University of Wisconsin-Milwaukee
Department of Mechanical Engineering (ME)
ME Ph.D. Qualifying Exams Guidelines and Syllabi
(Approved: 08/25/2023, Revised: 08/28/2023)

Students in the ME Ph.D. program must take and pass a Qualifying Examination (QE) to demonstrate that they are qualified for doctoral-level research work in their area of study. For students entering with a bachelor's degree, this examination may be taken after 18 credits of graduate work have been earned but must be taken before 30 credits of graduate work have been completed. Students admitted to the Ph.D. program after completion of an appropriate Master's degree must take the QE by the 3rd Semester. QE will be held twice in one academic year, in the Fall and Spring Semesters.

The student will select any of the **two areas** listed below for their QE in consultation with their advisor). The research advisor needs to approve the selected areas. The QE will assess the student's ability to solve advanced undergraduate/entry-level graduate problems. Four hours will be allotted for the open-book exam. A total of eight questions, four per area, will be given in the exam. Students must answer three out of four questions from each area. A sample exam will be provided as part of exam preparation. The passing score is 70% or above. For productive students, a score between 65%-70% can be considered a passing score based on the assessment of documented research performance by the ME Department.

Areas of Exam:

1. Machine Design
2. Kinematics and Dynamics
3. Control
4. Vibration
5. Fluid Mechanics
6. Heat Transfer
7. Thermodynamics

ME Ph.D. QE Syllabi

1. **Machine Design**

   Topics:

   - Basic concepts of stress and strain.
   - Deflection analysis, including statically indeterminate problems
   - Design of pressure vessels, and buckling of columns.
   - Failure theories for steady loads.
   - Design to safeguard against fatigue failure
   - Design of screws, fasteners, and welded joints.
   - Design of springs.
   - Design of ball/roller bearings and lubrication bearings.
   - Gearing design.
   - Shafting design, including keyways and flywheels.
   - Design of clutches and brakes.

   Suggested Courses:

   - MECHENG 364: Advanced Mechanics of Materials and Design of Machine Elements 1
   - MECHENG 368: Design of Machine Elements 2

   Suggested Textbooks:

   - *Shigley's Mechanical Engineering Design*, R.G. Budynas, and J.K. Nisbett, 11th ed., 2020.
   - *Fundamentals of Machine Elements*, B. Hamrock, 1999
   - *Machine Design: An Integrated Approach*, R.L. Norton, 5th ed, 2013

2. **Kinematics, and Dynamics**

   Topics:

   - Degrees of freedom of linkages
   - Displacement, velocity, and acceleration analysis of linkages
   - Design of linkages for three positions - function, path, and motion generation
   - Static and dynamic force analysis of linkages
   - Cams - layout of cam profile
   - Follower motion - simple harmonic, cycloidal, and polynomial profiles
   - Gearing and gear trains basic calculations
   - 2D and 3D kinematics/dynamics equations of motion
   - Euler methods, Cardan methods, Helical Axes
   - Methods, Lagrange methods

Suggested Courses:

- MECHENG 360: Mechanical Design I
- MECHENG 469: Introduction to Biomechanical Engineering

Suggested Textbooks:

- *Design of Machinery,* R.L. Norton, 6th ed, 2020.
- *Engineering mechanics: dynamics*. Hibbeler, R.C., 2004. Pearson Education.

3. **Control**

Topics:

- Modeling mechanical, electrical, fluid, and combined systems using Newtonian and Lagrangian Mechanics
- ODE, transfer functions
- Linearization
- Block diagram algebra
- Transient response and s-plane
- Routh-Hurwitz stability criterion
- Root locus method
- Dynamic compensation of feedback systems System type
- Steady-state errors
- Controllers: PI, PID controllers Lead/Lag

Suggested Courses:

- MECHENG 474: Introduction to Control Systems
- MECHENG 302: Introduction to System Dynamics

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Suggested Textbooks: .

- *Modeling and Analysis of Dynamic Systems*, Close, Frederick, and Newell, 3rd ed, John Wiley & Sons, 2002.
- *Modern Control Engineering*, Ogata Katsuhiko. (2010), 5th.ed (Fifth Edition). New Jersey: Pearson Prentice Hall.

4. **Vibration**

Topics

- Basic concepts in vibration and harmonic analysis.
- Fourier series.
- Free and forced vibrations of single degree of freedom systems.
- Systems response under harmonic, general periodic and non-periodic inputs.

- Free and forced vibrations of multi-degree of freedom systems,
- Vibration isolation and vibration absorbers.
- Modal analysis and decomposition.
- Vibrations of continuous systems such as beams, strings, and rods.

