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Note: Please be advised that the following topics are not inclusive. The department reserves the right to have exam problems not listed in this document.

STUDY TOPICS FOR PH.D. QUALIFIER EXAM

Section Covering Undergraduate Work

Fluid Mechanics

Problem 1.
Problem 2.
Problem 3.
Problem 4.

Fluid Mechanics (Dr. Chauhan)

The candidate should be able to find pressure distribution in fluids in motion and know topics in fluid kinematics

Calculation of hydrostatic forces on plane and curved surfaces.
Differential and integral forms of the continuity equations.
Fluid Kinematics
Momentum equation
Energy equation

Thermodynamics and Heat Transfer

Problem 5. Thermodynamics
Problem 6. Thermodynamics

Thermodynamics (Dr. Klett)

There will be two thermodynamics problems, one involving steam as the working substance and one involving an ideal gas. In general the student should be able to:

a) Analyze energy consuming devices (pumps, compressors, etc.) and energy producing devices (steam or gas turbines) via both first law and second law analysis. Specifically, determine the first law (adiabatic) efficiency and determine the magnitude of irreversibility associated with the above devices.

b) Use the steam tables and gas tables to evaluate state properties as needed to analyze the above devices.

Problem 7. Heat Transfer
Problem 8. Heat Transfer

Heat Transfer (Dr. Human)

Determine primary mode of heat transfer or whether mixed mode
apply relevant energy balance result (conduction, fins, convective coefficient, radiation equation) to obtain temperature distribution as function of position
Use distribution to obtain heat flux
Solve simple transient problems

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Show understanding of fundamental dimensionless quantities – Reynolds, Biot, Fourier and Nusselt numbers
Apply principles to formulation and solution of simple physical configurations, pipes, walls, extended surfaces, etc.

Solid Mechanics and Dynamics of Machinery
Problem 9. Solid Mechanics - Statics
Problem 10. Solid Mechanics - Statics

Statics (Dr. Ofori)
Equilibrium of a rigid body.
Analysis of structures and machine frames.
Friction.

Problem 11. Solid Mechanics- Strength of Materials
Strength of Materials (Dr. Kelkar)
(a) Stress and Strain
(b) Torsion
(c) Pure Bending
(d) Beam Deflections
(e) Stresses in Beams
(f) Combined Loading
(g) Mohr's circle
(h) Statically Indeterminate Members

Problem 12. Dynamics of Machinery - Dynamics
Dynamics (Dr. Layton)
Candidates should be able to:
develop Free Body Diagrams of objects in motion
develop equations of motion (both linear and angular equations)
solve and interpret the equations.

Materials Science and Engineering
Problem 13. Materials Science
Problem 14. Materials Science
Materials Science (Dr. Filatovs)
Problem 15. Materials Engineering
Problem 16. Materials Engineering
Materials Engineering (Dr. Sankar)

Machine Design
Problem 17. Design for Static Loads
Design for Static Loads (Dr. Ofori)
Determination of stress types on a machine member
Development of stress element

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Determination of principal stresses
Selection and application of appropriate failure criterion
Evaluation of Design (safety) Factor

Problem 18. Design for Fatigue Loads

Design for Fatigue Loads (Dr. Pai)
Development of S-N diagram
Interpretation of a given S-N diagram
Goodman and modified Goodman diagrams
Evaluation of Design (safety) Factor.

Problem 19. Vibration

Mechanical Vibrations (Dr. Schulz)
Analysis of a Spring-Mass system subjected to given force
Analysis of a Spring-Mass-Dashpot system subjected to given force

Problem 20. Design of Machine Element

Design of Machine Element (Dr. Wang)
This typically involved the design procedure for a specific machine element, including: Springs, shafts, gears, brakes and clutches, threaded fasteners and power screws, rolling elements bearings and sliding bearings.

