

**Colorado State University**

**Department of  
Mechanical Engineering**

**Guidelines**

*for*

**Written Diagnostic Exams**

*leading to the degree of*

*Doctor of Philosophy*

Purpose: To test the candidate's understanding of undergraduate topics in Mechanical Engineering and to determine the candidate's breadth of knowledge in selected topics.

Overview: Students are required to successfully pass tests in two out of the four following topical areas:

- 1) Energy & Thermal Sciences
- 2) Mathematics
- 3) Mechanics of Solid Bodies & Materials
- 4) Moving Systems

Each topical area is examined with a written test of 4-hour length. Students have at most two attempts per test (see below for more details). Outlines of the materials covered on the tests are included in the following pages. All tests are to be taken as closed book and closed notes. Calculators are only permitted for the Energy & Thermal Sciences and Mechanics of Solid Bodies & Materials tests and only the following non-programmable calculators may be used: Casio calculators with fx-115 in the model name; Hewlett Packard: HP 33 and HP 35 models only; Texas Instruments calculators with TI-30X or TI-36X in the model name. No other calculators, laptops, or cell phones will be permitted in the exam area. No calculators are permitted for the Mathematics and Moving Systems tests.

Each topical area has a test coordinator (an ME Faculty member) - see Graduate Program Coordinator for a list of the test coordinators. *It is highly recommended that students contact the test coordinators at least several months ahead of their scheduled tests and study all topics listed in the outlines.*

Scheduling and Requirements: Exams will be administered twice a year, in November and April. The Diagnostic Exam must be attempted (at least for the first time) during the student's first two semesters in the program. Students entering the Ph.D. program directly from a Bachelor's degree will be allowed to wait until their third semester. Other exceptions are only allowed with written approval from both the student's advisor and the Chair of the Graduate Committee. When a student attempts the diagnostic exam for the first time, the student must test in two topical areas. For each exam session in a which student will participate, the student must submit the "Intent to Take Written Diagnostic Exam" form signed by their advisor. The form will indicate which tests will be attempted, if they are first or second attempts, and if the topical area has changed. Forms are due by September 15<sup>th</sup> to take the exam in November, and by February 15 to take the exam in April.

The outcome of a given test is determined by the test coordinator based on the student's overall understanding of the material as demonstrated by responses to test questions. The three possible outcomes of a test are Pass, Conditional Pass, or Fail. Conditions of a Conditional Pass are set by the test coordinator and may require that the student take additional course(s) and achieve certain grades and/or other remedial measures (e.g. retest in a sub-area of the test, complete "homework" or independent study etc.). If the conditions are not satisfied (or are not satisfied in the prescribed timeline) then the Conditional Pass is changed to a Fail. In the case of Fail, there may also be a requirement of taking additional course(s) and achieving certain grades prior to reattempting the test a second time. (If these conditions are not met then the grade remains Fail

and the student cannot retest in this area.) If a test is to be re-attempted then it must be retaken during the next exam session (i.e. next semester) or, in the event that course(s) were prescribed, in the next test session following completion of the course(s). Students may only attempt the test in a given subject area twice. *A second failure will result in dismissal from the PhD program. In this case, if the student's advisor and the Chair of the Graduate Committee agree, the student may switch to a Masters program.* If a student who has failed an exam elects not to retest in a given area, but rather to test in a new area, then the new test will be considered as a second (and final) test, and must, therefore, be passed on the first attempt. Such tests must also be taken in the next exam session. Failure to comply with the required timeline also constitutes a Fail.

*All results are final and there is no appeals process.*

## INTENT TO TAKE WRITTEN DIAGNOSTIC EXAM

(To be completed by student and signed by advisor)

Name \_\_\_\_\_

Date: \_\_\_\_\_

Address \_\_\_\_\_

CSU ID#: \_\_\_\_-\_\_\_\_-\_\_\_\_

\_\_\_\_\_

Phone: \_\_\_\_\_

Email \_\_\_\_\_

### TEST TO BE TAKEN :

November 20 \_\_\_\_\_

April 20 \_\_\_\_\_

Identify the Topical Areas you will be tested in by placing an X on the line in front of the area.

\_\_\_\_ Energy & Thermal Sciences

\_\_\_\_ Mechanics of Solid Bodies & Materials

\_\_\_\_ Mathematics

\_\_\_\_ Moving Systems

Semester and Year you entered the Ph.D. program: \_\_\_\_\_

This is a: \_\_\_\_\_ 1st Attempt of Written Diagnostic Exam (Two Topical Areas)

\_\_\_\_\_ 2nd Attempt of Written Diagnostic Exam

\_\_\_\_ Retest One Topical Area Only

\_\_\_\_ Retest Two Topical Areas

\_\_\_\_ New Topical Area(s) to replace Second Attempt(s)

Advisor's Signature \_\_\_\_\_

Date \_\_\_\_\_

## REPORT OF WRITTEN DIAGNOSTIC EXAM

(To be completed by Department)

