Brittle fracture with or without a detected crack

1. What can be characterized by the discontinuity vector of a crack?
2. What can be determined on the basis of stress intensity factor
3. What is fracture toughness and under what stress-strain conditions can it be determined?
4. Under what conditions no crack propagation occurs under symmetric alternating normal stress cycles?
5. Under what conditions the LEFM (K-conception) can be used for judging the crack behaviour?
6. Write the general formula for evaluation of stress intensity factor on the basis of calculated stresses. What is its physical dimension?
7. Define the crack driving force.
8. Write the equation of the energy balance of a propagating crack, describe the quantities.
9. What is the shape of the limit surface of modified Mohr's (MOS) criterion in the Haigh (principal) stress space?
10. For a given shear stress state calculate the reduced stress using modified Mohr's (MOS) criterion.
11. For a stress state defined by values of principal stresses calculate the factor of safety against brittle fracture. Describe the unknown material characteristics and choose their values in their realistic range.
12. For a given stress tensor calculate the reduced stress values valid for ductile and brittle materials.
13. Calculate the factor of safety for a given stress tensor and for given ultimate stress values of ductile and brittle materials.
14. Draw the stress distribution in front of the crack tip in a ductile material.

Description of stress-strain states

1. Draw Mohr's diagram for a given plane stress state and describe there the input quantities, principal stresses and maximum principal stress.
2. Draw Mohr's diagram for a given plane strain state and describe there the input quantities, principal strains.
3. Identify plane, bar-like, shear and uniaxial stress states among stress states given by numerical values of stresses or drawn using an elementary cube.
4. What is the strain state under conditions of
    a) plane stress state
    b) uniaxial stress state
    c) shear stress state?
5. What is the stress state type under conditions of plane strain state?
6. For a given plane stress state calculate all the components of principal stresses.
7. For a given plane stress state calculate the maximum shear stress.
8. For a given plane strain state calculate all the components of principal strains.
9. For a given plane strain tensor formulate its characteristic equation.
10. For a given plane stress tensor formulate its characteristic equation.
11. What is characteristic equation of a stress (strain) tensor, what is its purpose? How its coefficients are calculated?
12. Write matrix formula for calculation of stresses (strains) in a general plane, define the applied matrixes and their dimensions.

Material fatigue

1. Calculate the asymmetry coefficient of a given stress cycle.
2. Draw the cyclic stress-strain curve. How it can be evaluated experimentally?

3. Draw the cyclic and monotonnous stress-strain curves for a stiffening (softening) material.
4. Draw the cyclic stress-strain curve and formulate the equation for its mathematical description.
5. Draw the Wöhler's curve and define the ranges typical from the point of view of the fatigue fracture (LCF, HCF etc.)
6. Draw a simplified Smith's (Haigh's) diagram and write the equation of its limit line.
7. What types of functions are used for simplified description of Haigh diagram?
8. Define and describe the basic material characteristic for evaluation of lifetime for LCF?
9. Draw and describe the graph showing the dependence of the crack propagation velocity on the stress intensity factor range. In what part the crack propagation velocity can be desribed by Paris-Erdogan formula?
10. Write the Paris-Erdogan formula describing the crack propagation velocity as function of the stress intensity factor K_I.
11. What is the main difference between concepts of nominal stresses and local stresses?
12. Draw the limit curve applicable for evaluation of the factor of safety against fatigue under combined load of beams.
13. Describe basic steps of the procedure of lifetime evaluation under stochastic (non-uniform) loading cycles.
14. What concepts can be used for finite life assessment in LCF region?
15. Calculate the bending (torsion) moment in the defined location of a given (statically determinate) 3D beam.
16. What are factors influencing the component specific endurance limit?
17. How the notch factor for fatigue can be evaluated?
18. How the factor of safety against fatigue can be calculated for proportional and non-proportional components of stresses in beams (σ_m and σ_a or σ and τ).
19. How the fatigue life can be evaluated for a set of loading cycles with different parameters?

