16.001/16.002 UNIFIED ENGINEERING I, II
Fall, 2008-09

MATERIALS & STRUCTURES
Contents of Lectures

The following is a detailed syllabus showing the 3 blocks, the 14 units within these blocks, and the topics covered within each unit. The readings assigned for each unit are given along with the lectures(s) in which the unit will be covered. Helpful additional readings are also noted *in italics*. The abbreviation key for the readings is noted below.

TEXTBOOKS:

Crandall, Dahl, and Lardner, *An Introduction to the Mechanics of Solids*, SI version, McGraw-Hill, 1978. (*referred to as* **CDL**)

M.F. Ashby and D.R.H. Jones, *Engineering Materials 1*, Pergamon Press, 1980. (or later version) (*referred to as* **A&J**)

Further useful references:

M.F. Ashby and D.R.H. Jones, *Engineering Materials 2*, Pergamon Press, 1986. (or later version) (Polymers, metal alloys)
M.F. Ashby, *Materials Selection in Mechanical Design*, Pergamon Press, 1992. (or later version) (Materials selection and design)
Bickford, *Mechanics of Solids*, Irwin, 1993

***(NOTE:** *Approximate* lecture numbers and dates are given in italics. Since the learning process is dynamic, these can only be planned, but not strictly adhered to. From time to time, any necessary major changes/shifts will be announced)

Block 1: Statics

Unit Number, Title, and Contents	Readings	Lectures*
1.1 *Introduction* What is Engineering?; What is a Model?; Fidelity of a model (assumptions and self-consistency); Why Materials & Structures?; Structural Engineering and its objective(s); How safe is "safe enough"/How right is "right enough"?; Structural integrity; 3 Great Principles of Solid Mechanics (Equilibrium, Compatibility of Displacements, Constitutive Relations)	CDL 1.1,1.2,1.3	*M1,2* *(9/15,16)*

Unit Number, Title, and Contents	Readings	Lectures*
1.2 *(All About) Mechanical Equilibrium* [U-A -- Dimensions and Units] Equilibrium of a particle; D'Alembert's principle; Equilibrium of a system (of particles); Particle vs. body; Planar force systems; Equipollent forces [U-B -- (All About) Forces and Moments]	CDL 1.6 CDL 1.4	*M2,3,4,5* *(9/16,19,26, 29)*
1.3 *Uses of Equilibrium* Types of supports (and their reactions); Free Body Diagrams; Three problem categories (Dynamic, Statically Determinate, Statically Indeterminate); Statically determinate systems: determination of reactions, examples	CDL 1.7,1.8	*M5,6,7* *(9/29, 10/1,3)*
1.4 *(All About) Trusses* Uses of trusses; Idealized planar truss; Determination of reactions; Method of Joints; Method of Sections; Joint/Truss realities	CDL 1.9	*M7,8,9* *(10/3,6,8)*
QFM2 -- *(10/15)*		
1.5 *Statically Indeterminate Systems* Review of definition; Approach via application of Three Great Principles; Constitutive Relations: spring, bar under axial load; Compatibility of Displacements; Examples; Displacement of Trusses; Symmetry and Superposition	CDL 2.1,2.3,2.4, 2.7	*M9,10,11* *(10/8,10,14)*

Block 2: Stress and Strain

Unit Number, Title, and Contents	Readings	Lectures*
2.1 *(More) Language for Stress and Strain* [U-A -- Transformations] Indicial (Tensor) Notation, Kronecker delta, permutation tensor; Transformation of coordinates -- basics and a revisit	CDL 4.1	*M11,12,13* *(10/14,17,20)*
2.2 *(All About) Stress* Concept/Definition of stress; Stress tensor and stress types; Symmetry of stress tensor; Stress equations of equilibrium; (More) Stress notation; Two-dimensional stress	CDL 4.2,4.3,4.4	*M13,14* *(10/20,22)*
QTM3 -- *(10/29)*		
2.3 *(All About) Strain* Concept/Definition of strain; Strain tensor and strain types; Small strain (vs. large strain); Strain-Displacement relations; Compatibility; (More) strain notation	CDL 4.8,4.9, 4.10	*M14,15,16* *(10/22,24,27)*

Unit Number, Title, and Contents	Readings	Lectures*
2.4 *Stress and Strain Transformations* Motivation; Tensorial form; Physical bases; Two-dimensional forms; Principal stresses/strains/axes; Extreme Shear stresses/strains; Mohr's circle (Handout)	CDL 4.5,4.6,4.7, 4.11,4.12, 4.13 *CDL 4.14,4.15*	*M16,17,18* *(10/27, 11/3,5)*

Block 3: Elasticity (and Materials)

Unit Number, Title, and Contents	Readings	Lectures*
3.1 *The Role of Material "Properties"* Classes of materials; Types of properties; Use of properties in design (and material selection); What is a "Property"?; The role of scale	A&J 1,2	*M18,19,20* *(11/5,7,12)*
QTMS4 -- *(11/19)*		
3.2 *General Stress-Strain Behavior* Uniaxial stress-strain; (Generalized) Hooke's Law; Elasticity and Compliance tensors; Classes of stress-strain behavior (anisotropy, orthotropy, isotropy); (Measurement of) Engineering constants	A&J 3 CDL 5.1,5.2,5.4, 5.10 *CDL 2.3*	*M20,21,22* *(11/12,14,17)*
3.3 *Physical Bases of Elastic Properties* Energy and Force: Atomic Bonds; Metals and Ceramics: Atomic Packing; Polymers and their structures; Estimate of moduli; Fibrous composites	A&J 4,5,6	*M22,23* *(11/17,21)*
3.4 *Stress-Strain Behavior (Revisited)* Explanation of Phenomena and Behavior; Role of scale -- "Effective Moduli"		*M23,24* *(11/21,24)*
3.5 *Summary of Equations of Elasticity* Governing equation summary; Boundary Conditions; Solutions approaches		*final recitation/ beginning of 2nd term*

QFMS5 -- *(12/3)*