### SCORES: (Pass or Fail)

\_\_\_\_ Energy and Thermal Sciences

\_\_\_\_ Mechanics of Solid Bodies & Materials

\_\_\_\_ Mathematics

\_\_\_\_ Moving Systems

## Energy & Thermal Sciences PhD Written Diagnostic Test

### **GOALS: The exam is designed to assess:**

- ability to prepare a neat, well labeled sketch of a system
- ability to model a simple system using a control volume approach, and write the corresponding governing equations in appropriate form (differential, algebraic or integral)
- understanding of mechanical engineering systems, within the topical areas listed below
- ability to formulate and communicate a rational approach to a problem

### **SUBJECTS INCLUDED ON TEST (note - related courses in parentheses):**

#### **Thermodynamics (ME337)**

- Properties of materials - Equations of state
- First law - Energy balance
- Second law - Reversibility, entropy, availability
- Power and refrigeration cycles

#### **Fluid Mechanics (ME342)**

- Hydrostatics
- Momentum balances (e.g. Bernoulli equation)
- Energy balances - Equation of mechanical energy
- Incompressible internal and external flows
- Pipe flows - Friction factor, loss coefficient
- Boundary layers
- Lift and drag

#### **Heat Transfer (ME344)**

- Transport Properties
- Conduction - 1D and 2D steady, 1D transient
- Convection - Forced and natural
- Radiation - Black and gray surface heat exchange
- Heat exchangers

# Moving Systems

## PhD Written Diagnostic Test

### **GOALS: The exam is designed to assess:**

- intuitive understanding of fundamental principles and ability to apply concepts to solve problems in the subject areas below
- ability to formulate and communicate a rational approach to the solution of a problem
- ability to convert a simple system description into a free-body diagram and to derive the equation of motion
- ability to apply work and energy principles and momentum principles

### **SUBJECTS INCLUDED ON TEST (note- related courses in parentheses):**

#### **Intro to Electrical Engineering (EE204)**

- DC and AC circuits
- Semiconductor devices and integrated circuits
- Electronic amplifiers
- Electromagnetic principles and applications
- Electric machines

#### **Dynamics (CE261)**

- Projectile motion
- Translational dynamics and associated equations of motion
- Rotational dynamics and associated equations of motion
- Momentum principles
- Energy principles

#### **Dynamics of Machines (ME324)**

- Kinematic analysis of mechanisms
- Dynamic analysis of mechanisms
- Vibrations

#### **Mechatronics (ME307)**

- Basic electrical circuits and electronic devices
- Semiconductor physics and semiconductor devices
- Basic digital electronics
- Theoretical and practical aspects of measurement system design
- Sensor and actuator theory, design, and application
- Combined sensors, circuits and computers as mechatronic systems
- Laboratory instrumentation and computer interfacing for mechanical engineering application

# Mechanics of Solid Bodies & Materials

## PhD Written Diagnostic Test

### **GOALS: The exam is designed to assess:**

- ability to understand undergraduate material and apply the material in limiting situations, in particular the limits of applicability of simple solutions will be well represented in the material
- intuitive understanding of fundamental principles and the ability solve problems in any of the specific subject areas listed below
- ability to formulate and communicate a rational approach to the solution of a problem and to discuss and characterize the results of the solution
- ability to construct free-body diagrams and determine equations of motion
- ability to apply material science fundamentals to the analysis and discussion of how materials will respond to manufacturing processes and different loading states

### **SUBJECTS INCLUDED ON TEST (note - related courses in parentheses):**

#### **Statics (CE260)**

- Vectors
- Forces and Moments
- Equilibrium
- Free Body Diagrams
- Trusses
- Influence Lines
- Frames - Machines
- Centroids
- Moments of Inertia
- Distributed Forces
- Friction
- Virtual Work
- Determining reaction forces

#### **Mechanics/Strength of Materials (CE360)**

- Stress-strain relations
- Mohr's Circle
- Failure criterion
- Stresses in beams/shafts
- Indeterminate Beams
- Columns
- Multi-axial states of stress

#### **Design of Machine Elements (ME325)**

- Stress-strain relations
- Mohr's Circle
- Failure criterion
- Stresses in beams/shafts/machine elements

#### **Material Science (ME331)**

- Stress-strain curves
- Phase diagrams
- Atomic bonding
- Strengthening mechanisms
- Structure property relationships for different materials
- Concept of Diffusion, Mechanisms
- Corrosion

# Mathematics

## PhD Written Diagnostic Test

### **GOALS:**

#### **The exam is designed to assess:**

- Knowledge and ability in the areas of undergraduate Mathematics most relevant to Mechanical Engineering, especially calculus
- Ability to coherently and creatively solve problems

**RELATED COURSES:** M160, M161, M261, M340, M369

### **SUBJECTS INCLUDED ON TEST:**

- Limits and continuity
- Sequences and series
- Linear algebra
- Fundamental theorems of calculus and interpretation of derivatives and integrals
- Differentiation and integration of elementary functions
- Multiple integrals and line integrals
- Polar, cylindrical, and spherical coordinates and coordinate transformations
- Complex numbers
- Taylor polynomials and series
- Vector functions, operations, and vector calculus
- First and second order ordinary differential equations