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STUDY TOPICS FOR PH.D. QUALIFIER EXAM

Section Covering Graduate Work

<u>Common Problems</u>

Finite Element Method (Dr. Kelkar)

(a) Potential Energy and Equilibrium
(b) The Rayleigh-Ritz Method and Galerkin Method
(c) One Dimensional Problem:

Coordinates and Shape functions
Finite Element Modeling
Potential Energy and Galerkin Approach
Assembly of Global Stiffness matrix and Load Vector
Formulation of K
Boundary conditions Treatment
Linear and Quadratic shape functions

(d) Trusses including Banded and Skyline solution

(e) Beams:
Finite element formulation, load vector, and boundary conditions.
Shape functions

Numerical Methods (Dr. Kelkar)

(a) Binary arithmetic
(b) Error Analysis
(c) Numerical Differentiation
(d) Solution of ODE and PDE
(e) Matrix and Determinants
(f) Simultaneous Linear Equations

<u>Mechanics and Materials</u>

Vibration (Dr. Schulz)

Reference: Engineering Vibration by Inman, Prentice Hall, 1994.
Exam Condition: Closed-book, no notes.

Chapter 4:

Spring-Mass System- Derive equation of motion of spring-mass systems. Compute mode shapes, natural frequencies.

Chapter 6: Distributed Parameter Systems

Modes and Natural Frequencies- Derive characteristic equation, determine natural frequencies and mode shapes.

Vibration of Strings, Rods, Bars, and Beams- Solve equation of motion, apply boundary conditions, determine mode shapes and natural frequencies.

Models of Damping- Proportional and modal damping.

Modal Analysis of the Forced Response- Solve forced response using modal summation and orthogonality of modes

Chapter 7: Vibration Testing and Experimental Modal Analysis

Receptance Frequency Response Function Matrix- Compute Frequency Response Functions (FRFs) of lumped parameter systems, write FRF matrix in terms of mode shapes, natural frequencies and damping ratios

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MEEN 789 Flexible Structures Course (Mark Schulz, 3/11/99)

Reference: Introduction to Dynamics and Control of Flexible Structures
John L. Junkins and Youdan Kim

Exam Condition: Closed-book, no notes.

Chapter 2: Mathematical Background: Matrix Analysis and Computation

Spectral Decomposition- Solve matrix equations using spectral decomposition.

Chapter 3: Stability in the sense of Lyapunov: Theory and Applications

Stability- Check stability of a nonlinear system.

Chapter 4: Mathematical Models of Flexible Structures

Equations of motion- Use Lagrange's approach to derive equations of motion for a lumped parameter system.

MEEN 789- STRUCTURAL HEALTH MONITORING
Instructor: Mark J. Schulz

Prerequisites: MEEN 706 Theory of Vibration or an equivalent graduate vibration course.

References: Class notes and handouts.

1- **Current Horizon for Structural Damage Detection Course, January 30-February 1, 1997, Orlando Florida, George H. James, David C. Zimmermen, Charles Farrar, and Scott W. Doebling.**
2- Structural Health Monitoring: Status and Promise, International Workshop on Structural Health Monitoring," September 18-20, 1997, Stanford University, Stanford, CA.

Ph.D. exam condition: closed book, no notes.

Ph.D. exam material covered:
The Ph.D. exam for this course covers the application of techniques learned to detect damage to a structure using the measured vibration response of the structure. Appropriate

equations will be given within the examination question. Students should be able to: (1) show by calculation how a specified damage changes the natural frequencies, vibration mode shapes, and frequency response functions of a structure, and (2) compute the strain vibration measured using a piezoceramic sensor on a bar or beam.

Plates and Shells (Dr. Craft)

Students should understand Stress and the Equations of Equilibrium of Stress components including the stresses along oblique axes and Mohr's Circle, and the transformation of Strains and Mohr's Circle.

Engineering Materials, stress-strain diagrams, Poisson's ratio, and factors of safety in design,

solutions of axially loaded & torsion in members, beams including loading, shear, bending, slope, and deflections by generalized functions, and failure by the application of theories of failure.

Bending in circular plates, and solutions to axisymmetric solutions for a Circular Plate for a variety of boundary conditions including annular plates, superposition.

finite difference solutions of rectangular and circular plates with various boundary conditions.

Energy/Thermo-fluid Science

Design and Manufacturing