Strength of Materials

14. Summary

SoM assumptions - summary

- Material continuum
  matter smeared in the physical space
- Static equilibrium
  any subpart of structure is in the static equilibrium (no inertia forces, no mechanisms)
- Solidification principle
  initial and actual configurations are almost identical (no influence of displacements onto static values)
- Small derivatives of displacements
  linearized geometric equations, infinitesimal strains
- Constitutive equations independent of time and environmental regime
  (it will be broken in the second semester)
- Material physical linearity
- Material elasticity
- Material isotropy

  } Hooke's material

  two material parameters only
- Material homogeneity

Statics

- Theorem of equivalence between sets of external and internal forces
- Proper cross-sectional coordinate set – cross-sectional forces
- Bar structures
    - geometric stability
    - constraints reactions
    - trusses (two-forces elements)
        - analytical method of joints
        - method of sections
        - method of bars conversion
        - method of virtual works (powers)
    - beams (basic and inverse problem)
    - slant beams
    - continuous beams (decomposition and equivalent scheme)
    - frames (nodes’ equilibrium checking)
    - arches (circular and other)
    - combined structures (beam-type and truss elements)

Continuum mechanics

- unloaded and actual configurations: spatial and material descriptions
- displacements
- strain definition and its linearization
  - Cauchy (infinitesimal) strain tensor
  - linear strains
  - angular strains
- stress definitions
  - normal and shear stresses
  - stress boundary conditions
- strain and stress analysis
- constitutive equations
  - two-way Hooke’s equations
  - volume change law
  - distortion law
  - material parameters
- boundary value problem
  - existence and uniqueness
  - methods of solution

Exam problems

1. Derive the theorem of an equivalence between external and internal sets of forces.
2. Give the necessary and sufficient conditions of geometrically stable connection of two shields.
3. Give the necessary and sufficient conditions of geometrically stable connection of three shields.
4. Define the virtual displacements. Are there linked to the virtual velocities?
5. Is hinge a characteristic point for the equations of cross-sectional forces?
6. Show graphically three theorems of the truss zero-force elements.
7. Draw the equivalent scheme for given Gerber's beam.
8. Based on the cross-sectional forces diagrams, verify balance of the frame composed node.
9. Sketch the idea of the Henneberg method for the trusses.
10. Which elements in combined structures would be analyzed first?

Exam problems – cont.

11. Give the transformation rule of the second rank tensor in the indices notation.
12. Describe shortly Lagrange and Eulerian descriptions of the material particle position.
13. Decompose the tensor $T = \begin{bmatrix} 5 & -2 & 3 \\ -2 & 7 & 4 \\ 3 & 4 & 8 \end{bmatrix}$ into the isotropic and deviatoric parts.
14. Write the Cauchy tensor of infinitesimal strains as a function of displacements in the index notation and in the extended form.
15. Interpret diagonal and beyond diagonal components of the Cauchy strain tensor.
16. What is the use of rosette strain gages?
17. Give the definition of the linear and angular strain.
18. What is the meaning of the compatibility equations?
19. Give the convention of the stress sign.
20. Write the formulae for principal values and principal directions in two dimensional state of stress.

Exam problems – cont.

21. Give the stress matrix $T_\sigma = \begin{bmatrix} 50 & 0 \\ 0 & 0 \end{bmatrix}$ transformed to the coordinate system turned by $30°$ degrees.
22. Write the static boundary conditions in the index notation.
23. Write the Navier (internal balance) equations and interpret quantities taken in.
24. Using the Mohr circles draw the solution to the eigenvalue problem of the tensor $T_\sigma = \begin{bmatrix} 5 & 5 \\ 5 & -10 \end{bmatrix}$
25. What is a homogeneous material?
26. Explain material isotropy.
27. Sketch the $\sigma = \sigma(\varepsilon)$ diagram for the tensile test of mild steel.
28. Write the Hooke's constitutive law in both ways ($\sigma = \sigma(\varepsilon)$ and $\varepsilon = \varepsilon(\sigma)$).
29. Give the volume change law in tensor (matrix) notation.
30. Give the shape change law in tensor (matrix) notation.

Good luck!