UNIFIED HANDOUT

MATERIALS AND STRUCTURES - #M-9

Fall, 2008

Concept Review Sheet

for Unified Q(MS)5: Units M3.1-3.2

MATERIAL PROPERTIES AND THEIR ROLE

- Material choice and structural design are integrally linked
- Design of structural elements depends on a number of factors: functional requirements, geometry, material properties, processing issues
- Materials and structures are selected based on primary requirements; secondary requirements; manufacturing, processing, and assembling considerations; and cost
- Tradeoffs are a key part in design
- Effort is made to quantitatively assess various materials for application using figures of merit which incorporate geometrical parameters, material parameters, and constraint parameters
- Material property charts can be effectively used in initial choices/assessments in the design process
- A property in not an inherent "truth" of a material but is (generally) a quantifiable engineering approximation of the behavior of a material system used in a model of the material behavior
- There are many *length scales* in dealing with a material/structure

STRESS-STRAIN BEHAVIOR

- Strain is related to stress through the material property of *elasticity*
- Generalized Hooke's law is a tensorial relationship between strain and stress in 3-D
- The elasticity tensor is a fourth-order tensor with the first two subscripts pertaining to the stress and the second two subscripts pertaining to the strain
- The elasticity tensor has several symmetries: switching the first two indices; switching the last two indices; switching pairs of indices
- The elasticity tensor can have, at most, 21 independent components
- The compliance tensor is the inverse of the elasticity tensor and relates stress to strain
- The elasticity tensor component (E_{mnpq}) indicates the amount of stress (σ_{mn}) caused by/related to the deformation/strain (ε_{pq})
- The compliance tensor component (S_{mnpq}) indicates the amount of strain (ε_{mn}) caused by/related to the stress (σ_{pq})

- Elasticity and compliance tensors are fourth order and require four direction cosines for transformation
- There are several classes of stress-strain behavior for materials, characterized by the number of independent components of the elasticity tensor: anisotropic -- up to 21; orthotropic -- 9; isotropic -- 2
- Engineering constants relate measured quantities to characterize material elastic behavior and include extensional (Young's) modulus, Poisson's ratio, and shear modulus
- Engineering constants are directly related to physical measurements of material behavior; elasticity tensors are convenient for mathematical manipulation
- Elasticity tensors are determined by making physical measurements to determine engineering constants, placing the stress-strain relations in compliance form using these engineering constants, and inverting the compliance matrix to obtain the elasticity matrix

NOTE: See **Handout M-8** for key pertinent equations