

PhD Qualifying Examination
Solid Mechanics and Materials Science Thematic Area

Examination Format

The examination will consist of 7 questions from the topics listed below. (The topic list should be considered a guideline and not an exhaustive list.) Students must answer 5 of the 7 questions. If the student answers more than 5 questions, the first 5 will be graded. Students should clearly mark answers they don't want included in their examination by writing "DO NOT GRADE" and marking a single line through the answer. Students will have 2.5 hours for the examination.

Reference Materials

Students taking the SMMS qualifying exam are allowed to develop a two-page (one page front and back), hand-written formula sheet to be used during the exam. The students can include anything they consider of interest to them. The two page formula sheet must be submitted to the Graduate Program Director at least three days before the qualifying exam. The formula sheet will be returned to the student at the start of the exam.

Topics

1. Basics
 - 1.1. Indicial Notation
 - 1.2. Vector and Tensor Operations
 - 1.3. Eigenvalue Problem
 - 1.4. Green-Gauss (Divergence) Theorem
2. Kinematics
 - 2.1. General finite deformation of a continuum
 - 2.2. Infinitesimal deformation
 - 2.3. Decomposition
 - 2.4. Compatibility
3. Kinetics and Constitutive relations of elasticity
 - 3.1. Conservation of mass, momentum, angular momentum
 - 3.2. Transport theorem
 - 3.3. Cauchy's tetrahedron argument
 - 3.4. Local equilibrium equations (current state, reference state)
 - 3.5. Symmetry of stress tensor (small deformations, conservation of angular momentum)
 - 3.6. Piola-Kirchhoff & Cauchy stress tensors
 - 3.7. Equations of motion in integral and differential forms
 - 3.8. Hyper- Hypo elasticity
 - 3.9. General anisotropic elasticity- Cauchy relation
 - 3.10. Isotropic linear elasticity
4. Work and Energy balance
 - 4.1. Strain energy for elastic materials

- 4.2. Basic equations of linear elasticity
- 4.3. Power and Work
- 4.4. Principal of virtual work
- 4.5. Reciprocal (Betti's) theorem
- 4.6. Castigliano's theorem
- 4.7. Minimum potential energy principle
- 4.8. Boundary value problem and uniqueness of solution
5. Solution methods to the boundary value problem of elasticity
 - 5.1. Displacement description (Navier equations)
 - 5.2. Cylindrical Polar and Spherical symmetry
 - 5.3. Thick wall pressure vessels (cylindrical and spherical symmetry)
 - 5.4. Thermoelasticity (shrink fit problem)
6. Plane problems of elastostatics
 - 6.1. Cartesian & Polar & Spherical Coordinates
 - 6.2. Beltrami Mitchell equations of elastostatics
 - 6.3. Plane stress, Plane strain
 - 6.4. Airy's stress function and other polynomial stress functions
 - 6.5. Stress concentrations around a circular hole embedded in an infinite body under remote tension
 - 6.6. General solution to the stress function
 - 6.7. Stress function under polar symmetry
 - 6.8. Stress description solutions for thick wall cylinders
 - 6.9. Concentrated line load (non-dimensional analysis approach)
 - 6.10. Punch problems
 - 6.11. Edge and Screw dislocations
 - 6.12. Asymptotic singular near-tip solution
 - 6.13. Gravity and body forces (spinning disc)