ECE PhD Technical Qualifying Exam Rules

The TQE tests knowledge of fundamental concepts in a particular technical area. Students select one of four areas for their TQE:

**Area 1: Control Theory**
**Area 2: Digital Design and Computer Organization**
**Area 3: Electronics and Circuits**
**Area 4: Signals and Systems**

The required material for each area is detailed in the following pages. The TQE is offered once a year in January before the start of the Spring semester. Students entering the program with a BS or an MS are required to take the TQE the first time it is offered after they have entered the program. A student who fails the exam will have a second and final chance to pass the exam in the following year. A student who obtains a marginal passing grade in the first attempt of the TQE will be required to take an oral exam in the same area within the subsequent four weeks. The oral exam will be administered by two ECE faculty members. A student who passes the oral exam will satisfy the TQE requirement. A student who fails the oral exam will either be dismissed from the program, or be allowed to take the written exam for the second and final time when it is offered in the following year.

The scope of the TQE is comparable to a final exam in a graduate course. Students have up to 3 hours to complete the TQE. The TQE is closed book and closed notes with no electronic devices of any kind allowed. If needed, the department will provide students with basic scientific calculators. Copies of old exams are available in the department office.

Outstanding students may be exempt from the TQE if they meet the requirements of their area as described in the following sections.
Area 1: Control Theory

Topics:

1. Classical Control Theory
   • Transfer Function
   • Block Diagrams
   • First-Order and Second-Order Systems
   • Root Locus Analysis
   • Polar Plots and Bode Plots
   • Routh and Bode Stability Criterion
   • Compensator Design

2. Modern Control Theory
   • State-Space and Input-Output Models
   • Classification of Linear Systems
   • Linear System Response
   • Internal and External Stability
   • Controllability and Observability with Special Forms
   • Realization Theory and Algorithms
   • State Feedback and Observer-Based Output Feedback

Suggested References


Comments

1. Students may benefit from ECE 421 and ECE 521 in preparing for the qualifying exam.
2. Both ECE 521 and ECE 528 are fundamental to the Control area Students are encouraged to take these two courses in their first semester.
3. Students who obtain at least an A in ECE 521 and in ECE 528 will be exempt from the TQE. This rule applies if the courses were taken within the 24 months preceding the first attempt at the TQE, or within the 12 months after the student has failed the TQE in the first attempt. This rule does not apply if the student was dismissed from the program following an oral TQE, or if the student has failed the written TQE twice.
Area 2: Digital Design and Computer Organization

The exams span three areas in computer engineering: 1) computer architecture 2) digital design and 3) mobile systems. All CpE students are required to take the computer architecture area exam and have a choice between Area 2 and Area 3. A total of only two areas may be attempted.

Topics:

1. Computer Architecture
   - Processor Pipelining
   - Cache Subsystem
   - Memory Hierarchy
   - Processor Performance Evaluation
   - Memory Technology
   - Virtual Memory
   - I/O and Bus
   - Instruction Set Architecture

2. Digital Design
   - Boolean Algebra
   - Digital Circuit Design
   - Modeling Digital Circuits in VHDL
   - Computer Arithmetic

3. Mobile Systems
   - Mobile Operation System
   - Mobile Display, Mobile Sensor, Mobile Network
   - Mobile Network Deployment
   - Mobile Machine Learning Framework
   - Mobile Interaction

Suggested References:


Comments

- Students may benefit from ECE 511 and ECE 545, and from ECE 516 if they choose Area 3--Mobile System and Applications, in preparing for the qualifying exam. Students are encouraged to take these courses in their first semester.
- Students who obtain at least an A in ECE 511 and in either ECE 545 or ECE 516 will be exempt from the TQE. This rule applies if the courses were taken within the 24 months preceding the first attempt at the TQE, or within the 12 months after the student has failed the TQE in the first attempt. This rule does not apply if the student was dismissed from the program following an oral TQE, or if the student has failed the written TQE twice.
Area 3: Electronics and Circuits

The qualifying exam in a given year, normally offered at the end of the fall semester, will focus on two of the four areas below. The corresponding material will be covered in two of the following courses: ECE 584, ECE 586, ECE 587 and ECE 684, and these two courses will be offered in the fall semester immediately preceding the exam.

Topics:

1. Semiconductor Theory:
   - Semiconductor Crystal Structures
   - Energy Band Model, Electrons and Holes
   - Carrier concentrations at Different Temperatures and Doping
   - Thermal Motion, Drift and Diffusion current
   - Einstein Relationship between Diffusivity and Mobility
   - Electron-Hole Recombination and Thermal Generation

2. Semiconductor Devices:
   - PN Junction Theory
   - Reverse-Biased and Forward-Biased PN Junctions
   - Capacitance-Voltage Characteristics
   - Carrier Injection and Excess Carriers
   - Bipolar Transistors: Model and Current
   - Bipolar Transistors: Base-Width Modulation
   - MOS Transistors: Model, Current and Short-Channel Effects

3. Digital Circuits:
   - MOSFET Operation
   - CMOS Inverters: Static and Dynamic Operation
   - Combinational MOS Logic Circuits
   - Sequential CMOS Logic Circuits

4. Analog Circuits:
   - Differential Amplifiers
   - Passive and Active Current Mirrors
   - Operational Amplifiers
   - Stability and Frequency Compensation of Amplifiers
   - Switched-Capacitor Circuits

Suggested References:


Comments:

- Students are encouraged to take the relevant two courses in the fall semester immediately preceding the qualifying exam.
- Students who obtain at least an A in the two courses offered in the Fall semester preceding their first TQE date will be exempt from the TQE. This rule applies if the courses were taken within the 24 months preceding the first attempt at the TQE, or within the 12 months after the student has failed the TQE in the first attempt. This rule does not apply if the student was dismissed from the program following an oral TQE, or if the student has failed the written TQE twice.
Area 4: Signals and Systems

Topics:

1. Continuous and Discrete-Time Deterministic Signals
   - Fourier Series
   - Fourier Transform
   - Unilateral Laplace Transform
   - Classifications of Linear Systems
   - Representation of Linear Systems by Linear Differential Equations
   - Transfer Function
   - State Variables
   - Stability: Asymptotic and BIBO
   - Impulse Response
   - Convolution
   - Frequency Domain Representation
   - Steady State Response
   - Z-Transform
   - Sampling
   - Discrete Fourier Transform

2. Random Signals
   - Random Variables
   - Common Distributions (Bernoulli, Binomial, Poisson, Geometric, uniform, Negative Binomial, Exponential, Normal)
   - Multiple Random Variables
   - Jointly Gaussian Random Variables
   - Conditional Distributions and Densities
   - Total Probability and Bayes Rule
   - Mean, Variance and Conditional Mean of random Variables
   - Transformation of Random Variables
   - Gaussian Random Processes and their Transfer through Linear Systems

Suggested References:

- Y. Ephraim, Class Notes in ECE 528: Introduction to Probability and Random Processes in ECE. Notes are sold (Mason Money only) by the department (at the Tech Shop - ENGR 3916) for nominal fee of about $10.00 to cover printing costs.

Comments

- Students may benefit from ECE 220 and ECE 528 in preparing for the qualifying exam.
- Students are encouraged to take ECE 521 or ECE 535, and ECE 528, in their first semester.
- Students who obtain at least an A in ECE 521 or ECE 535, and in ECE 528, will be exempt from the TQE. This rule applies if the courses were taken within the 24 months preceding the first attempt at the TQE, or within the 12 months after the student has failed the TQE in the first attempt. This rule does not apply if the student was dismissed from the program following an oral TQE, or if the student has failed the written TQE twice.