Department of Applied Physics and Applied Mathematics
Doctoral Qualifying Examination 2020-2021

The Doctoral Qualifying Examination is a two-day written test, with the General Exam on the first day and the Specialty Exam on the second. It is given once a year, usually in May, during the week of commencement. Both examinations are four hours in length, and each is closed book. Although all doctoral/doctoral track students will take the qualifying examination at the same time, students will answer different questions depending upon their graduate programs. Four problems will be solved on the first day; four problems will be solved on the second day. Each graduate program defines its own requirements for a subset of the problems that must be solved. These requirements are described below.

DAY ONE: GENERAL EXAM

The Day One, or General Exam, consists of problems in fundamental subject areas. These questions are intended to be basic and should be solved by a typical doctoral student in about 40 minutes. The course listed for each subject area is recommended for preparation, but a student can choose the subject area without first taking the corresponding course.

Applied Physics and Applied Mathematics
Students choose *four* of *seven* (4/7) problems.
Applied Physics (Plasma or Solid State/Optical) students must do #1-3 and choose one (1) from #4-7.
Applied Mathematics/Applied Analysis students must do no fewer than three (3) of problems #4-7.
Applied Math/Atmospheric Science students choose any four (4) of the seven (7) problems.
Medical Physics students choose any four (4) of the seven (7) problems.

1. Classical mechanics[1] (PHYS GU4003y "Advanced mechanics")
2. Electromagnetism (APPH E4300x "Applied electrodynamics")
3. Quantum mechanics (APPH E4100x "Quantum physics of matter")
4. Linear algebra[2] (APMA E4001y "Principles of applied math I")
5. Partial differential equations I (PDEs I) [3] (APMA E4200x "Partial differential equations")
6. Applied dynamical systems (APMA E4101x "Introduction to dynamical systems")
7. Numerical Methods (APMA E4300x "Introduction to Numerical Methods")

Materials Science and Engineering
Students must do problems #1-3 and choose either #4 or #5, for a total of four (4) problems.
1. Crystallography: symmetry, structure, anisotropy (MSAE E4100x, "Crystallography")
2. Materials thermodynamics (MSAE E4201y, "Materials thermodynamics and phase diagrams")
3. Kinetics of solids (MSAE E4202y, "Kinetics of transformations in materials")
4. Linear algebra[2] (APMA E4001y "Principles of applied math")
5. Partial differential equations[3] (APMA E4200x* "Partial differential equations")

Notes:
[1]At the level of Chapters 1-6 and 8 in Classical Mechanics, Third Edition, by H. Goldstein, C. Poole and J. Safko, Pearson
[2]At the level of Chapters 1-6, Linear Algebra and its Applications, Fifth Edition, by Gilbert Strang, HBJ Publishers.

[3] At the level of Chapters 1-5 and 7-10 in Applied Partial Differential Equations, Fifth Edition, by Richard Haberman, Pearson Publishers

DAY TWO: SPECIALTY EXAM

Each student must select the Specialty Examination of the program into which they have been admitted. Plasma Physics, and Solid State and Optical Physics students must have completed no fewer than two (2) of problems #1-3 on Day One before taking the Day Two examination. Applied Mathematics / Applied Analysis must have completed no fewer than two (2) of problems #4-6 on Day One before taking the Day Two examination.

The Specialty Examination consists of four (4) problems. A typical doctoral student should solve each specialty problem in about 40 minutes. Each Specialty Examination lists the problem options; required problems are underlined. Students should bring any questions about the requirements to faculty or graduate student advisors for these graduate program areas.

Applied Mathematics/Applied Analysis

Students choose *any four* (4) problems out of #1-#5.
1. PDEs II (APMA E4200 "Partial differential equations")
2. Applied functional analysis (APMA E4150x "Applied functional analysis")
3. Numerical methods for PDEs (APMA E4301y "Numerical methods for partial differential equations")
4. Applied real and complex analysis[4] (APMA E4204x "Functions of a complex variable")
5. Stochastic analysis (APMA E4991y "Stochastic analysis")

Notes:
[4] Students must also know vector calculus, at the level of Vector Calculus, by J. E. Marsden and A. J. Tromba, Sixth Edition, Freeman.

