BK80A4020 Engineering Mechanics III

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Exam 10.9.2026

Allowed: Calculator (no model restrictions), writing tools, formulae sheet of the course. No other written material besides the formulae sheet. No own markings or modifications are allowed in the formulae sheet.

Exam has two sections:

- **Section A, which contains 10 short & easy questions each worth 1p**
- **Section B, which contains broader questions worth 40p in total (point values for each question in parentheses)**

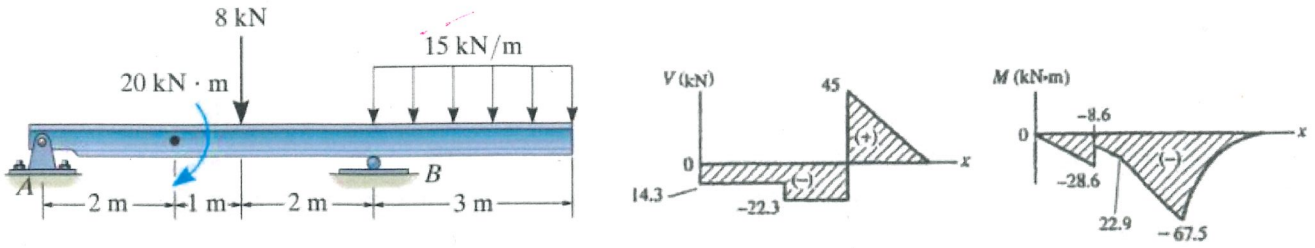
Student must get at least 6 points from section A, or section B won't be graded.

General advice:

- **Write your answers to all questions in the answer paper – not question paper!**
- **Answer section A on the front page of your answer paper**
    - **There is no NEED to provide explanations in section A - plain answers are sufficient (unless you think the question is a bit controversial; in this case please elaborate)**
    - **That said, calculations are naturally welcome**
    - **Please use CAPITAL LETTERS for the sake of clarity**
- **Tasks don't need to be solved in order, but please mark clearly the task numbers**

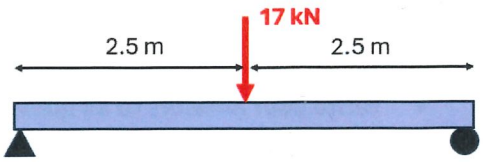
SECTION A

1. A beam is loaded as shown below on the left. The resulting shear and moment diagrams of the beam are shown on the right. If the beam is made of S420 steel and we want to use a safety factor of 1.5, what is the smallest IPE profile that can withstand the loading? (In terms of bending stress.)



A) IPE 140 B) IPE 180 C) IPE 220 D) IPE 270

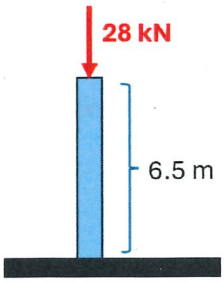
2. A steel beam (HEA 180, E = 210 GPa) is loaded as shown on the right. What is the deflection of the beam in the center? (One-decimal accuracy; positive direction down, neglect own weight.)



A) 1.0 mm B) 8.4 mm

C) 22.8 mm D) 89.6 mm

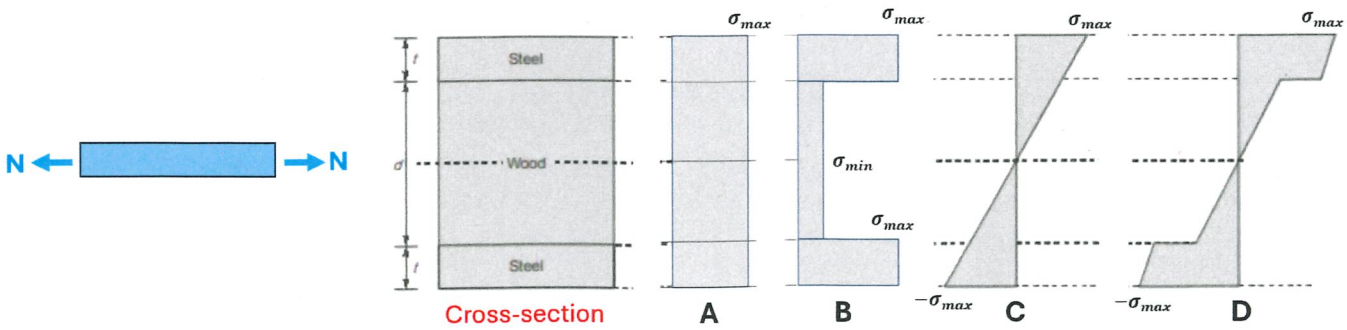
3. The column on the right is HEA 140 (S355, E = 210 GPa). It is loaded as shown. What is the safety factor?



