

Ph.D. Written Preliminary Exam Purpose, Procedures, Policies and Format

- 1) The purpose of Ph.D. preliminary exam is to determine if a student is well prepared for pursuing Ph.D. study in the Department of Electrical & Computer Engineering.
- 2) The Ph.D. Written Preliminary Exam shall be administered by the ECE Graduate Committee Chair (GCC), or by his or her designee.
- 3) Students must take the exam during the first two semesters (excluding Spring/Summer session) of doctoral study. Failure to take the exam in the 2nd semester constitutes a failed attempt. Failure to take in the third semester constitutes a failed 2nd attempt and will result in dismissal from the Ph.D. program.
- 4) The exam shall be administered every Fall and Winter semester. It shall be administered in the Fall semester on the third Friday of November and in the Winter semester on the Friday after Spring Break.
- 5) The exam shall test three areas of specialization, consist of two three-hour sessions and administered on one day, A student must pass the exams administered during the two sessions to satisfy the preliminary exam requirement.
- 6) Students shall choose three of the ten areas of specialization listed below in which they will be tested; they must notify the GCC of their chosen areas no later than three weeks before the exam.
 - a) Communications;
 - b) Electromagnetic Fields and Waves;
 - c) Network Theory and Electronic Circuits;
 - d) Photonics;
 - e) Software Engineering;
 - f) Solid State Electronics;
 - g) Switching Theory;
 - h) Computer Organization;
 - i) Systems and Control; and
 - j) Mathematics;
- 7) Faculty serving on subcommittees in each of the areas of specialization selected by students shall submit two one-hour sets of questions for the exam, one set for the morning session and one set for the afternoon session.
- 8) There shall be a closed-book morning session from 9:00 a.m. to 12:00 noon that consists of three sets of questions for each student, one for each of the three areas of specialization that were chosen by the student. The questions shall address fundamental concepts in the areas of specialization. No materials other than writing instruments and student I.D. card shall be permitted. The GCC will proctor the exam and provide paper and calculators.

- 9) There shall be an open-book afternoon session of the exam from 2:00 p.m. to 5:00 p.m. that consists of three sets of questions for each student, one set for each of the three areas of specialization that were chosen by the student. The questions shall address advanced concepts in the areas of specialization. Students shall be permitted to bring reference books suggested by faculty. The reference books will be checked for inappropriate contents by GCC. No other materials than writing instruments and student I.D. card shall be permitted. The GCC will provide paper and calculators.
- 10) The Faculty shall grade the exams and meet within two weeks to discuss the performance of the students on the exam. They will judge the performance of each student to be either pass or fail. The GCC shall inform each student in writing of the outcome of the exam. Only pass or fail grades shall be reported to each student.
- 11) Students attempting the exam for the second time must be tested on the same three areas of specialization chosen by the student.
- 12) Each student must pass the Ph.D. Written preliminary exam in at most two attempts. A student who fails the first attempt must take the exam again the next semester. Failure to take the exam in the next semester constitutes a 2nd failure. Students who fail the exam twice will be dismissed from the Ph.D. program by ECE Graduate Committee. The committee's decision is final and cannot be appealed.

The Ph.D. Preliminary Topics

The knowledge level of the Ph.D. preliminary exam is at the ECE 4000 to 6000 course level. Below are listed the topics in the ten specialization areas of the Department of Electrical & Computer Engineering; the recommended courses and suggested references for providing a minimal background in the topics; and the faculty coordinators for each area of specialization. The coordinators are recommended by the ECE Graduate Committee and appointed by the chair of the department. The coordinators design and grade the exam, and make recommendations to the Graduate Committee regarding student performance.

Communications

Coordinators: Professors Y. Zhao (in charge), and John Liu

Applicants planning on taking this exam should expect to be tested on the following topics:

1. Fourier series and Fourier transform
2. Frequency response of linear systems
3. Discrete and continuous probability distributions and their characteristic functions
4. Stationary random processes
5. Auto correlation, cross correlation, and power spectral density
6. Convolution Theorem
7. Sampling Theorem
8. PCM, DM, DPCM
9. AM & FM
10. Digital Modulation Techniques
11. Error Control Coding

12. Introduction to Communication Networks

WSU courses recommended as providing a minimal background in the above topics are: ECE4700, and ECE5700

Suggested reference:

S. Haykin, *Communication Systems*, latest Ed, John Wiley

(2) Electromagnetic Fields and Waves

Coordinators: I. Avrutsky (in charge), and J. Woodyard

Applicants planning to take this exam should expect to be tested in the following major topics:

1. Electrostatics:

- (i) Static electric field and scalar potentials (Coulomb's and Gauss's laws)
- (ii) Electrostatic boundary conditions
- (iii) Electrostatic energy and forces
- (iv) Application (computation of fields, potentials, energy, capacitance, etc.)

2. Magnetostatics:

- (i) Static magnetic fields and vector potentials (Biot-Savart's law)
- (ii) Boundary conditions
- (iii) Magnetic energy, forces, and torques
- (iv) Magnetic dipoles, magnetization, and magnetic circuits
- (v) Applications (computation of fields, energy, forces, inductance, etc.)

