Case Western Reserve University
Department of Physics
PhD Qualifying Exam
Frequently Asked Questions (FAQ)

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Information provided here is meant to be "illustrative", not "definitive". For more information, contact Corbin Covault, chair, Qual Committee.

Q01: What are the dates of the qualifying exam:

Generally the qualifier is given twice per year. The exam is given to all first-year students in the PhD program during the end of May, approximately two or three weeks after the end of the Spring semester, sometimes around Memorial Day. (For 2009: the exam dates are Friday May 22 and Tuesday May 26.)

Generally a second exam is given near the end of the summer just before classes start, usually a Monday and Tuesday. The August exam will be given if one or more students who take the exam in May do not pass at the PhD level and therefore need to take a second exam.

Q02: What are the times (hours) of the exam:

Generally each exam will be broken into two parts, each lasting a total of three hours. Exact times are to be determined, but are usually scheduled for the mornings.

Q03: Who should take the qualifying exam:

Normally all first-year students will take the qualifying exam in May after they have completed a full year of course work. The only exception is for any students who passed the exam the previous August.

Q04: Do I need to register for the exam:

Yes. All first year students and anyone else planning to take the exam must register with Pat Bacevice in the department chair's office.

Q05: Can I get a copy of previous years' exams?

Yes. When you register, Pat will give you a packet that includes several previous exams. Usually this will go back "a few years". The purpose is to give students a rough idea of the range and difficulty they might expect on the exam.

Q06: Can I get solutions to previous years' exams?

Some of the exam problems that are provided in the packet to the students in previos years exams include partial or complete solutions. Note that not all problems will have answers. Note also that the completeness and/or correctness of any given answer in the practice problem set is not guaranteed. Solutions that are included with the prior exam packet were developed for illustrative purposes only over the course of each exam. The verification and accuracy of any given solution to any given problem is fundamentally the responsibility of the faculty grader and not the author of the problem. What this means is that for any given problem a grader and/or reviewer may have found errors or inconsistencies in a given problem solution and it may be the case that these errors and/or inconsistencies were not subsequently applied to amend the submitted solutions.

In other words, beware: the solutions presented with the exam packets have not been carefully checked for accuracy.

Q07: What are the main topic areas for the exam?

There are four of these:

(1) Classical Mechanics (CM)
(2) Quantum Mechanics (QM)
(3) Electricity and Magnetism (EM)
(4) Statistical Mechanics (SM)

Q08: How are the different topics assigned for the exam?

Students will work problems in CM and QM on the first day of the exam. Students will work problems on EM and SM on the second day

of the exam. During each exam, students will have three hours to work two problems, one in each area. Students may divide the three hours between the two problems however they wish.

Q09: Are notes or books allowed at the exam?

No. The exam is completely closed book. No notes, no books.

Q10: Will there be a sheet with equations and/or formulae and/or constants?

Not exactly, no. For each question on the exam, the committee will consider in some detail what sorts of equations and/or physical constants are required to solve a problem. Equations that fall into the category of "expected fundamental knowledge" will not be provided to the student. Equations, formulae, and constants that do not fall into the category of "expected fundamental knowledge" will be provided to the student in the context of the question.

Q12: Can you give me examples of the kinds of equations we are expected to know vs. those that we would be given?

For example, you are expected to know (memorize) Maxwell's equations in both integral and differential form. You are expected to be able to write down the Schrodinger Equation. If you were asked to work an optics problem to evaluate the Stoke's parameters, you could expect to get a reminder of how these parameters are defined. If you were asked to evaluate the flux of energy in an electro-magnetic system, you might expect to be given a formula for the Poynting's vector, or you might not. Values of constants, such as the mass of the earth or the atomic number of Xenon would also be provided to students if needed for a given problem.

Q13: What about math. Are we expected to know how to do difficult integrals and/or to memorize special functions?

Again, you are expected to have a basic and working knowledge of mathematics required for graduate work in physics, which includes elements of calculus, differential equations, linear algebra, numerical methods, and complex analysis. But any equations, integrals or functions that would lie outside of those corresponding to "expected fundamental knowledge" will be provided to the student in the context of a problem. Our

aspiration is to evaluate physics ability. As a rule, if an integral or a function is needed to solve a problem, it will be provided in the context of the problem. Students can also expect to see formulae if needed for differential operators, transforms, and or conversions from linear to cylindrical or spherical coordinate systems.

Q14: What else should I bring to the exam?

You should bring a calculator, several pens/pencils, and perhaps a ruler. The calculator must not be a PDA or a pocket PC or laptop. As a rule of thumb, a calculator is acceptable if it does not provide a mechanism for alpha-numeric keyboard text entry. Do not bring scratch paper.

Q15: Where will the answers be written by students?