System of equations of the general theory of elasticity

1. How many are the unknown functions in a general problem of elastic analysis? List them using their common symbols.
2. How many equations are necessary for solving a general problem of elastic analysis? List their type and numbers.
3. In the deformation variant of the general problem of elastic analysis, what are the basic unknown functions?
4. How are the principal strains (stresses) defined?
5. Draw and describe Mohr's diagram of the strain (stress) tensor for given components of principal strains.
6. Formulate the characteristic equation of the strain (stress) tensor and formulas for calculation of its invariants. What is the objective of this equation?
7. Formulate the spherical and deviatoric parts of the strain (stress) tensor.
8. Formulate the equations of static equilibrium of an inner element of a body in a cartesian coordinate system.
9. Write the basic geometrical equations in a cartesian or cylindric coordinate system. What are the basic limitations of their validity?
10. What are the basic types of boundary conditions for a general problem of elastic analysis?

Constitutive relations

1. What are the basic features of a Hookean material?

2. Draw the loading and unloading curves of a non-linear elastic material.
3. Draw the loading and unloading curves of an elastic-plastic material a) with stiffening; b) without stiffening – perfect elastic-plastic material; c) real elastic-plastic material.
4. Write all the formulas necessary for calculation of elastic parameters E, μ from the results of the tension test.
5. Write the formulas describing the general (3D) Hooke's law (in the cartesian or cylindic coordinate system).
6. What elastic parameters occur in the inverse form of Hooke's law (with explicitely expressed stresses)?
7. Write the formula defining the bulk modulus of elasticity? What is its physical dimension (unit)?
8. How the relative volumetric change can be calculated from strain components?
9. What is the dimension of the matrix of elastic constants of a homogenneous isotropic linear elastic material? How many independent elastic parameters are necessary for its formulation?
10. How can the value of σ_z stress be calculated under plane strain conditions (for $\varepsilon_z = 0$)?
11. Calculate the components of strain tensor from the given values of stress tensor (in the principal or general coordinate system).

Thick-wall cylindric body

1. List and characterise the basic types of model bodies solvable by the analytical methods of elasticity theory.
2. What components of the stress tensor must be zero in an axisymmetric body? Write the matrix form of stress tensor for an axisymmetric body.
3. Formulate the geometrical equations (relations between displacements and strains) for a cylindric body.
4. Formulate the boundary conditions for solving a cylindric body loaded by the inner (p_1) and outer (p_2) pressures.
5. Write the general formulas for stresses in a thick-wall cylindric body.
6. Calculate the axial stress in a cylindric vessel loaded by an inner pressure p_1 (outer pressure p_2).
7. Draw the distribution of all principal stresses in a cylindric vessel loaded
   a) by the inner pressure p_1
   b) by the outer pressure p_2.
8. What ways can be used to increase the load-bearing capacity of a cylindric pressure vessel, when the increase of the wall thickness is not more applicable?
9. Draw the distribution of all principal stresses in a cylindric double layer vessel (with interference at the interface of layers) loaded by the inner pressure p_1 or without any load.
10. Formulate boundary conditions for a wheel forced on a shaft with interference.

Rotating disc

1. Draw an inner element of a rotating circular wall (disc) isolated as a free body.
2. Formulate boundary conditions for solving a rotating axisymmetric wall for
   a) annular wall loaded by the inner or outer pressure
   b) annular wall loaded by the inner pressure and tension on the outer surface.
   c) circular wall loaded by the outer pressure.
3. Draw the radial distribution of all principal stresses in

a) annular wall loaded by the inner or outer pressure
b) annular wall loaded by the inner pressure and tension on the outer surface.
c) circular wall (rotating disc) loaded by the outer pressure (tension).
d) a rotating disc with a small central hole and unloaded surfaces

4. How does the thickness of a rotating disc change? Draw its dependence on the radius.
5. Calculate the change in thickness in a given point of a rotating disc from the known stress values in this point.

