows: Paper 0 - 3; Presentation 0 - 3; Questions 0 - 4. The OEC will discuss the result and conclude whether the candidate has passed or failed: candidates may pass at the PhD candidacy level, the Master's level, or fail parts or all of the exam. A passing score at the PhD level for each part of the exam is 50% or better.

9.1 Retaking Failed Portions of the Exam

If you do not pass the entire exam, you will be informed of the areas of deficiency. Candidates who fail all or parts of the exam should meet with their mentor/adviser to discuss the problems and set up a plan for improvement.

Generally, the OEC will decide on a date or period of time to re-do the failed part(s). For example, it can set a date for resubmission of an unacceptable part of the paper, or set a time limit to repeat failed oral portions of the exam.

If a new paper is required, the CEC may accept or decline the use of the original proposal for the second research paper. Students who fail on the first attempt may request a new committee for the second attempt. Even without the student's request, a new examination committee may be appointed at the discretion of the CEC.

10 Guidelines for Receiving a Master's Degree (MS)

The Comps II exam is used as the Master's Exam in the Physics Department. Once you have successfully completed Comps II, and you have completed or are in the process of completing all 30 course credits, you are eligible to receive a Master's in Science (MS) degree. You will need to apply to the Graduate School through myCUInfo by the Master's deadline set by the Graduate School. Check the Registrar's calendar for dates. If you miss the deadline, you will need to apply for the following semester.

You should apply for an MS only after you have successfully completed all parts of Comps II.

10.1 Who May Chair a Master's Exam

The person who is recorded as Chair on your Master's Exam Report form must be allowed to chair committees by the Grad School. If you are unsure whether a particular faculty member is allowed to do so, check with the Graduate Program Assistant.

11 Additional Important Rules

11.1 Taking the Exam During Summer Session

You must be signed up for classes or dissertation credit during the semester you take Comps II for it to count as a Master's Exam. In all cases, the only time you ***CANNOT*** take Comps II is roughly between June 1 and August 10. (The exact dates change from year-to-year. For the exact dates, contact the Graduate Program Assistant.) If you take Comps II in May, it counts as Spring term.

12 Comps II Failures

Normally Comps II will be completed by the end of your third year, or early the following Fall at the latest. You are allowed precisely one retake if you fail all or a portion of your exam on the first try. You are considered to have

failed Comps if you have failed both the original exam and the retake. You are considered to have failed Comps II if you do not take a first attempt by the end of the second semester of your third year. You are also considered to have failed Comps II if you have not retaken the failed portion(s) of the exam within the time set by your OEC.

In the case of a failed re-take of Comps II, you are permitted to complete the semester for which you are enrolled.

12.1 Recourse, Requests for Exemptions, and Similar

It is the CEC's responsibility to administer the Comps II exam and to enforce the policies that have been put into place by the Physics Department. If you have questions or concerns regarding the policies and procedures, it is appropriate to contact the CEC Chair. You will want to understand that the Comps II process is carried out independently of, and without particular regard for, your research obligations. While your research advisor is urged to participate in the exam and is often included on email communications with you, we do not negotiate with advisors about the timing or execution of your exam: such things are between only you and the CEC. Thus, you will need to manage on your own your travel and other research commitments that could potentially conflict with your Comps II process.

If you fail Comps II, (whether by taking and failing the exam twice, do not meet the required deadlines, or other reason) do not contact the CEC for reconsideration. Once you are deemed to have failed, it is up to the Graduate Committee, not the CEC, to consider petitions for exceptions to the rules established by the department.

13 Suggested Reading

The following reading and references may be of help for students preparing for the Comps II paper and presentation.

The Mayfield Handbook of Technical & Scientific Writing, Leslie C. Perelman, et al, Mountain View, CA: Mayfield, (1998).

The Craft of Research, Wayne C. Booth, et al, Chicago, IL: U of Chicago Press (2003).

Keys for Writers, Ann Raimos, fourth edition, Houghton Mifflin, (2004).

The Science of Scientific Writing, George D. Gopen and Judith A. Swan,
American Scientist Volume 78, 550-558 (Nov-Dec 1990).