**General Information for EE Exam**

The Electrical Engineering Qualifying Exam is divided into a morning session and an afternoon session. Each session is of three hour duration. Each student, when they register for the exam will select 4 specialization areas for the morning exam and 3 specialization areas for the afternoon exam. Students will only be provided problems for the areas selected. Possible specialization areas that can be chosen include all emphasis areas of electrical engineering (Circuits/Electronics; Communications/Signal Processing; Control Systems; Electromagnetics/Devices/Optics; and Power/Machinery) and no more than one single emphasis area of computer engineering (Computer Architecture, Integrated Circuit & Logic Design, Embedded Computer Systems; Computational Intelligence; or Network and Software Engineering). Students are not required to choose a specialization area from computer engineering.

The morning session problems are selected to cover fundamental material in electrical engineering. As a general rule, basic material from undergraduate and 5xxx-level courses will be covered although some material, of a fundamental nature, may be from 5xxx-level courses. The problems are designed so that each problem should take approximately 15-20 minutes to work. The student is required to work any eight of the sixteen problems. The sixteen problems will consist of four problems from each of the four areas selected.

The afternoon session problems are selected to be more in-depth in order to demonstrate proficiency in an area. The problems will take approximately 30 minutes each to work. In general, the afternoon session problems will be over material from 5xxx-level and 6xxx-level courses. The student is required to work any five of the twelve problems. The twelve problems will consist of four problems from each of the three areas selected.

**Reference Material**

No reference material is allowed. The only items students are allowed to bring to the exam are pencils, pens, erasers, and calculators. Extra answer sheets will be provided by the exam proctor upon request. Extra calculator batteries or other supplies will not be available from the exam proctor. In order to keep track of the amount of time remaining during the exam each student should bring his or her own watch.

**Grading for PhD Exam**

Each problem on the EE exams will be graded by the faculty member who wrote the problem. Generally, partial credit is given. A percentage grade is given for each of the eight morning problems and each of the five afternoon problems. The average percentage grade for each exam is determined by averaging eight scores for the morning session and five scores for the afternoon session.

An average score of 80% on both the morning and afternoon EE sessions is usually sufficient to pass the PhD Qualifying Exam.

Scores on the morning and afternoon EE sessions for each student will be reviewed by the EE PhD Committee consisting of three EE Faculty. The Committee will determine if each
student passes or fails each session. Results of the exam, indicating "pass or fail" will be mailed to students approximately two weeks after the exam is given.

Students who fail the PhD Exam on their first attempt will be given a second opportunity to pass the exam when it is given in the following semester. Students who fail the morning or afternoon session but not both, need only to retake the session failed. Students who fail the exam once and do not take the exam in the subsequent semester will no longer be considered degree candidates in this department.

A candidate who fails the ECE Ph.D. Qualifying Exam on two consecutive tries may file a written petition with the ECE Graduate Studies Committee for a third attempt. The petition must include at least three faculty recommendations, documentation of academic and research progress, and documentation of extenuating circumstances. The ECE Graduate Studies Committee will vote, by simple majority, to approve or deny the petition. If the petition is approved, it will be forwarded to the Office of Graduate Studies as a request to waive the requirement for passing the Ph.D. Qualifying Exam by the end of the second semester after completion of the M.S. degree.

**Additional Information**

The following material, broken down by area, is intended to provide you with more information on the exam. Previous PhD Qualifying Exam problems are now posted on the department web site at [http://ece.mst.edu/usefullinks/qualifyingexams.html](http://ece.mst.edu/usefullinks/qualifyingexams.html).

1. **Circuits/Electronics:**

   The morning session covers basic concepts and problems in circuit theory and electronic circuits:
   
   a. theorems, such as superposition, reciprocity, Thevenin's, Norton's, maximum power transfer, and Tellegen's;
   
   b. methods for writing linearly independent equations for circuits, such as loop-current, node-voltage, and state equations;
   
   c. characterizations of a network, such as the two-port parameters (z, h, chain, etc.), the indefinite admittance matrix, and the scattering matrix;
   
   d. DC (operating point and/or transfer characteristics) and AC (magnitude and/or phase frequency response) steady-state and transient solutions of various circuits;
   
   e. circuits may contain R's, L's, C's, coupled coils, transmission lines, independent and controlled sources, bipolar transistors, JFET's, MOSFET's, nullors, NIC's, GIC's gyrators, etc.;
   
   f. circuits may be in any of the standard configurations, such as amplifiers (difference, operational, etc.), or gates (TTL, ECL, etc.).

