Department of Aerospace Engineering

MIDTERM: AE 238-AEROSPACE STRUCTURAL MECHANICS

Time: 2 hours

Date: 24/02/2021

Max Marks: 30

Instructions:

- **Question 3 is compulsory and except that attempt any 5 questions from the remaining.**
- You are allowed to look at your notes, class slides and books. However, if you are found to have copied the solution from someone else, then both students will receive FR grade in the course.
- Take pictures of your answer-sheets and upload them on Moodle by **11:15 am.**
- If you face any problems with uploading, email your answer-sheets to susmitanaskar@iitb.ac.in and your respective TA. Answer-sheets received after 11:15 am. will not be evaluated.

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1. A uniformly tapered bar of circular cross-section is attached to a rigid support at A. There is a gap of 0.25 mm between end B of the bar and the rigid wall at C as shown in Fig. 1. The area of cross-section at A and B are 100 mm^2 and 75 mm^2 respectively. The Young's modulus is 200 GPa and coefficient of thermal expansion is 10^{-5} per °C. If the temperature of the rod is increased by 100°C, find the maximum and minimum axial stresses (in MPa) developed in the bar.

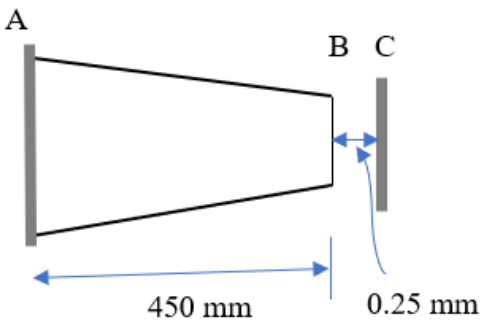


Fig. 1

5 marks

2. Consider a rigid bar pinned at A and supported by a linear spring at B and a steel rod at D as shown in Fig. 2. A vertical load of 30 kN is applied at C. Draw the free body diagram of the system and compute the vertical displacement (in mm) of point D.

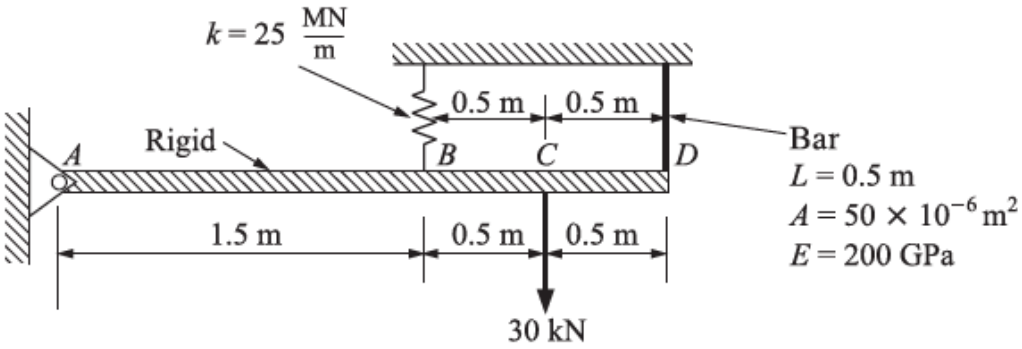
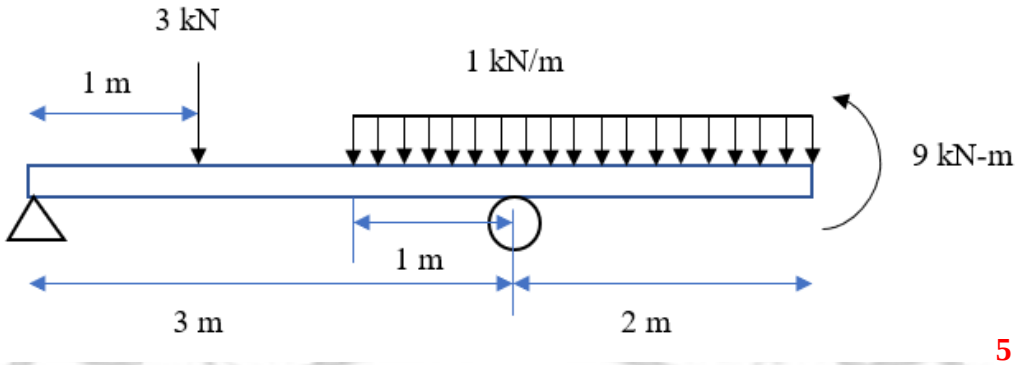


Fig. 2

5 marks

3. A simply supported beam is loaded as shown in Fig. 3. Draw the shear force and bending moment diagrams. What is the magnitude of maximum bending moment?



