The Preliminary Examination for Prospective Doctoral Students in Mechanical Engineering

SCHEDULE FOR PRELIMINARY EXAMINATIONS

EXAMINATION	PROCTOR	DATE	TIME	ROOM
HEAT TRANSFER	*Prof.* Grigoropoulos	19-Aug	10:00 A.M. - NOON	Zoom
FLUIDS	*Prof.* Savas	19-Aug	10:05 A.M. - 12:05 P.M	Zoom
DESIGN	*Prof.* Lieu	19-Aug	10:05 A.M. - 12:05 P.M	Zoom
LUNCH BREAK				
CONTROLS	*Prof.* Mueller	19-Aug	2:00 P.M. - 4:00 P.M.	Zoom
MATERIALS	*Prof.* Keaveny	19-Aug	2:05 P.M. - 4:05 P.M.	Zoom
MECHANICS	*Prof.* Casey	19-Aug	2:10 P.M. - 4:10 P.M.	Zoom

POLICY AND PROCEDURES

A. Introduction:

This is the policy pertaining to the Doctoral Preliminary Examination. Please read it carefully for answers to questions you may have concerning the examination. You must take and pass the Preliminary Examination to be considered eligible for the PhD program.

B. Objective:

The objective of the Preliminary Examination is the early assessment of a student's potential for satisfactory completion of the doctoral degree. The exam is entirely closed books and notes.

All students admitted to the PhD program are required to take the Preliminary Examination only in their selected major field. Students who enter with a declared MS degree goal and wish to petition for a change in degree goal to PhD or DEng must pass the Preliminary Examination before such petitions can be approved. Change of degree goal petitions must be filed before completion of the MS degree requirements and must be approved if a student is to register beyond the MS degree.

C. When to Take the Preliminary Examination?

Whether you have been admitted into the ME program with either a BS or MS degree, the earliest you may take the Preliminary Examination is after one registered semester of graduate coursework completed at the University of California at Berkeley.

The examination will be given twice a year, the first week of the Spring and Fall semesters. The examination must be taken following two semesters of registration as a graduate student at the latest. Some flexibility is allowed for students who do not have undergraduate degrees in Mechanical Engineering or closely related areas. These students may petition the Preliminary Examination Committee to take the examination at a later than normal time.

The Preliminary Examination results are valid for five (5) years.

D. Eligibility:

All students must have a minimum graduate GPA of **3.3** overall and **3.5** in their major field from courses taken at the University of California at Berkeley to take the Preliminary Examination.

At least two-third of the units (excluding courses with S/U grading option only such as ME 298, 299, 301) or two courses per semester must be taken for a letter grade prior to taking the Preliminary Examination. It is noted that 5 courses in the major field area and 2 courses in each of the minor field areas must eventually be taken for a letter grade to meet the doctoral degree requirements.

If your major field is not included in the list of Preliminary examination areas, you must declare an area as your major field for the purpose of satisfying the exam requirement from that list at least one week before the beginning of the Preliminary Examination. You may take the exam of your choice in the area(s) that may align with your research interests

Candidates who do not meet the above requirements will automatically fail their first attempt.

E. Registration Procedure:

Sign up for the Preliminary Examination online by the first Monday of March for Fall examination and the first Monday of October for Spring examination. MS students who intend to change their degree goal must complete the paper form and turn it to the Student Services Office (6189 Etcheverry Hall) by same deadline.

After you sign-up for the exam, you will be assigned an identification number, which you will use to identify your examination paper. REMEMBER IT! Students are responsible for obtaining information regarding the date, time, and location of the exam.

F. Exceptions to Preliminary Examination

Petitions for exceptions should be addressed to the Chair of the Preliminary Examination Committee, and delivered to Mr. Yawo D. Akpawu in 6189 Etcheverry Hall

no later than the first Friday of May for Fall examination and first Friday of December for Spring examination. Petitions are considered only in cases of serious extenuating circumstances that are beyond the student's control and are decided on a case-by-case basis. The committee reserves the right to impose any requirements that it deems necessary. Supporting evidence should be submitted with the petition.

G. Results

The Preliminary Examination Committee will meet approximately one week after the last exam to discuss and finalize the results of the exam. The final decision will then be emailed to the students and posted on the online Graduate Student database. The results of the examination will be one of the following:

Pass: This means that you continue in the doctoral program (for change of degree goal candidates, admit to doctoral program). You can then start preparing for the PhD Oral Qualifying Examination, which you must take no later than the end of the 4th year of your study in the PhD program.