Axisymmetric plate

1. What are the limitations of applicability of Kirchhoff's plate theory, presented in the course? What are its assumptions on the stress distribution throughout the plate thickness?
2. Write the matrix form of the stress tensor for an axisymmetric plate and draw the distribution of stress components throughout the thickness of an element of an axisymmetric plate.
3. Draw the components of line inner resultants acting onto an element of an axisymmetric plate and write the formulas defining them on the basis of stresses.
4. Write the boundary conditions for solving the deflections of a circular plate with different loads and supports.
5. Calculate the shear force magnitude T on a general radius r of a circular plate with different loads and supports.
6. Write the formulas for calculation of extreme stresses from the line moments at an axisymmetric plate.
7. Calculate the extreme stresses for given values of line moments in a plate.
8. What is bending stiffness of a plate?

Membrane theory of axisymmetric shells

1. What are the factors causing disruption of the membrane stress state in a shell?
2. Judge acceptability of supports of a membrane shell and change the accordingly.
3. Formulate Laplace eqaution valid for a membrane axisymmetric shell and explain all the related quantities.
4. Write the matrix form of the stress tensor in an axisymmetric membrane shell and draw the distribution of stress components on a shell element.
5. Calculate the circumferential (axial) stress in a given cylindric membrane shell.
6. Calculate conical radius of curvature in a given point of a conical shell.
7. Write the basic form of equation of static equilibrium of a membrane shell in axial direction.
8. Calculate the radial displacement of a cylindric membrane shell on the basis of known stresses.

Momentum theory of cylindric shells

1. Write the matrix form of the stress tensor in an cylindric momentum shell and draw the distribution of stress components on an infinitesimal shell element.
2. Draw free body diagram of an infinitesimal element of momentum cylindric shell with using (line distributed) inner resultants.
3. How the (line distributed) inner resultants in a cylindric momentum shell are defined?
4. How are formulated the geometric equations of an axisymmetric body?
5. What is bending stiffness of a shell?
6. Write the formulas for calculation of extreme stresses at a cylindric shell.

7. What is the type and order of the differential equation derived for solving a short or long cylindric momentum shell.
8. Formulate boundary conditions for a given momentum cylindrical shell.

Finite element method (FEM)

1. What types of problems can be solved using FEM? What problem in mechanics cannot be solved by finite elements at all?
2. What is a functional?
3. Formulate the theorem of minimal quadratic functional.
4. What are degrees of freedom of a 3D hexagonal (brick) element?
5. What are degrees of freedom of a 3D shell (beam) element?
6. Write the equation for Lagrange potential (total potential energy of a body) and describe the symbols.
7. Draw the graphical dependences of the potential of external loads, strain energy and total potential energy of a unidimensional body as functions of the displacement magnitude.
8. What is the distribution of displacements, strains and stresses throughout a finite element with a linear (quadratic) base function?
9. What types of elements are better in description of stress concentration and why?
10. What types of material behaviour can be used in FEM?
11. What are the basic parts of FE software? What is their role?

Experimental methods in mechanics

1. What types of experimental methods are used in mechanics?
2. What is the role of experiments in mechanics?
3. List basic methods for experimental evaluation of strains and stresses.
4. What physical principles can be used for strain gauges?
5. What physical principles can be used for detection of body movement?
6. What methods can be applied for monitoring of fracture process?
7. When strain measuring chains of strain gauges are used? What quantity is decissive for the choice of strain gauge size?
8. How the (electric resistance) strain gauge sensitivity is defined?
9. Under what conditions rosettes of strain gauges are used?
10. Under what conditions T-rosettes of strain gauges are used?
11. Under what conditions only one simple strain gauge is sufficient to evaluate the principal stress?
12. What information can be gained by using the brittle lacquer method?
13. What principles of gauges can be used for detection of fast dynamic body movement?
14. How the principal stresses can be calculated from the strains measured by using a T-rosette for strain measuring?
15. How the principal strains can be calculated from the values measured by means of a rosette of strain gauges?