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 use that coursework in one of two ways to satisfy the Comps I requirement. They may petition the CU graduate school to grant credit toward the total of 30 credits required for the PhD and to satisfy the Comps I course requirement. Alternatively, they may document their previous coursework to the graduate committee of the Physics Department to satisfy the Comps I requirement but not receive credit from the University of Colorado at Boulder for the class.

Comps II should ideally be undertaken by graduate students who have selected a research field and have an advisor. Graduate students who entered the program in Spring 2010 or later, and who have not taken Comps II by the end of their sixth enrolled regular semester, are considered to have failed Comps II and therefore may not remain in the program. Those who entered the program before Spring 2010 will be considered to have failed Comps II if they have not taken the exam by the end of the Fall 2012 semester.

A student who fails a first attempt before the deadline, or needs to retake any part of the exam, may continue through the following regular semester to allow time to complete the exam process. Retakes in the Fall semester of first-tries taken in the previous Spring must be completed by September 30.

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

The typical student trajectory should bring the student ready to address Comps II by the beginning of their 5th 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. Prior to the exam are two “deliverables” that you are to submit. The first is a “Topic Proposal”, that 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 6th semester, and therefore it is wise to plan ahead.

3 The Comps II Process

The Comps II process is comprised of six 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:

- Set Topic Proposal Due Date.
- Submit Topic Proposal to CEC Chair.
- Coordinate schedules with oral exam committee to choose an exam date.
- Notify CEC Chair of exam date.
- Compose and submit Comps II Paper to oral exam committee and CEC Chair.
- Take oral exam.
- Retake/redo failed parts of oral if necessary.

4 Timing

The figure on the next page summarizes the timing of the Comps II process. Again, note that the entire process is nominally 3.5 - 4 months long. The Comps II process normally begins with an email from the Comprehensive Examination Committee (CEC) Chair that provides you with these guidelines and asks you for a date by which you intend to submit a Topic Proposal. You should provide that date within 10 days of that request. If for some reason your proposed date is unacceptable, or special circumstances apply, you and the CEC Chair should commence a conversation to settle on an acceptable date. Working backwards from the end of the semester by the 4 month process time suggests that your proposed date should be no later than sometime in January. Since January may leave you trying to schedule an Oral during finals, or even afterwards when scheduling is difficult, it is not recommended that you wait until then in any case. September – November is an ideal time frame for Topic Proposal due dates.

The Topic Proposal due date begins your personal Comps II clock ticking. By that date you should submit the topic proposal in PDF format by email to the Chair. Normally it will take about two weeks for the proposal to be reviewed by all of the CEC members and to cast a vote for or against approval. Once the votes are cast the Chair will write to you indicated whether the proposal is accepted or not, and if not, provide comments from the committee. You should submit a new or
revised proposal within two weeks. 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, and optionally your research advisor.

Once appointed 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.

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

It is wise to send email reminders to your EC 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. In AY-2011, more topic proposals were 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, you 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, such as gravity wave detection.

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, and not simply Wikipedia references

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. 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
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 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. A new Topic Proposal should be submitted within 10 days.

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. 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 then at the end as expected by some publishers.

6.1 **WRITING ASSISTANCE**

Debra Biasca is available to provide technical writing assistance. We urge you to seek her advice and help. Whether English is your second language, or you are simply concerned about your technical writing ability, her 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 his/her 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 the graduate secretary) 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.

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. You are responsible for bringing all necessary department forms to the exam.

8.1 Public Attendance

By default the Comps II oral exam is not open to the public (or your guests, colleagues, etc.) If you wish, you may ask your OEC Chair if s/he is amenable to allowing a guest audience. Make your request well in advance of the exam date. In any case, the guest audience is not allowed to ask questions during your presentation.

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 strictly 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 in 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 he/she does not need to read from a script.

While your committee members have guidelines indicating questions about the paper and presentation should follow the actual presentation, 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 extent 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 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.

You can retake the failed parts of the exam a second time, no later than the end of the following semester. If the following is the Summer semester, then you may delay the exam retake but it must be taken no later than September 30th of the following Fall semester.

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, you are eligible to receive a Masters 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. These are early Oct 1, Feb 1, and June 1. If you miss the deadline, you will need to apply for the following semester (although not Summer). Thus, for example, if you miss the deadline of Feb 1, you will need to apply to receive the degree for December.

10.1 WHO MAY CHAIR A MASTER’S EXAM

Whoever 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 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 most cases, the only time you CANNOT take Comps II is roughly between June 1 and August 10 unless you sign up for Summer term. (The exact dates change from year-to-year. For the exact dates, contact the Graduate Secretary). If you take Comps II in May, it counts as Spring term. If you take it during the two weeks prior to the start of Fall term, it will count as Fall term. 3)

11.2 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 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 three months, or by Sept. 30th of the Fall semester following your third attempt if the three-month deadline occurs within the Summer. In the case of a failed re-take of Comps II, you are permitted to complete the semester for which your are enrolled.

11.3 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 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. The only exception that the CEC made in the past two years was on behalf of a student whose research was carried out at the South Pole for a period of months. In this case, the circumstances were clearly out of the student’s control, and the consequences for not postponing the exam were substantially deleterious to the student’s degree progress.

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.

12 Suggested Reading

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

13 **Comprehensive Exam Committee 2013-14**

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