   The afternoon session covers the same material as the morning session but to a more thorough and fundamental degree. For example, the circuit for which it was required to write the state equations in the morning session would likely be linear and time invariant and contain no capacitive loops nor inductive cutsets; but in the afternoon session any or all of the above
characteristics might be reversed. In addition, the afternoon session may include problems involving:

a. design of the bias and/or coupling circuit(s) for any of the devices in any of the amplifier configurations listed above;
b. synthesis of active and/or passive circuits;
c. Butterworth and Chebyshev approximation functions and frequency transformations;
d. fundamental concepts, such as positive real functions (definition and testing), stability, sensitivity, and the effects of positive and negative feedback and feed forward;
e. design of transmission-line matching circuits for high frequency amplifiers.
f. radio frequency (rf) circuits and power electronics.

2. **Communications/Signal Processing:**
Problems will be selected from the areas of:

* Linear System Theory, topics may include, but are not limited to: Laplace Transforms, Fourier Transforms, Linear Time-Invariant Filters, Fourier Series.

* Digital Signal Processing, topics may include, but are not limited to: Sampling Theory, Basic Z-transform theory, LTI Filter design, Discrete Fourier Transforms, Discrete Time Fourier Transforms, Fast Fourier Transforms

* Analog Communications, topics may include, but are not limited to: AM, FM, PM, VSB, SSB, frequency translation, superheterodyne receivers

* Digital Communications, topics may include, but are not limited to: amplitude, phase and frequency modulated signals, signal space, typical modulation and demodulation structures, performance of digital communication systems in AWGN channels, function of all basic elements in a digital communication system

* Probability and Stochastic Processes, topics may include, but are not limited to: Definitions of Probability, independence, orthogonality, Bayes Theorem, total probability, pdf, CDF, moments, characteristic functions, orthogonality principle, correlation matrices and functions, stationarity, PSD, filtering stochastic processes, PSD estimation, Markov Chains.

Morning problems will focus only on the first four topics (Linear System Theory, DSP, Analog and Digital Communications) and will not cover probability or stochastic process theory.
Afternoon problems may be selected from any of the 5 areas listed above.
3. Control Systems:

The intent of the morning session is to examine the general background and understanding of classical and modern control system analysis and design techniques. Topics covered in a first course in classical control (EE 3320) and a first course in digital control (EE 5300) should be reviewed. Such topics would include (for EE 3320), but are not limited to:

1. System modeling
2. Steady state errors
3. Stability analysis
4. Transient response analysis
5. Controller/Compensator design

Suitable review texts might include those by Phillips/Harbor, Dorf, Hostetter/Savant/Stefani, Franklin/Powell/Emami-Naeini, Kuo, or Ogata.

For EE 5300, morning problems would be expected to cover the more elementary concepts of:

a. Representation of discrete-time systems, including state variable representations
b. Transient response and error analysis of discrete-time systems
c. Design of controllers and compensators using root locus and pole placement techniques
d. Controllability and observability
e. General Linear System Theory.

Suitable review text might include the Digital Control texts by Phillips/Nagel, Kuo, or Franklin/Powell.

The afternoon session is designed more for the student specializing in control and system theory. It would include more challenging problems covering morning session topics as well as more advanced topics from EE 6300 such as:

a. System realizations and transformation of variables
b. MIMO System Theory
c. Advanced control law design
d. General Linear System Theory.


This information is provided to the student for general guidance. It should not be construed as representing an exhaustive set of exam topics.
4. Electromagnetics/Devices/Optics:

This area includes electromagnetics and physical electronics. The morning session problems in this area are chosen from topics normally covered in EE 3600 (Fields and Waves I), and EE 3250 (Electronic & Photonic Devices), as well as topics covered in any prerequisite courses.