Applied Mathematics/Atmospheric, Oceanic and Earth Physics

Students do both (2) problems #1-2 and any two (2) of #3-9, for a total of four (4).
1. Introduction to atmospheric science (EESC GU4008x "Introduction to atmospheric science")
2. Geophysical fluid dynamics (APPH/EESC E4210y "Geophysical fluid dynamics")
3. Physics of fluids (MECE E4100y "Mechanics of Fluids")
4. PDEs II (APMA E4200 "Partial differential equations")
5. Numerical methods for PDEs (APMA E4301y "Numerical methods for partial differential equations")
6. Applied real and complex analysis[4] (APMA E4204x* "Functions of a complex variable")
7. Applied functional analysis (APMA E4150x "Applied functional analysis")
8. Statistical Mechanics (CHAP E4120x "Statistical mechanics")
9. Stochastic analysis (APMA E4991y "Stochastic analysis")

Materials Science and Engineering

Students do *all four* (4) problems
1. Crystallography: diffraction (MSAE E4100x, "Crystallography")
2. Theory of crystalline materials: phonons (MSAE E4200x)
3. Electronic and magnetic properties of solids (MSAE E4206x)
4. Mechanical behavior of materials (MSAE E4215y "Mechanical behavior of materials")

Applied Physics/Plasma Physics

Students do *all four* (4) problems

1. Plasma A: MHD (APPH E6101x "Plasma Physics I"/APPH E4301y "Introduction to plasma physics")
2. Plasma B: Two fluid theory (APPH E6101x "Plasma Physics I")
3. Plasma C: Kinetic theory (APPH E6102y "Plasma physics II")
4. Advanced E&M (APPH E4300x "Applied electrodynamics")

Applied Physics/Solid State and Optical Physics

Students do three (3) problems #1-3 and choose one (1) of #4 or #5, for a total of four (4)

1. Solid state I[5] (APPH E6081x "Solid State Physics I")
2. Optical physics (APPH E4110y "Modern Optics")
3. Statistical mechanics (CHAP E4120x "Statistical mechanics")
4. Laser physics (APPH E4112x "Laser physics")
5. Solid State II[6] (MSAE E4203y "Theory of Crystalline Materials: Electrons")

Medical Physics

Students do *all four* (4) problems

1. Nuclear medicine physics (APPH E6319y "Clinical Nuclear Medicine Physics")
2. Radiological physics and dosimetry (APPH E4600x "Fundamentals of Dosimetry")
3. Diagnostic radiology physics (APPH E6330y "Diagnostic Radiology Physics")
4. Radiation therapy physics (APPH E6335y "Radiation Therapy Physics")

Notes

[5] At the level of chapters 1-9, 10-23 and 27 in Solid State Physics by Ashcroft and Mermin.

[6] At the level of chapters 10, 13, 14, 20-34 and Appendix K in Solid State Physics by Ashcroft and Mermin.

All PhD degree candidates who have not yet passed the written Qualifying Exam must take this exam when offered, typically in May (at the end of the first year for study). All doctoral track MS candidates who are registered as full-time degree candidates in the Fall or prior semesters and have not yet passed the written Qualifying Exam also must take the exam when offered, typically in May, if they intend to continue after the MS toward the PhD degree.

Use this outline of the qualifying examination to help you plan your course schedule for the first year. You may make copies of previous exams, which are available in the department office. Practicing problems from old exams is *excellent* preparation for taking the qualifying examination.

Incoming APAM Doctoral Students:

Signing up for Courses in the Fall and Spring Terms Needed for Doctoral Qualifying Exam Preparation

and

Initial Registering for Fall Courses During \ Registration

For the 2020-21 Academic Year (Rev. 7-21-20)

For each discipline, these are the courses that qualifying (quals) exam questions are based on, as given below for each quals discipline. (This note contains the same information as the doctoral qualifying examination document.)

You should be signing up for each of these courses in your discipline, unless you and your advisor agree that you need not do so because you have taken the equivalent (and may or may not be taking a more advanced course) or there are options in your quals exam and you need not take it to cover all the questions you need to take.

It is recommended that TAs and others sign up for 12 points (courses are typically 3 points each, with some exceptions). After meeting with your first-year advisor during orientation week, you can change your fall course registration as needed.

Note that with very few exceptions, courses are given only once a year.

In the Day One and Day Two exams there are required questions for a discipline and, in several cases, a set of questions among which you have a choice. These latter questions are based on courses listed below as "*optional.*" You should be signing up for enough of these courses to fulfill your quals preparation needs. If you expect any of these courses to be in the fall term, you must sign up for them during registration. You can change such courses you will be taking in both terms after speaking with your advisor.