Students will be provided a stack of blank 8-1/2" by 11" sheets of paper to write their answers on. Students answer will be written on blank (white) sheets. If a student would much prefer to write on lined sheets, then this should be requested in advance. Students are asked to work only one problem on each individual sheet. There is no limit to the amount of sheets per problem a student may use for writing the answer. Students must write their answers one one side of each sheet only. Students are asked to put all of their work -- including scratch work -- on the sheets that are turning in for evaluation. Students should take care to indicate their final answers (with a box or circle) and students must make sure that a coherent organization is provided so that the grader can follow the path to the student's answer.

Q16: For each topic, what is required of each student?

For each topic area students will be given choice. Students should expect one of two possible cases for each topic area:

Case 1: The students will be given two separate problems for a given topic. Students will select only one of the two problems to complete.

Case 2: The students will find a single problem on a topic. In this case student will be given some explicit choice as to which parts of the problem to solve. For example, if a problem has sub-parts

(a), (b), (c) and (d) the student make be asked to chose to complete any two sub-parts.

Generally speaking "Case 1" is much more common than "Case 2".

Note that students will need to clearly indicate their choice on the exam, and only work associated with the student's choice will be graded. For example, on the topic of classical mechanics, a student initially selects the "A" problem, but then after 20 minutes of work the student changes his mind and starts and completes the "B" problem. In this case, the student must indicate that he is only answering choice "B". None of the work on choice "A" will be evaluated or graded.

Q16: How are the exams graded?

Each topic area will be graded on a 25 point scale for a total of 100 points for the entire exam. Each student will be randomly assigned an ID number. Each question will be graded independently and anonymously by two faculty graders and a final score will be determined by consultation between the graders and possibly other members of the committee. If there is substantial disagreement on any problem between the two graders scores, a third or fourth independent grader may be asked to grade the problem.

Each exam is graded anonymously. Each student is randomly assigned an ID number and all submitted work is identified by ID number only and not name. Student exams remain anonymous throughout the evaluation procedure, including during the determination of passing level and endorsing of final scores by faculty vote. Only after all votes and passing levels are settled are the faculty shown the names of each individual students.

Q17: What are the passing levels for the exam?

Each student will earn a "level" grade on the exam that is one of three possibilities:

-- Pass at PhD level (required to move on to candidacy)
-- Pass at master's level. Students who pass at the masters level will need to take the exam again if they wish to continue to pursue PhD candidacy. For the purpose of PhD candidacy this is NOT a passing grade.
-- Fail. Students who fail will have to take the exam again

if they wish to continue to pursue PhD candidacy.

Q18: When and how to students learn their grades?

Student will receive in their mail slots a written statement of their grade level: Pass PhD, Pass Masters, or Fail. The written statement will be generated and placed in the mail box as soon as possible immediately following the special faculty meeting to review the exam (see Q21 below).

Q19: Do students learn their numerical scores (out of 100 points). Do students learn their scores on each part?

No. Sorry. Students do not get to see their marked/graded exams nor are they told explicitly their scores for each problem. However, students' advisor's will usually give students who do not pass the exam some general guidelines that can be helpful for students who need to re-take the exam. For example a student might be unofficially told something like: "you did really well in quantum mechanics but you completely bombed the stat mech problem..." Students will not be shown exam solutions and in general will have no mechanism for appeal of assigned exam scores.

Q20: How are the grade passing levels determined?

The three levels (Pass PhD, Pass Masters, and Fail) are assigned to exams based strictly on the numerical score total for each exam. The Qual Exam committee recommends to the faculty what the cutoff score for each level is for a particular exam. The cutoff level is determined based on historical precedent and the perceived relative difficulty of any particular exam. There is no fixed numerical score that corresponds to passing at any particular grade level. However, as a "rule of thumb" students who pass as the PhD level generally earn at least half the points on each of the points in each of the four topic areas and a total score of not less than 60 percent of all of the points.

It is worth emphasizing that the actual point scores that correspond to a passing level are set by the faculty after discussing the exam itself and the (anonymous) scores of the students. This is done so that adjustments can be made. For example, if a particular exam is judged by the faculty to be significantly more difficult than a typical exam, then the faculty may decide to adjust the score boundaries corresponding to a

passing grade downward.

Q21: Does the Qual Exam Committee determine final scores and who passes and who does not?

Recommendations of the Qual Committee for passing level score determinations are ultimately determined by the entire physics department faculty who meet in a special meeting to review each exam. While the recommendations of the Qual Committee are often approved without change by the faculty, the faculty will generally review in detail the work of the Qual Committee for each individual exam, and reserves the right to reconsider grade scoring and passing levels for each exam. All deliberations during the faculty meeting are done on exams with anonymous ID numbers only. Student names on individual exam are not revealed until after a final vote. The faculty has final responsibility to ensure that the exam has been administered and graded properly and that each student is assigned the proper grade. All such deliberations are considered strictly confidential.