Not Pass: The Committee will decide whether or not such students may take the examination a second time. The examination may not be taken more than twice.

Candidates must pass their proposed or designated doctoral major field.

If a student decides to change major field after passing the Preliminary Examination in a certain area, then he/she will have to pass the Preliminary Exam in the designated new major field to continue in the doctoral program.

A student may request to review the graded exam and solutions to the exam problems by contacting the major field advisor of the particular exam.

H. Topics & Courses Covered

Students may wish to familiarize themselves with the syllabi of the following course(s) listed for their exam, which are generally indicative of the exam coverage as further clarified below.

1. CONTROLS	MEC134, ME C232
2. DESIGN	ME102B, ME110, & prerequisites
3. DYNAMICS	ME 104, ME 175
4. FLUID MECHANICS	ME 106
5. HEAT TRANSFER	ME 109
6. MATERIALS	ME C85, ME 108
7. SOLID MECHANICS	ME 185
8. THERMODYNAMICS	ME 40, ME 254

I. Areas, Topics

Area 1: CONTROLS

Questions will be drawn from the following list of topics:

- Linear control system analysis and design in the frequency and time domain.
- Derivation of state equation and transfer functions for mechanical and mechatronic systems.
- Derivation of the characteristic equation and Root locus and Routh-Hurwitz stability conditions.
- Nyquist and Bode frequency response plots and Nyquist stability theorem.
- Compensator design using time domain and frequency response techniques.
- State space and transfer function description of continuous time and discrete time dynamic systems.
- Solutions of linear state equations. Discrete time models of continuous time systems.
- Stability of linear systems and the Lyapunov equation.
- Controllability and Observability.
- State feedback and state observers, the separation principle.
- Continuous time linear quadratic regulators (LQR). Riccati equations, symmetric root locus. Guarantee gain and phase margins.

Area 2: DESIGN

Questions will be drawn from the following list of topics:

- Product design (customer-driven design and design for assembly, manufacture, and environment).
- Machine design (design applications of dynamics, force, mass, displacement, velocity, acceleration, energy, momentum, the kinematics of planar motion; mechanics of materials; static failure; fatigues failures.)

Area 3: DYNAMICS

Questions will be drawn from the following list of topics:

- Planar and 3-D kinematics of systems of particles and rigid bodies.
- Stationary and moving reference frames, coordinate transformations, linear and angular momentum, energy methods, impulsive motion (linear and angular).
- Lagrange's equations.
- Mechanical vibration of systems with one or two degrees of freedom.

Area 4: FLUID MECHANICS

Questions will be drawn from the following list of topics:

- Boundary conditions on fluid motion.
- Control volume formulation of problems involving mass, momentum and energy balances.

- Boundary layers. Similitude.
- Steady compressible flow: isentropic flow, shock waves.
- Dimensional analysis principle, Bernoulli.
- Potential flow, sources and sinks, point vortices.

Area 5: HEAT TRANSFER

Questions will be drawn from the following list of topics:

- Conduction: Steady and transient. 1D and multidimensional. Separation of variables. Similarity solutions.
- Convection: Basic principles. Control volume analysis. Internal and external flows. Thermal boundary layers. Free, forced, laminar, and turbulent convection. Elementary concepts of the boiling curve. Heat exchangers.
- Radiation: Planck spectrum and band emission. Solar and environmental radiation. View factors, radiation exchange among diffuse surfaces, radiation shields.

Area 6: MATERIALS

Questions will be drawn from the following list of topics:

- Statics.
- External and Internal Forces.
- Free Body Diagrams. Shear/Axial Force and Bending/Twisting Moment Diagrams for Beams.
- Mechanical Testing.
- Heat Treatment. Stress and Strain. Complex Stress/Strain States.
- Special Topics on Complex Stress States.
- Isotropic/Anisotropic Elasticity.
- Generalized Hooke's Law.
- Viscoelasticity.
- Elastic-Plastic Deformation.
- Strain Hardening.
- Strain Rate and Temperature Effects on Deformation.
- Dislocations, Twinning, and Hardening.
- Ductile and Brittle Fracture.
- Fracture Mechanics.
- Time-Dependent Deformation, Creep.
- Fatigue.
- Cumulative Fatigue Damage.
- Notch Effects in Fatigue.
- Crack Growth.
- Friction and Wear.

Area 8: SOLID MECHANICS

Questions will be drawn from the following list of topics:

- Kinematics of deformation.
- Balance laws.
- Constitutive relations.
- Invariance requirements for constitutive equations.
- Fundamental equations of elasticity and viscous fluids.
- Elementary boundary value problems.