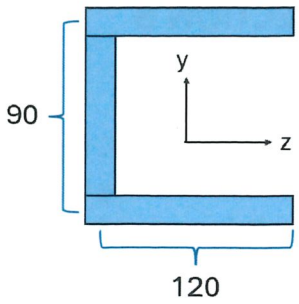
A) 1.70 B) 2.17 C) 4.51 D) 18.05

4. A composite beam that consists of a wooden section placed between two steel sheets is subjected to **normal force N**. $E_{steel} = 210\ GPa, E_{wood} = 15\ GPa$. Which of the options below depicts the **stress distribution** in the beam cross-section?

A) Option A B) Option B C) Option C D) Option D



5. The C-profile shown on the right has a constant thickness of t = 5 mm. Dimensions are given as midplane dimensions in millimeters. Using the given coordinate system, what is the product of inertia for this profile? (Two significant digits.)



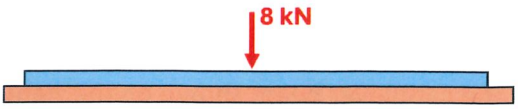
A) $I_{yz} \approx -0.76 \cdot 10^6\ mm^4$

B) $I_{yz} = 0\ mm^4$

C) $I_{yz} \approx 1.6 \cdot 10^6\ mm^4$

D) $I_{yz} \approx 3.2 \cdot 10^6\ mm^4$

6. An IPE 160 beam (blue; E = 210 GPa) is resting on concrete floor (orange) whose $k = 5\ MPa$. The center-point of the beam is loaded by a 8-kN point force. What is the greatest deflection of the beam? (Two significant digits.)



A) 0.73 mm B) 1.4 mm C) 1.6 mm D) 6.6 mm

7. We have solved the eigenvalues of our stress component matrix (units MPa) to be -90, 130 and 200. What is the corresponding Von Mises stress? (Rounded to nearest integer.)

A) 221 MPa B) 255 MPa C) 262 MPa D) 290 MPa

8. A beam is made of structural steel whose yield strength is 590 MPa and ultimate strength 800 MPa. The reduced endurance limit for the beam is 285 MPa. The beam is subjected to bending loading which is of fatigue nature. What is the slope of its S-N-curve? (One-decimal accuracy.)

A) 7.5 B) 11.1 C) 11.8 D) 34.7

9. A laminate has been formed from orthotropic laminas by gluing n pieces of laminas in $+50°$ and n pieces of laminas in $-50°$ orientation. Which one of the following is the consequence?

A) Transformation matrices become identity matrices

B) Laminate will be isotropic

C) Global elastic matrix Q will become an identity matrix

D) Global elastic matrix Q will be symmetric

10. A process tank has an external diameter of 80 mm and wall thickness of 15 mm. The hydraulic liquid inside the tank is pressurized to 350 bar. What is the longitudinal stress in the tank wall? (3 significant digits.)

A) 22.4 MPa

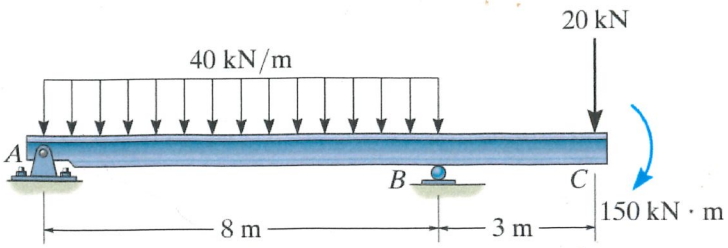
B) 29.2 MPa

C) 46.7 MPa

D) 58.3 MPa

SECTION B

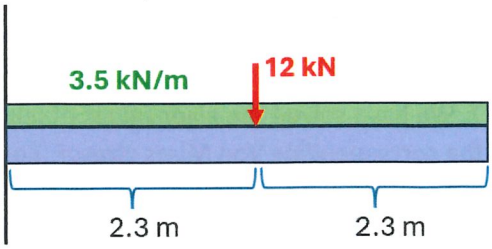
1. The beam ABC shown on the right is loaded according to the picture. Choose the lightest possible IPE so that the beam will be able to endure the loading with a safety factor of 1.5. Material is S420, own weight of the beam can be neglected. (7p)