5 marks

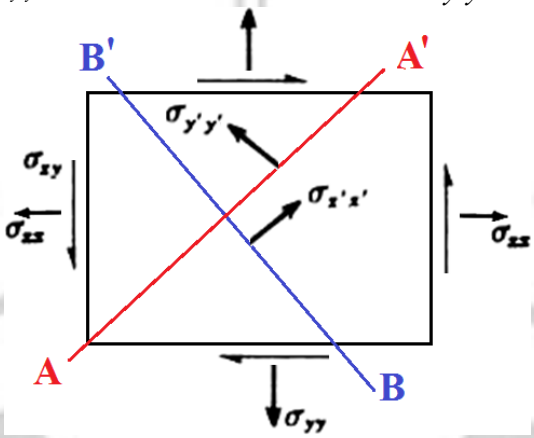
Fig. 3

4. The displacement field is given by
$\boldsymbol{U} = kxy\,\mathbf{i} + kxy\,\mathbf{j} + 2k(x+y)\,\mathbf{k}$, where k is a small constant enough to ensure applicability of small deformation theory.

a) Write down the strain matrix.
b) Determine the strain components at the point (1, −2, 0).
c) Verify whether the strain compatibility condition is satisfied.

5 marks

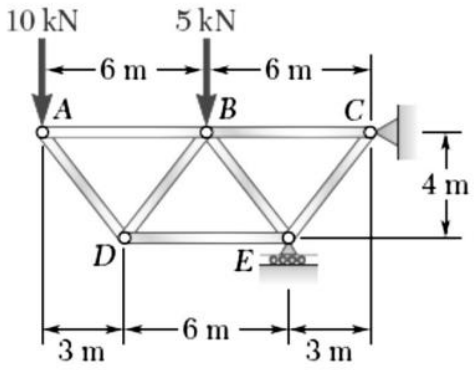
5. The stresses on a 2D element are given as $\sigma_{xx} = \sigma$, $\sigma_{yy} = 2\sigma$, $\sigma_{xy} = \sigma/2$. Consider two different mutually perpendicular planes AA' and BB' as shown in Fig. 4. The normal stresses on the planes AA' and BB' are given by $\sigma_{x'x'}$ and $\sigma_{y'y'}$. Find the summation of $\sigma_{x'x'}$ and $\sigma_{y'y'}$.



5 marks

Fig. 4

6. A truss is shown in Fig. 5. Find the forces in the members AD and EC.



5 marks

Fig. 5

7. A beam with an internal hinge is shown in Fig. 6. A uniformly varying load is applied over a span of 3 m. Find the reactions at A, B and D. Draw the shear force diagram. What is the maximum bending moment?

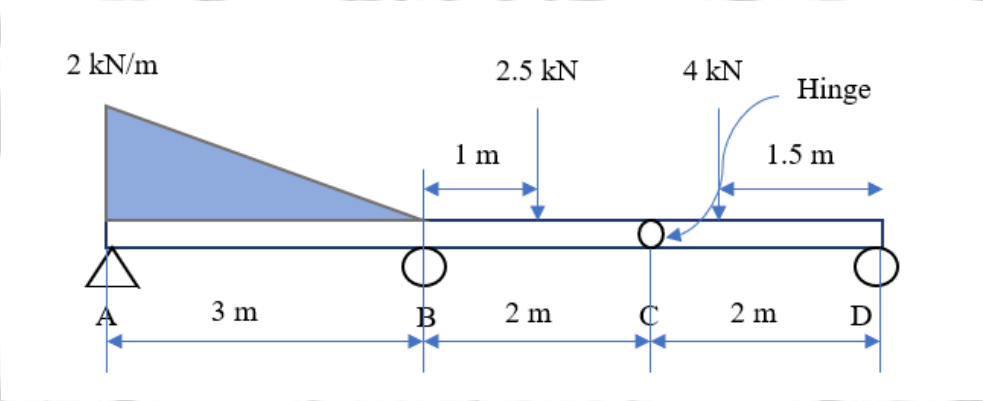


Fig. 6

5 marks