Typical topics discussed in EE 3600 include:
- a. Coulomb's law and Gauss's law
- b. Biot Savart law and Ampere's law
- c. Laplace's and Poisson's equations
- d. Energy, work, and potential
- e. Electric and magnetic properties of materials including boundary conditions, capacitance, resistance and inductance
- f. Electromagnetic waves
- g. Transmission lines.

Typical topics covered in EE 3250 include:
- a. Fermi statistics and band theory
- b. Electronic processes in materials
- c. Optical processes in materials
- d. P-n junction theory
- e. MOS theory
- f. Junction diodes, bipolar transistors, field effect transistors and optical devices.

Suggested review texts for the morning session problems in this area are:
2. William H. Hayt, Jr./John A. Buck: Engineering Electromagnetics

Three of four afternoon session problems are based upon topics covered in EE 6600, (Advanced Engineering Electromagnetics) and EE 6200 (Electromagnetic Optics) as well as topics covered in all prerequisite courses.

Typical problems based on EE 6600 might involve concepts such as:
- 1. Electromagnetic wave propagation in rectangular, cylindrical or spherical coordinates
- 2. Polarization and antisotropic electromagnetic materials
- 3. Radiation and scattering problems
- 4. Various equivalence theorems.

Typical problems based on EE 6200 (Electromagnetic Optics) topics might include concepts as:
- 1. Polarization of optical waves
- 2. Optical propagation in birefringent materials
Suggested review texts for these three courses (EE 6600 and EE 6200) are:

5. Saleh and Tiech, *Fundamentals of Photonics*

The fourth afternoon session problem will be based upon topics covered in one or more of the following courses:

1. EE 5600 (Grounding and Shielding)
2. EE 5640 (Antennas)
3. EE 5660 (Microwave Theory and Techniques).
4. EE 6260 (Integrated Microsystems Engineering).

Suggested review texts for EE 5600, EE 5640, and EE 5660 are course textbooks.

Typical problems based on EE 6260 might include:

1. Microfabrication and micromachining technology
2. Typical MEMS device structures based on poly-silicon layers and oxide layers
3. Principles of mechanical, optical, and biochemical transduction mechanisms in microsensors and microactuators

Suggested review texts:


5. **Power/Machinery:**

The morning session will include one or more problems on the basics of power system analysis, such as is taught in EE 3540. Subjects include:

a. 3-phase ac circuit analysis, per unit representative
b. Transmission line basics
c. Transformer, generator, motors as system components
d. Unbalanced systems and symmetrical components
e. System representation and basic power flow analysis
f. Fault analysis.

The morning session will also include one or more problems on the basics of electrical machines and transformers (basically EE 3500 material). Subjects include:

a. Basic magnetic circuits
b. Energy Conversion
c. Synchronous, induction, and brushless dc machines
d. Transformers.
The morning session may also include problems from the following courses:

b. Distribution System design and protection to include fuse, breaker, relay coordination studies. (EE 5560)

The four problems for the afternoon session will be on specific and more advanced topics of power systems, which are covered in the graduate power courses. Subjects include:

a. Electrical Machines - A more detailed study of different types of machines, with emphasis on advanced machine theory. (EE 5500, EE 6500)
b. Electronic Drives & Compensation - A study of machine drives, and FACTS Devices for power transmission and distribution. (EE 4001)
c. Power Electronics - A study of power semiconductor devices applied to rectifiers, converters, and inverters. (EE 5520)
d. Economic operation of Power Systems - Application of optimization methods to minimize cost of generation (includes optimal power flow). (EE 6580)
e. Computer Methods are studied and applied to power system analysis. (EE 6540)
g. Power System Stability - A study of transients in power systems and solutions to stability problems. (EE 6550)
g. Power system reliability and surge phenomena (EE 6530)
h. Power system electrical transients (EE 6570)
i. Power system protection (EE 6560).

Computer Engineering: Students choosing a specialization area from computer engineering should see the guidelines for the computer engineering qualifying exam.