2. The cantilever beam shown on the right is an IPE 300 made of S235 steel (E = 210 GPa). It is loaded according to the picture.

a) Calculate the maximum normal stress in the beam. (2p)

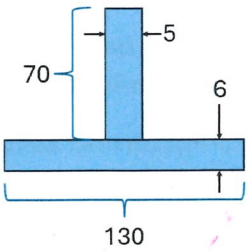
b) Calculate the maximum shear stress in the beam. (1p)



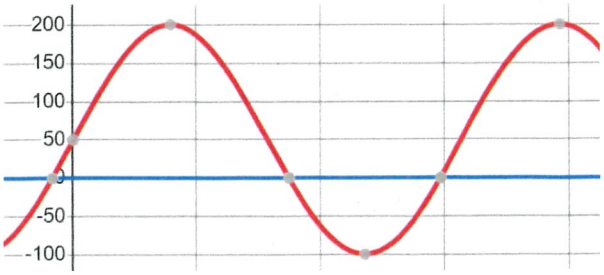
c) Calculate the maximum deflection of the beam. Neglect its own weight and the effect of shear force. (4p)

3. a) A HEA 200 column of length 7 m (S420, E = 210 GPa) is supported in such a way that the column can be considered fixed-pinned in x-x-direction and fixed-fixed in y-y-direction. Calculate the compression capacity of the beam in kN. (4p)

b) A T-profile whose cross-section is shown on the right (all dimensions in millimeters) is subjected to a torsional moment of 350 Nm. Calculate the resulting greatest shear stress in the profile. (4p)



4. The stress variation in our structure follows the graph on the right (units MPa). Material is S390, ultimate strength 520 MPa. Reduced endurance limit of our structure is 190 MPa.

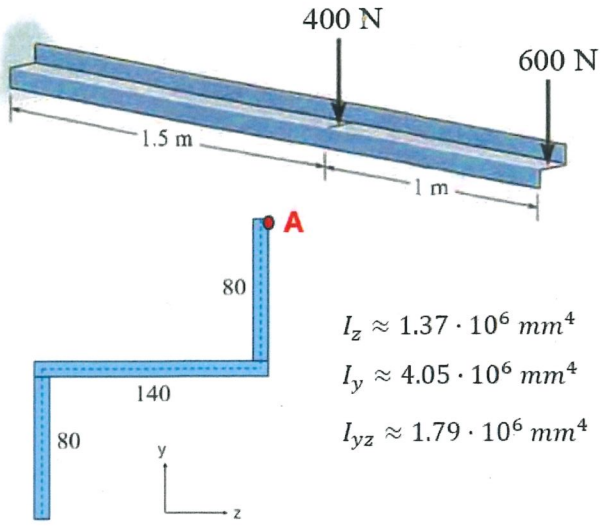


a) Define the mean stress and stress amplitude in our structure. Will the structure last indefinitely or will it fatigue at some point? (3p)

b) If the answer is indefinitely, calculate the safety factor using Haigh-Goodman diagram. Otherwise, fit the appropriate S-N-curve and calculate the resulting fatigue life in cycles. (4p)

5. A cantilever Z-profile whose thickness is 4 mm (picture on the right; cross-section with centerline dimensions in millimeters below the picture) is loaded as shown. Calculate the normal stress at top right corner A. (6p)

Note: Moments of inertia are readily calculated.



$I_z \approx 1.37 \cdot 10^6\ mm^4$

$I_y \approx 4.05 \cdot 10^6\ mm^4$

$I_{yz} \approx 1.79 \cdot 10^6\ mm^4$

6. A wooden 100 mm x 150 mm beam (orange) is strengthened by attaching two steel plates (blue; thickness 8 mm each) to opposite sides of the beam. The resulting beam is then subjected to a bending moment of $M_z = 2.4\ kNm$. Calculate the greatest normal stress in both wood and steel. Use $E_{st} = 210\ GPa$ and $E_w = 14\ GPa$. (5p)