University of Wisconsin-Milwaukee
Department of Mechanical Engineering
Guidelines for Ph.D. Qualifying Exams
(Document revised in 2/00, 12/00, 12/08)

The Qualifying Exam is a college exam given under the authority and responsibility of the Graduate Program Subcommittee (GPSC). The purpose of the examination is to establish the student's readiness to undertake advanced (doctoral level) work in his/her 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 Ph.D. program after completion of an appropriate master's degree must take the examination before 12 credits of course work have been earned at UWM.

The examination is composed of two half-day written examination taken on consecutive days. Total time allowed is 4 hours on each of the two days. The first-day examination contains 10 problems in mathematics and fundamentals with the student required to choose 8 problems with at least one from each group. The second-day examination contains 9 problems within the student's area of concentration with the student required to choose 6 problems with at least one from each group. A sample exam will be provided by the department to each candidate as part of exam preparation.

Grading is on the basis of the total examination (both half days) with the student either passing or failing the total examination. In cases where the student has passed the examination, but has exhibited a glaring weakness, recommendations are made in an appropriate manner such as requiring additional courses in the area of weakness.

Day One

Part I - Mathematics and Fundamentals - Closed Book 4 hrs

Subject	Problems
Ordinary Differential Equations	2
Partial Differential Equations	2
Linear Algebra	2
Calculus	2
Numerical Methods	2
TOTAL	**10**
Student Selections	**8**

A student must select at least one problem from each subject.

Day Two

Part II - Area of Concentration - Open Book 4 hrs

Machine Design Stem

Subject	Problems
Machine Design	3
Kinematics & Dynamics	3
Controls/Vibration	3
TOTAL	**9**
Student Selections	**6**

A student must select at least one problem from each subject.

Thermal Science Stem

Subject	Problems
Fluid Mechanics	3
Thermodynamics	3
Heat Transfer	3
TOTAL	**9**
Student Selections	**6**

A student must select at least one problem from each subject.

PART I: MATHEMATICS AND FUNDAMENTALS

Ordinary Differential Equations

Topics:
- First Order Differential Equations
- Linear Second Order Differential Equations
- Higher Order Differential Equations
- Laplace Transform
- Series Solutions of Differential Equations
- Sturm-Liouville Theory & Eigenfunction Expansions

Course: Math 601: Advanced Engineering Mathematics I

References: *Advanced Engineering Mathematics,* E. Kreyszig, 7th Ed. Wiley.

Advanced Engineering Mathematics, P.V. O'Neil, Wadsworth Publishing, 3rd Ed., 199 1.

Partial Differential Equations

Topics:
- Solution of Equations (Wave Equation, Heat Equation, Potential, Elastic Membrane, etc.)
- Separation of Variables, Use of Fourier Series
- Laplace Transform
- Error Functions
- Use of Sturm-Liouville Theory & Eigenfunction Expansions

Course: Math 601: Advanced Engineering Mathematics I

References: *Advanced Engineering Mathematics,* E. Kreyszig, 7th Ed. Wiley.

Advanced Calculus for Applications, F. B. Hildebrand, Prentice-Hall.

Linear Algebra

Topics:
- Matrices and Determinants
- Solutions to Systems of Linear Equations
- Gauss Elimination Method
- Cayley Hamilton Theorem
- Definiteness of a Matrix
- Ranks
- Euclidean Norm
- Eigenvalues and Eigenvectors

- Jordan Forms
- Repeated Eigenvalues

Course: Math 601: Advanced Engineering Mathematics I

References: *Advanced Engineering Mathematics,* E. Kreyszig, 7th Ed. Wiley.

Introduction to Applied Mathematics, G. Strang, Wellesley-Cambridge Press, 1986

Calculus

Topics:
- Derivatives, Differentiation and Partial Derivatives
- Taylor's Series
- Curvature of a Curve
- Definite and Indefinite Integrals
- Functions of Several Variables
- Line and Surface Integrals
- Green's Theorem

Course: Math 601: Advanced Engineering Mathematics I

Reference: *Advanced Engineering Mathematics,* E. Kreyszig, 7th Ed. Wiley.