Discipline: Applied Mathematics: Applied Analysis

Fall

APMA E4200x Partial differential equations (optional but with restrictions)
APMA E4300x (Fall B) Introduction to numerical methods (optional but with restrictions)
APMA E4001x Principles of applied math (optional but with restrictions)
APMA E4204x Functions of a complex variable (optional but with restrictions)
APPH E4300x Applied Electrodynamics (optional but with restrictions)
APPH E4100x Quantum physics of matter (optional but with restrictions)

Spring

APMA E4101y Introduction to dynamical systems (optional but with restrictions)
APMA E4200y Partial differential equations (optional but with restrictions)

APMA E4150y Applied functional analysis (optional but with restrictions)
APMA E4301y Numerical methods for partial differential equations (optional but with restrictions)
APMA E4991y Applied Stochastic Analysis (optional but with restrictions)
PHYS GU4003y Advanced Mechanics (optional but with restrictions)

Discipline: Applied Mathematics: Atmospheric, Oceanic and Earth Physics

Fall

(Not Given) APPH E4200x Physics of Fluids
APMA E4200x Partial differential equations (optional)
APMA E4204x Functions of a complex variable (optional)
APMA E4300x Introduction to numerical methods (optional)
APMA E4001x Principles of applied math (optional)
APPH E4100x Quantum physics of matter (optional)
APPH E4300x Applied electrodynamics (optional)
CHAP E4120x Statistical mechanics (optional)
EESC GU4008x Introduction to atmospheric science

Spring

EESC GUE4210y Geophysical fluid dynamics
MECE E4100y Mechanics of Fluids (optional)
APMA E4101y Introduction to dynamical systems (optional)
APMA E4150y Applied functional analysis (optional)
APMA E4200y Partial differential equations
APMA E4991y Applied Stochastic Analysis (optional)
APMA E4301y Numerical methods for PDEs (optional)
PHYS GU4003y Advanced mechanics (optional)

Discipline: Applied Physics: Solid State/Optical Physics

Fall

APPH E6081x Solid State Physics I
APPH E4100x Quantum physics of matter
APPH E4300x Applied Electrodynamics
CHAP E4120x Statistical mechanics
APMA E4001x Principles of applied math (optional)
APMA E4200x Partial differential equations (optional)
APMA E4300x Introduction to numerical methods (optional)
APPH E4112x Laser physics (optional)

Spring
APPH E4110y Modern Optics
PHYS GU4003y Advanced mechanics
APMA E4200y Partial differential equations (optional)
APMA E4101y Introduction to dynamical systems (optional)
MSAE E4203y Theory of crystalline materials: electrons (optional)

Discipline: Applied Physics: Plasma Physics
Fall
APPH E4100x Quantum physics of matter
APPH E4300x Applied Electrodynamics
APPH E6101x Plasma physics I
APMA E4001x Principles of applied math (optional)
APMA E4200x Partial differential equations (optional)
APMA E4300x Introduction to Numerical Methods (optional)

Spring
APPH E6102y Plasma physics II
PHYS GU4003y Advanced Mechanics
APMA E4101y Introduction to dynamical systems (optional)
APMA E4200y Partial differential equations (optional)

Discipline: Materials Science and Engineering
Fall
MSAE E4100x Crystallography
MSAE E4200x Theory of crystalline materials: phonons
MSAE E4206x Electronic and magnetic properties of solids
APMA E4200x Partial Differential Equations (optional)
APMA E4001x Introduction to applied math (optional)

Spring
MSAE E4215y Mechanical behavior of materials
MSAE E4201y Materials thermodynamics and phase diagrams
MSAE E4202y Kinetics of transformations in materials
APMA E4200y Partial Differential Equations (optional)

Discipline: Medical Physics
Fall

APPH E4600x Fundamentals of Dosimetry
APPH E4100x Quantum physics of matter (optional)
APPH E4300x Applied electrodynamics (optional)
APMA E4101x Introduction to dynamical systems (optional)
APMA E4200x Partial differential equations (optional)
APMA E4300x Introduction to numerical methods (optional)

Spring
APPH E6319y Clinical Nuclear Medicine Physics
APPH E6330y Diagnostic Radiology Physics
APPH E6335y Radiation Therapy Physics
APMA E4001y Principles of applied math (optional)
PHYS GU4003y Advanced mechanics (optional)