Q21: Can a students earn a "pass" in one of the four topic area so as not to have to re-take the exam on that one topic?

No. Pass PhD, Pass Masters, or Fail is assigned for the whole exam. Students who do not pass at the PhD level will need to re-take the entire exam.

Q22: Can a student pass if he does really well on three topics but very poorly on the fourth?

It depends. Passing levels are set by total points only. As a rule, the committee usually sets the passing PhD level at a value that effectively requires a decent performance in all four topic areas. If a student earns an distinctly high score in one topic area, this can compensate somewhat for a weaker performance on another topic.

Q23: What does it mean to "Pass at the Master's level".

This means that a student did not pass at level required to move on to PhD candidacy, and the exam must be re-taken. However, the student did earn enough points to qualify for a master's degree.

Students who leave the PhD program after passing at the master's level can earn a master's degree provided other departmental requirements are met. Since students who take the PhD qualifying exam are not generally seeking a terminal master's degree, this corresponds to a "consolation prize" for students who are unable to pass the exam at the PhD level.

Q24: Under what circumstances must I re-take the exam?

If you do not pass at the PhD level in May you must re-take the exam in August.

Q25: What if I do not pass at the PhD level on the second exam in August?

In general students have only two opportunities to pass the qualifying exam and students who do not pass at the PhD level on the second exam will be asked to consider leaving the PhD program. On rare occasion, a student who has failed to pass on two attempts may petition for an opportunity to take the exam a third time. Such a petition may be granted if the student is actively involved in physics course-work and/or research and/or if there are extenuating circumstances that might have negatively impacted the students performance on earlier exams and/or there is some optimism that given a third attempt there is a reasonable chance that the student will pass at the PhD level. All such petitions must be submitted for approval before the start of classes.

Q26: What about incoming students?

Incoming graduate students who are entering the department in the fall are also allowed to take the qualifying exam in August if it is being given. In this case, incoming students can optionally take the exam as a "free-bie" -- that is it will not count as an "attempt" if the student does not pass at the PhD level. Note that in the unlikely event that all first year students pass the May exam at the PhD level then the Committee reserve the right to cancel the August exam.

Q27: Where do the questions come from?

Previous exams can provide a guide. Exam questions generated by the members of the committee and are also solicited from all members of the department. The following excerpt from an email to the faculty might be illuminating:

> Dear Physics Faculty:
>
> As you pursue your end-of-semester tasks, I would like to ask each of you to consider what you might be able to do to help support the goal of the PhD qualifying exam committee.
>
> I would like to ask each member of the faculty to seriously consider submitting at least one question that might be considered for use in the qualifying exam. You may pick any one of the four topic areas: Quantum Mechanics, Classical Mechanics, Statistical Physics, or E&M. It's your choice.
>
> Most questions that we put on the exam are designed to reflect the extent to which the students have mastered topics presented in the first year graduate courses. Therefore I want to especially encourage faculty who have been instructors for a graduate course any time during the past year or two to consider submitting a question for the exam. Perhaps there is a questions that you created for the course but did not use.
>
> I also want to encourage people to submit questions even if they are unsure of the appropriate difficulty level and/or if they have not been an instructor in a graduate course recently. Remember, under the new format students will have a choice for each topic area. For each topic area students will choose between two questions. This gives us more leeway to consider questions that are somewhat non-standard or that might yield to a different approach. In particular, I want to encourage instructors for undergraduate courses who might come up with good problems for the better students to consider submitting a question.

Q28: How are questions selected?

The exam committee reviews every submitted question for consideration and possible modification before inclusion in any given exam. In my opinion exam questions are selected so as to best assess the students ability to work physics and to think physically. This is the central aim of the exam: to make sure

that our students understand the fundamentals of physics at a level required to proceed to PhD research.

Having said this, there are two somewhat contradictory sub-goals:

(1) The Qual should be designed to ensure that students have a good understanding of fundamental physics topics as presented in the context of there first year graduate courses, and

(2) The Qual should be designed to ensure that students have a good understanding of fundamental physics topics as presented OUTSIDE of the context of there first year graduate courses.

In other words for some questions on some topics you should expect problems that are typical and familiar with respect to material you covered in your first year graduate courses. But some questions may involve material that you are unfamiliar with. In these cases we may ask students to somewhat extend their application of basic physics knowledge to an area that they may not have directly worked with before. Conversely, since physics is a cumulative discipline, some questions may be framed at a level and in a context that is more characteristic of materials presented in an undergraduate course. So students should expect to find a mix of "graduate" and "undergraduate" questions, some with emphasis on techniques and methods learned in first year courses, and some with emphasis on physical concepts and applications.