StM1 Syllabus & Assessment

1 Structural Loads in Trusses and Beams (20% of Exam)

1.1 Trusses

1.1.1 Definitions, assumptions, sign conventions

1.1.2 Degree of redundancy (DoR)

1.1.3 Method of Joints

1.1.4 Method of Sections

1.1.5 Method of Tension Coefficients (for information only, not assessed)

1.2 Beams

1.2.1 Definitions, assumptions, sign conventions

1.2.2 Bending moment and shear force diagrams

- Point loads
- Uniform load distributions
- Linear (‘triangular’) load distributions

1.2.3 Principle of superposition (for information only, not assessed)

2 Stress, Strain and Deformation (40% of Exam)

2.1 Direct stresses and strains

2.1.1 Axial stresses and strains

- Stiffness and modulus
- Axial strains and deformation
- Yield stress and proof stress
- Thermal stresses (for information only, not assessed)

2.1.2 2D stresses and strains

- Poisson’s effects in 2D
- Application: pressure vessels
- Application: thermal stresses / strains

2.2 Shear stresses

- Concepts, definitions, sign conventions
- Shear modulus

2.3 Bending stresses / strains

- Concepts, definitions, sign conventions

- 2nd moment of area of rectangular and circular cross-sections (solid & hollow)
- 2nd moment of area of triangular cross-sections
- Parallel axes theorem, composite cross-sections (*e.g.* I-beams)

2.4 Bending deflection

- Double-integration method for finding slope and deflection equations (using Heaviside functions and boundary conditions)
- Double-integration method: beams with point loads
- Double-integration method: beams with distributed loads

2.5 Torsion

- Concepts, definitions, sign conventions
- Equations for the polar 2nd moment of area of circular cross-sections (solid & hollow)
- Torsion equation and its application

2.6 Buckling loads

- Concepts, definitions
- Derivation of the Euler buckling load (for information only, not assessed)
- General expression of the Euler buckling load
- Buckling load for fixed-fixed and pinned-pinned conditions
- Buckling load for other end conditions (for information only, not assessed)

3 Structures Lab (30% of A-Str)

- Data analysis and interpretation
- Technical writing

4 Energy methods (70% of A-Str)

4.1.1 Principle of Stationary Potential Energy (PSPE)

- Concept, derivation
- Application: statically determinate structures, DoR = 1
- Application: statically indeterminate structures, DoR > 1

4.1.2 Castigliano's 2nd theorem

- Concept, derivation
- Application: displacement at the loading point
- Application: displacement elsewhere

5 Introduction to Aircraft Structures (50% of B-Str)

- Introduction, major aircraft loads
- Loading and construction
- Fuselage structures
- Fuselage construction
- Wing structures

- Wing construction
- Composite structures
- Aircraft structural requirements
- Fatigue and damage tolerance

6 Structural Design (50% of B-Str)

- Design terminology (limit, ultimate, allowable, reserve factor, *etc.*)
- The Design Process (define, scheme, check and trade-off)
- Element Design (stiffness, strength & stability design of bars, beams and shafts under uniaxial & combined loading)
- Joint Design (Ultimate net-section average-stress design of single & multi-fastener riveted or bolted joints)

7 Material Properties (~30% of C-Mat)

7.1 Definitions & general formulae for the different properties

- Young's modulus, shear modulus
- Yield strength, ductility, UTS, failure strength
- Poisson's ratio
- Modulus of resilience
- True stress / true strain
- Brittle *vs.* ductile behaviour
- Tensile toughness
- Fracture toughness *vs.* critical strain energy release rate
- Impact toughness
- Wear rate
- Hardness

8 Materials Selection (~40% of C-Mat)

8.1 Ashby's materials selection method

- Concepts, procedure, usefulness in design
- Detailed derivation of material indices
- Operations on actual Ashby plots

9 Materials Lab (30% of C-Mat)

- Data analysis and interpretation
- Errors and limitations of the procedure

10 Atomic Structures and Deformation (20% of Exam)

10.1 Atomic Structures

- Types of bonds
- Potential energy: bond stiffness, thermal expansion, cohesive energy

- Atomic packing factor
- Atomic lattices: BCC, FCC, HCP
- Theoretical density *vs.* material density
- Crystal directions and planes

10.2 Deformation

- Plastic slip, slip planes
- Detailed rules on slip systems
- Dislocations, dislocation glide, work hardening
- Solution, dispersion and grain size strengthening
- Single crystals in aerospace

11 Polymers and Composites (20% of Exam)

11.1 Polymers

- Polymeric structures, amorphous *vs.* semi-crystalline polymers
- Thermoplastics *vs.* thermosets
- Glass transition
- Stiffness of glassy polymers
- Plastic deformation, chain alignment
- Viscoelastic behaviour
- Maxwell relaxation time

11.2 Composites

- General properties of fibres and matrices
- Moduli of composites: aligned and unaligned fibres
- Anisotropy
- Strength of composites: aligned and unaligned fibres
- Toughness of composites