3. Steady Electric Currents:

- (i) Current density and Ohm's law
- (ii) Electromotive force and Kirchhoff's voltage law
- (iii) Equation of continuity and Kirchhoff's current law
- (iv) Boundary conditions for current density
- (v) Applications (computations of currents, power dissipation, resistance, etc.)

4. Electrodynamics:

- (i) Time varying fields and Maxwell's equations
- (ii) Electromagnetic wave boundary conditions
- (iii) Wave equations and their solutions
- (iv) Plane waves and propagation
- (v) Reflection and refraction of plane waves at a dielectric interface
- (vi) Flow of electromagnetic power (Poynting vector)

Mathematical background in vector algebra, integral calculus, and differential equations is assumed.

The WSU course recommended as providing a minimal background in the above topics is ECE 4800

References:

1. D. K. Cheng, *Fundamentals of Engineering Electromagnetics*, Addison-Wesley, 1993
2. L. C. Sheng, J. A. Kong, *Applied Electromagnetism*, 3rd ed., Prindle, Weber, and Schmidt, 1995
3. W. Hayt, *Engineering Electromagnetics*, 5th ed., McGraw-Hill, 1989

(3) Network Theory and Electronic Circuits

Coordinators: M. H. Hassoun (in charge), R. Erlandson, M. Cheng, A. Basu, and Y. Xu

Students are allowed one textbook and a scientific calculator. No other material is permitted during the exam. No sample exam questions are provided.

Applicants planning on taking this exam should expect to be tested on the following topics:

1. Analysis of general linear passive/active circuits:
 - (i) Formulation of network equations (nodal and mesh formulation)
 - (ii) Time domain analysis (complete response, impulse response, etc)
 - (iii) Sinusoidal steady state analysis (Phasor analysis)
 - (iv) Fourier analysis
 - (v) Frequency domain (s-domain) analysis: Laplace Transform analysis technique, transfer functions, complex-frequency plane, etc.
 - (vi) Power computations
2. Passive Network Synthesis:
 - (i) Tellegen's Theorem and positive real functions (Hurwitz polynomials)
 - (ii) Driving point synthesis (synthesis using partial fraction expansion)
 - (iii) Transfer function synthesis (unterminated and singly terminated ladder networks)
3. Basic Active Filter Synthesis:
 - (i) Synthesis using inductance simulation
 - (ii) Cascade realization
 - (iii) Coefficient matching techniques

WSU courses recommended as providing a minimal background in the above topics are: ECE3300, ECE3330, ECE3570, ECE4330, and ECE5310

Suggested references:

1. Dorf and Svoboda, *Introduction to Electric Circuits*, 5th ed., John Wiley, 2001.
2. G. Daryanani, *Principles of Active Network Synthesis and Design*, John Wiley, 1976
3. D. Schilling & C. Belove, *Electronic Circuits: Discrete and Integrated*, 2nd Ed, McGraw-Hill, 1979

(4) Photonics

Coordinators: I. Avrutsky (in charge), and Y. Zhao

Applicants planning to take this exam should have a background in the following major topics:

1. Geometrical optics, Snell's law, total internal reflection.
2. Wave propagation, diffraction, interference.
3. Optical waveguides, fiber and integrated optics.
4. Semiconductor light sources and detectors.
5. Optoelectronic devices for communication applications: couplers, filters, multiplexers/demultiplexers, switches, routers, wavelength converters, amplifiers.
6. Multiplexing technologies: WDM, TDM, CDMA

WSU courses recommended as providing a minimal background in photonics are ECE 4850 and ECE 5870. Electromagnetic fields and waves are also covered by ECE 4800.

Suggested references:

1. G. Keiser, *Optical Fiber Communications*, 3rd ed., McGraw-Hill, 2000.
2. R. Ramaswami, K. N. Sivarajan, *Optical Networks, A Practical Perspective*, 2^d ed., Morgan Kaufmann, 2002.

(5) Software Engineering

Coordinators: Professors N. Sarhan, H. Singh (in charge), J. Song, and C. Xu

Applicants planning on taking this exam should expect to be tested on the following topics:

1. Planning Phase:
 - (i) Life cycle approach to Software Engineering
 - (ii) Myths & Realities in Software Engineering
 - (iii) Cost estimates in Software Engineering: Feasibility study; cost benefit analysis; lines of code; costing techniques

- (iv) Requirement analysis and Specifications
- 2. Development Phase
 - (i) Data Flow diagrams & Structure diagrams: Stepwise refinement; top down and bottom up approaches
 - (ii) Transform flow and Transaction flow
 - (iii) Software Structure, Cohesion and Coupling
 - (iv) Software Metrics: Software Complexity: McCabe's complexity, Halstead software science; software reliability; software security
 - (v) Software coding, testing, structured languages, code efficiency and code reliability
- 3. Maintenance Phase
 - (i) Importance of Software Maintenance and Structured languages
 - (ii) Maintainability
 - (iii) Maintenance tasks
 - (iv) Maintenance side effects
 - (v) User Manual
- 4. New Approaches in Software Engineering
 - (i) Object Oriented Design
 - (ii) Portability and Reusability of Software

