Screening Exam Topics

Academic Year 2020 - 2021

The Screening Exam aims to achieve three objectives:

(i) To determine if the student has a deep understanding of the basic knowledge of at least two areas of emphasis in Mechanical Engineering.

(ii) To determine if the student has the mathematical skills required for a deep understanding of the basic knowledge of the two areas of emphasis.

(iii) To assess if the student has the analytical ability and critical thinking skills required to embark on independent research in one area of emphasis.

The Screening Exam is meant to test the student’s broad understanding of fundamental concepts and the student’s ability to draw connection inside and across disciplines. The following list of courses and reading material are not to be understood as required courses and assigned reading, but rather as suggested courses and reading. The aim of the screening exam is not to merely assess whether or not students have memorized the content of the suggested courses or reading materials. The suggested courses or reading materials are thus to be understood as an indicator of the type of material, breadth and level that is expected from the candidates.

**Important note:** This document pertains only to the Spring 2021 and Fall 2021 screening exams. Successive exams will be based upon revised versions of this document.
Area 1: Bio-Engineering and Systems Biology (BESB)

Topics:

(i) Biomechanics and mechanobiology
   (a) Cytoskeleton
   (b) Molecular motors
   (c) Cell adhesion

(ii) Systems Biology
   (a) DNA, RNA and protein regulation
   (b) Signaling cascades

Suggested Reading Material:


Suggested Courses:

(i) ENGR 220A - Molecular BioEngineering (Winter)

(ii) ENGR 220B - Cellular BioEngineering (Spring)
Area 2: Computational Science and Engineering (CSE)

Topics:

(i) Numerical methods for nonlinear initial value problems for ODEs
   (a) Basic Methods: Euler’s method, modified Euler and backward Euler
   (b) Runge Kutta methods
   (c) Multistep and predictor corrector methods
   (d) Stability properties
   (e) Stiffness

(ii) Numerical Methods for Partial Differential Equations using Finite Difference Methods
   (a) Standard Methods for Hyperbolic, Elliptic and Parabolic Partial Differential Equations
   (b) Consistency and Stability Analysis, Well-Posedness
   (c) Order of Accuracy
   (d) Dissipation and Dispersion
   (e) Systems of PDEs in Higher Dimensions

Suggested Reading Material:


Suggested Courses:

(i) ME 210B “Numerical Simulation” (Winter)

(ii) ME 210C “Numerical Solution of PDEs with Finite Difference Methods” (Spring)
Area 3: Dynamics, Control and Robotics (DCR)

Topics:

(i) Basic models: linear, nonlinear, solutions, equilibria, limit cycles, phase portraits

(ii) Stability analysis: asymptotic, linearization, Lyapunov

(iii) Controllability, stabilizability, observability and detectability

(iv) Invariant manifolds: stable, unstable, center

(v) Bifurcation analysis

Suggested Reading Material: The following chapters contain a superset of the required topics.

    or, alternatively,
    J. Hespanha “A Course in Linear Systems Theory”, Selected topics in Part I, II, III and IV


Suggested Courses:

(i) ME 243A “Linear Systems I” (Fall)

(ii) ME 215A “Applied Dynamical Systems I” (Fall)

Alternative and supplementary course: ME 236
Area 4: MicroElectroMechanical Systems (MEMS)

Topics:
(i) Electrostatics and Magnetostatics
(ii) Maxwell’s Equations
(iii) MEMS applications
(iv) Fabrication of Micro/Nanosystems
(v) Design of Micro/Nanosystems

Suggested Reading Material:
(i) U.S. Inan and A.S. Inan “Engineering Electromagnetics”. Ch 4,5,6,7
(iii) S. Senturia “Microsystem Design”. Ch 1,3,7,8,19

Suggested Courses:
(i) ME 291A “Physics of Transducers” (Fall)
(ii) ME 292 “Design of Transducers” (Spring)
Area 5: Solid Mechanics, Materials and Structures (SMMS)

**Topics:** Roughly half of the exam will cover topics in continuum mechanics and the other half will emphasize applications to materials including principles of elasticity, plastic deformation and fracture mechanics.

(i) Continuum Mechanics
   (a) Stress/strain notions, balance equations, principal stresses, invariants
   (b) Displacement fields and small strain theory
   (c) Virtual work, isotropic elastic stress/strain relations
   (d) Constitutive laws, elastic potential energy

(ii) Deformation and Fracture
   (a) Elastic properties
   (b) Dislocations, slip and dislocation mechanics
   (c) Yielding and strain hardening
   (d) Strengthening mechanisms
   (e) Linear elastic and fracture mechanics
   (f) Fracture of metals and brittle solids
   (g) Fatigue and fatigue crack growth

**Suggested Reading Material:**

(i) Continuum Mechanics Online Notes, available at [http://motion.me.ucsb.edu/GradProgram](http://motion.me.ucsb.edu/GradProgram)

(ii) T. H. Courtney “Mechanical Behavior of Materials,” pp. 1-210


**Suggested Courses:**

(i) ME 219 “Mechanics of Materials” (Fall)

(ii) ME 264 “Mechanical Behavior of Materials” (Winter)
Area 6: Fluid and Thermo Sciences (FTS)

Topics:

(i) General conservation laws
(ii) Transport phenomena (diffusion and convection) for mass, momentum and energy
(iii) Incompressible flows and introductory topics on compressible flows
(iv) Laminar flows and introductory topics on turbulent flows
(v) Boundary layer theory

Suggested Reading Material:

(i) W. M. Deen “Analysis of Transport Phenomena”
(ii) R. L. Panton “Incompressible Flow”
(iii) J. D. Anderson “Modern Compressible Flow”, 3rd ed

General conservation laws: Deen Ch 2, Panton Ch 5, Anderson Ch 2
Transport phenomena: Deen Ch 4-6, Panton Ch 6, Deen Ch 9-10
Incompressible flows: Panton Ch 10-11 18, 21
Boundary layer: Panton Ch 20, Deen Ch 8
Turbulence: Panton Ch 23, Deen Ch 13
Compressible flows: Anderson Ch 3

Suggested Courses:

(i) ME 220A “Fundamentals of Fluid Mechanics I” (Fall)
(ii) ME 220B “Fundamentals of Fluid Mechanics II” (Winter)