Numerical Methods

Topics:
- Systems of linear algebraic equations. Direct and iterative methods. Error analysis.
- Eigenvalue problems. Power and inverse power methods.
- Solutions to nonlinear equations. Fixed-point, secant, and Newton's method. Error analysis, convergence rates.
- Polynomial Approximation and Interpolation. Forward, backward and centered differences. Error analysis.
- Numerical differentiation and integration. Extrapolation techniques, and error analysis.
- One dimensional initial value problems. Single-step, multi-step and predictor-corrector methods.
- One dimensional boundary value problems
- Solutions to Elliptic PDEs
- Solutions to Parabolic PDEs (Von Neumann, Discrete Perturbation Stability Analyses)
- Solutions to Hyperbolic PDEs

Course: ME 715: Numerical Methods in Engineering

Reference: *Numerical Methods for Engineers and Scientists,* Joe D. Hoffman, McGraw-Hill, 1992.

PART II: MACHINE DESIGN STEM

Machine Design

Topics:
- Basic concepts in stress and strain.
- Deflection analysis including statically indeterminate problems
- Design of pressure vessels, 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.

Course: ME 365: Mechanical Design-II

Reference: *Mechanical Engineering Design,* J.E. Shigley and C.R. Mischke, 5th ed., 1989.

Fundamental of Machine Elements, B. Hamrock 1999

Machine Design: An Integrated Approach, R.L. Norton, 2nd edn, 2000

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 trainsB basic calculations

Course: ME 360: Mechanical Design-I

Reference: *Design of Machinery,* R.L. Norton, 2nd edn, 1999.

Controls/Vibration

Topics:
- 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
- Frequency response methods
    - Bode plots
    - Nyquist diagrams
    - Frequency domain lead/lag controllers
- State space formulation
- 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.

<u>Course</u>: ME 474: Introduction to Control Systems
ME 475 Vibrations in Mechanical Design OR
ME 726: Mechanical Vibrations

<u>Reference</u>: *Modern Control Systems,* R.C. Dorf and R.H. Bishop, 8th edn

Mechanical Vibrations, S.S. Rao, 3rd edn, 1995

Theory of Vibrations with Applications, W.T. Thomson, 4th edn

PART II: THERMAL SCIENCE STEM

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 Saturater, etc.)
- Heat Engine Power and Refrigeration Cycles (Analysis of Vapor and Gas power and Refrigeration Cycles such as Rankine, Brayton, Otto, Diesel, etc.)
- Thermodynamics of Combustion (Stoichiometric Equations, Organic Fuel Modeling, Heat of Formation, Heat of Reaction, Chemical Equilibrium and Dissociation, etc.)
- Stability of Thermodynamic Systems (First & Second Order Phase Transitions, Phase Diagrams for Binary Systems, etc.)

Courses:
ME 301: Basic Engineering Thermodynamics
ME 402: Applied Engineering Thermodynamics
ME 702: Advanced Engineering Thermodynamics

References:
Thermodynamics - An Engineering Approach, Cengel and Boles, McGraw-Hill.

Fundamentals of Engineering Thermodynamics, Moran and Shapiro, John Wiley & Sons

Advanced Thermodynamics for Engineers, Wark, McGraw-Hill.

Advanced Engineering Thermodynamics, A. Bejan, John Wiley & Sons.

Fluid Mechanics

Topics:
- Fluid Statics
- Bernoulli's and Euler's Equations
- Control Volume Analysis
- Differential Forms of Conservation Laws
- Solutions of Navier-Stokes Equations
- Dimensional Analysis
- Potential Flow (Stream Function, Velocity Potential,
- Pipe Flow (with Friction Losses, Single and Multiple Pipe Line Systems)
- 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.)

Courses: ME 320: Introduction to Fluid Mechanics
ME 721: Advanced Fluid Mechanics

References: *Fundamentals of Fluid Mechanics,* Munson, Young, Okiishi, Wiley

Introduction to Fluid Mechanics, R.W. Fox and A.T. McDonald, Wiley.

Fluid Mechanics, Cengel and Cimbala, McGraw-Hill

Fluid Mechanics, F.M. White, McGreaw-Hill

Viscous Fluid Flow, F.M. White, 2nd Ed., McGraw-Hill.

Heat Transfer

Topics:
- Conduction (Separation of Variables, Laplace Transformation, Integral Methods)
- 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

Courses: ME 321: Basic Heat Transfer
ME 711: Conduction Heat Transfer
ME 712: Convection Heat and Mass Transfer

References: *Fundamentals of Heat and Mass Transfer,* Incropera and De Witt, 3rd Ed. Wiley.

Heat Conduction, Ozisik, Wiley.

Thermal Radiation Heat Transfer, Siegel and Howell, Hemisphere Publishing.

Convective Heat and Mass Transfer, Kays and Crawford, McGraw Hill.

Basic Heat and Mass Transfer, A.F. Mills, Irwin, 1995.