Suggested Courses:

- MECHENG 475: Vibrations in Mechanical Design
- MECHENG 726: Mechanical Vibrations

Suggested Textbooks:

- *Theory of Vibrations with Applications*, W.T. Thomson, 4th edn
- *Mechanical Vibrations*, S.S. Rao, 3rd edn, 1995

5. Thermodynamics

Topics:

- First Law of Thermodynamics (with Applications to Open/Closed Systems, Energy Balance in Steady and Unsteady Systems)
- Second Law of Thermodynamics (with Applications to Open/Closed Systems, Entropy Production Mechanisms in Steady and Unsteady Systems)
- General Thermodynamic Property Relations (Phase Diagrams, Property Tables, Generalized Charts, Equations of State, Maxwell Equations, etc.)
- Homogeneous Non-Reacting Mixtures of Gases and Vapors (Properties of Real and Ideal Gas Mixtures, Psychrometrics, Adiabatic Saturator, etc.)
- Heat Engine Power and Refrigeration Cycles (Analysis of Vapor and Gas power and Refrigeration Cycles such as Rankine, Brayton, Otto, Diesel, vapor-compression refrigeration, etc.)
- Thermodynamics of Combustion (Stoichiometric Equations, Heat of Formation, Heat of Reaction)

Suggested Courses:

- MECHENG 301: Basic Engineering Thermodynamics
- MECHENG 402: Thermo-Fluid Engineering
- MECHENG 702: Advanced Engineering Thermodynamics

Suggested Textbooks:

- *Advanced Engineering Thermodynamics*, A. Bejan, John Wiley & Sons, 3rd edition (August 18, 2006)
- *Thermodynamics - An Engineering Approach*, *Cengel and Boles*, McGraw-Hill, (January 7, 2014)

- *Fundamentals of Engineering Thermodynamics*, Moran and Shapiro, 8th Ed. John Wiley & Sons.
- *Advanced Thermodynamics for Engineers*, Wark, McGraw-Hill.

6. Fluid Mechanics

Topics:

- Fluid Statics
- Bernoulli's and Euler's Equations
- Control Volume Analysis
- Differential Forms of Conservation Laws
- Solutions of Navier-Stokes and Energy Equations
- Dimensional Analysis
- Potential Flow (Stream Function, Velocity Potential, Plane Flow solutions)
- Pipe Flow (with Friction Losses
- Boundary Layer Theory
- Flow Over an Immersed Body
- Gas Dynamics (Stagnation State Properties, Converging-Diverging Flows, Flows, Choked Flow, Normal/Oblique Shock Waves, Nozzle and Diffuser Efficiencies, Heat Transfer/Friction, etc.)

Suggested Courses:

- MECHENG 320: Introduction to Fluid Mechanics
- MECHENG 420: Intermediate Fluid Mechanics
- MECHENG 490: Introduction to Water Engineering
- MECHENG 722: Advanced Fluid Mechanics

Suggested Textbooks:

- *Fundamentals of Fluid Mechanics*, Munson, Young, Okiishi, Wile
- *Introduction to Fluid Mechanics*, R.W. Fox and A.T. McDonald, Wiley.
- *Fluid Mechanics*, Cengel and Cimbala, McGraw-Hill
- *Fluid Mechanics*, F.M. White, 9th Ed., McGraw-Hill
- *Viscous Fluid Flow*, F.M. White, 2nd Ed., McGraw-Hill.

7. Heat Transfer

Topics:

- Conduction (Steady and Unsteady problems, Separation of Variables, Integral (Laplace) transforms, conduction with local heat sources, conduction with phase change)

- Forced Convection (Laminar and Turbulent Heat Transfer in Internal and External Flows)
- Free and Mixed Convection
- Radiation (Blackbody Radiation, Non-Black Surfaces, Electro-magnetic Theory and Radiative Properties of Solids, Radiation Energy Interchange between Black, Gray, Diffuse, and Specular Surfaces, etc.)
- Heat Exchangers

Suggested Courses:

- MECHENG 321: Basic Heat Transfer
- MECHENG 411: Heat Transfer
- MECHENG 711: Thermal Radiation and Conduction
- MECHENG 712: Convection Heat and Mass Transfer

Suggested Textbooks:

- *Fundamentals of Heat and Mass Transfer*, *Bergman*, *Lavine*, Incropera and De Witt, 7th Ed. Wiley.
- *Heat Conduction*, Ozisik, Wiley, 3rd ed., 2012
- *Heat Conduction*, 5th edition, by Kakac, Yener and Naveira-Cotta, Taylor & Francis.
- *Thermal Radiation Heat Transfer*, Siegel and Howell, Hemisphere Publishing.
- *Convective Heat and Mass Transfer*, Kays and Crawford, McGraw Hill.
- *Heat and Mass Transfer*, Cengel and Ghajar, McGraw Hill, 6th Edition
- *Conduction Heat Transfer*, Arpaci, Addison Wesley, 1st Ed.