Topics and questions for examination test in Strength of materials I

Basic terms

1. Write an overview of model bodies soluble by analytical methods of solid mechanics.
2. Describe how residual stresses can be induced in a body. Are there other mechanisms inducing existence of stresses in a body without action of external loads?
3. How temperature stresses can be induced in a body?
4. How many independent components are needed for description of a stress (strain) state in a point of a body? List these components.
5. Write the matrix form of strain or stress tensor.
6. Make a decision on acceptability of statically equivalent replacements of real loads for calculation of stresses (with taking Saint Vénant's principle into consideration).
7. Draw the stress-strain diagrams for linear elastic, non-linear elastic an elastic-plastic materials.
8. Draw the simplest models of elastic-plastic material behaviour.
9. Define basic types of failures (limit states) in mechanics of solids.
10. Define factors of safety against different limit states.
11. What is the difference between direct and inverse (indirect) problems? What methods are applicable in both categories of problems?

Basic formulations of linear theory of elasticity

1. Write an equation relating displacement and strain components.
2. Write all the equations needed for experimental evaluation of Young's modulus from the quatitites measured in experiment.
3. Write the formulas of Hooke's law for uniaxial and shear stress states. Write the formula for calculation of shear modulus.
4. Write the formula for work done by a system of isolated forces or/and couples during deformation of the body.
5. On the basis of Castigliano's theorem formulate the basic equation for calculation of displacement (angle of rotation) in a given point of a loaded body.
6. Specify basic types of nonlinearities in stress analyses.
7. What is strain energy density (and its unit) and how it can be calculated for uniaxial and shear stress states?

Inner resultants in bars

1. Draw the distribution of inner resultants in a given straight bar (statically determinate as well as indeterminate, with isolated or distributed loads).
2. Draw the distribution of inner resultants in a given angular or curved statically determinate bar with isolated loads.
3. Write the basic formulations of Schwedler's theorem used in evaluation of inner resultants.
4. Determine the dangerous section of a bar and calculate the magnitude of given components of inner resultants in this section or in another given section.

Stress-strain analysis of bars

1. Write basic formulas (for stress component, deformation parameter, strain energy) valid for different types of load of bars and their limitations (when there are any additional to the bar assumptions).
2. Draw the distribution of relevant stress components throughout a bar cross section (with different shapes) under different types of loads (including shear) and specify the dangerous points of the section.
3. Draw the stress distribution in a notched bar under different types of loads and define the stress concentration factor.
4. Draw the Mohr's diagram of a given tensor of second moments and calculate its principal values.
5. Write the differential equation of the deflection curve of a beam and formulate limitations of its application.
6. Formulate differential equation(s) of the deflection curve of a given beam.
7. Formulate boundary conditions for differential equation(s) of the deflection curve of a given beam.
8. Specify basic properties of neutral axis. How its position in the cross section can be found for 2D and 3D flexion?
9. Under what conditions the influence of shear force in beams may be relevant?
10. What is shear centre of a beam cross section, what is its importance? Where is it positioned at basic cross section shapes?
11. Under what conditions production inaccuracy can influence the risk of failure?
12. What are the conditions of simple tension, flexion or torsion of bars? How can they differ for statically indeterminate bars?
13. Create a released (primary) structure of a given body (structure) with rigid, compliant and/or circumstantial supports and specify application of Castigliano's theorem in the compatibility equations.
14. Create a released (primary) structure of a given strut frame with inner or outer static indeterminacy and specify application of Castigliano's theorem in the compatibility equations.

Angular and curved, opened and closed beams

1. Draw the distribution of normal stresses throughout the cross section of a curved beam. What are the differences in comparison with a straight beam?
2. Under what conditions the formulas for calculation of stresses and displacements valid for straight beams can be applied at curved beams? When the shear force can be neglected?
3. What components of inner resultants have zero values on the axis of symmetry (antisymmetry)?
4. Create a released (primary) structure (including compatibility equations) of a given closed beam exploiting its symmetry (antisymmetry).
5. Create a released (primary) structure (including compatibility equations) of a given curved or angular beam.

Buckling of columns

1. Write the formula for critical force for a free or supported column.
2. How the critical force of buckling can be increased without changes in geometry and material of the column?
3. Calculate the factor of safety against buckling for a given free or supported column.

4. Draw the dependence of deflection of a column under compressive load on the magnitude of this load (for both perfect and real inaccurately produced and loaded column).
5. Under what conditions the basic formulas for buckling of columns are applicable?
6. How the applicability of buckling formula can be assessed for a non-perfect column?
7. How the risk of buckling can be solved for columns with stepwise changes of cross section dimensions?
8. Define the slenderness of a bar applied in evaluation of the risk of buckling.
9. Write the formula for calculation of the critical slenderness of a free (supported) column.
10. Draw the dependence of critical stress in a free column under compressive load on the slenderness of this column.
11. What is the complication of solving a bended beam with two pin supports?

Mathematical description of stress states

1. Write the matrix equations for calculation of general stress (traction), normal and shear stresses in a section given by direction vector of its normal line (cosinuses of angles to the coordinate axes).
2. What are principal stresses, principal directions, principal planes? Which is mutual position of principal directions?
3. How the magnitude of octahedric normal and shear stresses can be calculated?
4. Formulate the theorem of equality of shear stresses.
5. For a given state of stress
    a) write the matrix form of the stress tensor
    b) draw the non-zero stresses acting on an infinitesimal cube
    c) draw the Mohr's diagram.
6. Write the characteristic equation of stress tensor. What is this equation used for?
7. Draw Mohr's diagram for a plane stress state given in a general coordinate system, specify the input quantities needed and define (calculate) principal stresses and maximum shear stress.
8. Identify plane, bar-like, shear and uniaxial stress states among stress states given by numerical values of stresses or drawn using an infinitesimal cube.
9. Write the matrix form of stress deviator.

Theory of limit states (failures)

1. Which components of stress tensor are chosen as decisive for failure in Tresca, Mises or MOS criterion?
2. Write the equation for evaluation of the factor of safety using MOS criterion, describe all the quantities.
3. Write the equations for evaluation of the reduced stress using Tresca or Mises criterion, for both general and bar-like stress states.
4. What is the shape of the limit envelope of Tresca, Mises, or MOS criterion of failure in Haigh space of principal stresses?
5. Specify the factors increasing the tendency of a material to its brittle behaviour.
6. Under what conditions fracture can occur for reduced stresses lower than yield stress of the material? Under what limitations MOS criterion is applicable?
7. For a given stress state calculate the reduced stress valid either for ductile or brittle material, using MOS, Tresca or Mises criterion.
8. Calculate the factor of safety for given stresses in a bar and for given ultimate stress values of a ductile or brittle material.

9. For a plane stress state defined by values of general or principal stresses calculate the factor of safety against brittle fracture (or plastic deformation for ductile materials). Specify the material characteristics needed and choose their values within a realistic range.
10. Specify the factors significant for magnitude of fatigue strength of a component part.
11. Calculate the factor of asymmetry of a given loading cycle.
12. What is the difference between static and cyclic stress-strain curve?
13. What is the basic material characteristic for high cycle fatigue?

Combined loading of bars, FEM, experimental methods

1. How the factor of safety can be calculated in combined loading of bars?
2. How the displacement (angle of rotation) of a point of bar centreline can be calculated under combined loading?
3. What is the basic mathematical principle of finite element method?
4. What types of problems can be solved using finite element method?
5. What types of constitutive relations are applicable in finite element method?
6. Describe any of basic principles of strain gauges. How can they be used for evaluation of stresses?