WSU courses recommended as providing a minimal background in the above topics are: ECE5600 and ECE6600

Suggested reference:

R.S. Pressman, *Software Engineering*, McGraw-Hill, 1987

(6) Solid State Electronics

Coordinators: Professors G. Auner, X. Han (in charge), M. Cheng, and A. Basu,

Applicants planning on taking this exam should expect to be tested on the following topics:

1. Crystal Properties and Growth of Semiconductors
2. Atoms and Electronics
3. Energy Bands and Charge Carriers in Semiconductors
3. Excess Carriers in Semiconductors
4. Junctions
5. p-n Junction Diodes
6. Bipolar Junction Transistors
7. Field-Effect Transistors

WSU courses recommended as providing a minimal background in the above topics are: ECE4570 and ECE5550

Suggested reference:

B. G. Streetman, *Solid State Electronic Devices*, Prentice Hall, New Jersey

(7) Switching Theory

Coordinators: Professors H. Singh (in charge) and P. Siy

Applicants planning on taking this exam should expect to be tested on the following topics:

1. Selected Topics from Combinational Circuits
 - (i) Minimization of Multiple Output Combinational Circuits
 - (ii) Special Classes of Combinational Functions: Symmetric Functions; Unate Functions; Threshold Functions
2. Selected Topics from Synchronous Sequential Circuits
 - (i) Synthesis of Synchronous Sequential Circuits
 - (ii) Simplification of Completely and Incompletely Specified Machines
 - (iii) Structure of Sequential Machines: State Assignments
 - (iv) Linear Sequential Circuits: Analysis and Synthesis of Linear Sequential Circuits
3. Selected Topics from Asynchronous Sequential Circuits
 - (i) Analysis and Synthesis of Asynchronous Sequential Circuits
 - (ii) Simplification of Asynchronous Sequential Circuits

- (iii) State Assignment in Asynchronous Sequential Circuits
- (iv) Identification of Linear Sequential Machines
- (v) Delay Transfer Function Matrix

WSU courses recommended as providing a minimal background in the above topics are: ECE3610 and ECE5680

Suggested references:

1. M. Mano, *Digital Design*, Prentice-Hall, 1984
2. Z. Kohavi, *Switching and Finite Automata Theory*, McGraw-Hill, 1978

(8) Computer Organization

Coordinators: Professors C. Xu (in charge), S. Mahmud, N. Sarhan, J. Song, and A. Pandya

Applicants planning on taking this exam should expect to be tested on the following topics:

- Instruction set architecture
- Computer arithmetic and ALU
- Processor design (data path and control unit)
- Pipelining
- Hierarchical memory systems
- Storage systems
- Input/output devices and interfaces
- Basics of multiprocessor systems
- Performance evaluation of computer systems

WSU courses recommended as providing a minimal background in the above topics are: ECE4610, ECE4680, and ECE5620.

Suggested references:

J. Hennesey and D. Patterson, *Computer Organization and Design: The Hardware/Software Interface*, Morgan Kaufman, Third Ed.

(9) Systems and Control

Coordinators: Professors F. Lin, L. Y. Wang, and H. Ying (in charge)

Applicants planning on taking this exam should expect to be tested on the following topics for both continuous-time and discrete-time systems:

1. System Representation
2. Control System Characteristics
3. Frequency Response
4. Closed-Loop Tracking and Disturbance Rejection
5. Root-Locus Techniques
6. Cascade and Feedback Compensation
7. Structural Properties of Linear Systems
8. State Variable and Output Feedback
9. Synthesis of Linear Regulators, Observers and Trackers
10. Parameter Sensitivity
11. Lyapunov's Second Method
12. Optimal Control Using a Quadratic Performance Index

WSU courses recommended as providing a minimal background in the above topics are ECE4470, ECE5440, and ECE5470.

Suggested references:

1. K. Ogata, *Modern Control Engineering*, 4th Edition, Prentice Hall, 2002.
2. K. Ogata, *Discrete-time Control Systems*, 2nd Edition, Prentice Hall, 1995.

(10) The Mathematics Preliminary Exam:

Coordinators: Professors I. Avrutsky, Y. Xu, H. Ying (in charge), and John Liu

Applicants planning on taking this exam should expect to be tested on the following topics:

Calculus

1. limits and continuity
2. derivatives and partial derivatives
3. monotonicity
4. extremes of functions (one variable and multiple variables)
5. definite integral
6. indefinite integral
7. double and triple integrals
8. sequences and series
9. linear ordinary differential equations
10. applications (one variable and multiple variables)

WSU courses providing a minimal background in the above topics are: MAT 2010, MAT 2020, MAT 2030, and MAT 2150

Suggested references:

James Stewart, *Calculus, Early Transcendentals* (6th edition), CENGAGE L, 2008.

R. Nagle, *Fundamentals of Differential Equations* (7th edition), Pearson, 2008.