Area 9: THERMODYNAMICS

Questions will be drawn from the following list of topics:

- Equations of state: Ideal Gas, non-ideal equations of state
- Work, heat, internal energy
- First Law for closed and open systems
- Enthalpy, heat capacities
- Reversibility
- Second Law for closed and open systems
- Entropy, Clausius inequality, Carnot cycle
- Entropy production, exergy
- Power and refrigeration cycles
- Gibbs and Helmholts functions, the Maxwell relations
- Gas mixtures
- Equilibrium
- Reacting mixtures and combustion
- Chemical potential, Gibbs-Duhem equation
- Phase equilibrium, Clapeyron equation
- Microstates and macrostates, ensembles
- Boltzmann energy distribution
- Partition functions: calculation and applications to
  - *Specific heat*
  - *Equilibrium in Ideal-Gas mixtures*
  - *Monoatomic crystals, Einstein and Debye theories*
- Maxwell-Boltzmann distribution
- Kinetic theory of gases and molecular collisions
- Intermolecular forces

J. Depth of Each Area Examination

In general, the exam questions are thought provoking and require a clear understanding of the fundamentals of each technical area. Although the reference list below is not meant to be exhaustive, it provides reference text books and class notes for the scope of the Preliminary Examination.

K. Reference List

Area 1: CONTROLS

- Gene Franklin, J.D. Powell and Abbas Emami-naeini, **Feedback Control of Dynamics System**, Prentice Hall, 6th or earlier edition.

- Nise, N.S., **Control System Engineering**, Wiley, 5th or earlier edition Ogata, K. **Modern Control Engineering**, Prentice Hall, 5th or earlier edition.
- Golharaghi, F. and Kuo, B., **Automatic Control Systems**, Wiley, 9th or earlier edition.
- **ME C232 Class Notes** by Professors M. Tomizuka, R. Horowitz and K. Poolla.
- Joao P. Hespanha, **Linear Systems Theory**, Princeton, 2009.

Area 2: DESIGN

- Product Design: Ulrich, Karl T. and Steven D. Eppinger, **Product Design and Development**, McGrawHill.
- Machine Design: Compiled text (chapters on design of machine components), **Mechanical Engineering Design** (custom), McGraw Hill. Sold at ASUC bookstore.

Area 3: DYNAMICS

- Greenwood, D.T., **Principles of Dynamics**, 2nd edition, Prentice-Hall, 1988.
- O'Reilly, O.M., **Intermediate Dynamics for Engineers**, Cambridge University Press, 2008.

Area 4: FLUID MECHANICS

- B. R., Young, D. F. and Okiishi, T. H., **Fundamental of Fluid Mechanics**, Wiley, 2005.
- Okiishi, T. H.J. , and Huebsch, W. W., **Brief Introduction to Fluid Mechanics**, Wiley, 2008.
- Fox Pritchard and McDonald, **Introduction to Fluid Mechanics**, J. Wiley

Area 5: HEAT TRANSFER

- Bergman, Lavine, Incropera, & DeWitt, **Fundamentals of Heat and Mass Transfer**" 7th Edition, Wiley, 2011.
- Excluded from exam scope: Mass transfer. Numerical methods. Radiation in a participating media.

Area 6: MATERIALS

- N.E. Dowling, **Mechanical Behavior of Materials**, 4th ed., Prentice Hall, 2013.
- Komvopoulos, **Mechanical Testing of Engineering Materials**, 2nd ed., Cognella, San Diego, CA, 2017.

Area 7: SOLID MECHANICS

The references are listed in order of relevance to the Preliminary Examination:

- P. M. Naghdi, **ME 185 Class Notes.** These notes are available online at: http://me.berkeley.edu/csml/PMNnotes/ME185Naghdi.pdf
- Chadwick, P., **Continuum Mechanics: Concise Theory and Problems**, Dover Publications, 1999.

Area 8: THERMODYNAMICS

- Y.A. Çengel and M.A. Boles, **Thermodynamics: An Engineering Approach**, 7th or 8th edition, McGraw Hill.
- V. P. Carey, **Statistical Thermodynamics and Microscale Thermophysics**, Cambridge University Press, New York, 1999.
- N. Laurendeau, **Statistical Thermodynamics: Fundamental and Applications**, Cambridge University, 2005.

The Preliminary Examination Committee will periodically review the content and format of the Preliminary Examination.

L. Availability of Previous Preliminary Examinations

These previous exams can be found in the online archive.