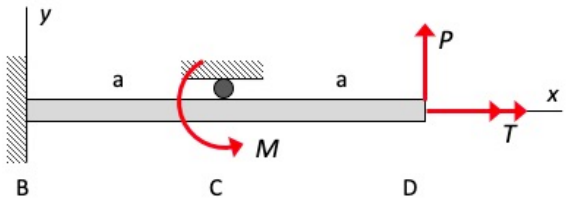
Course Summary Example No. 1

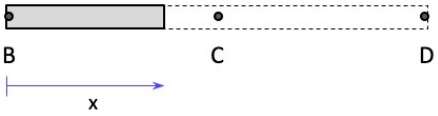


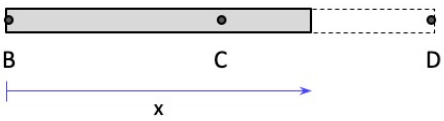
The propped-cantilevered beam shown above has a circular cross-section (of radius r), and is made of a ductile material having a Young's modulus of E and yield strength of σ_Y. The beam has a transverse load P and an axial torque T applied at the free end D, where $T = Pr$ and a bending couple M applied at C, where $M = P$a. For this problem, use r/a = 0.1. Here we are asked to determine the factor of safety against yielding on either the top or lower surfaces of the beam. In this solution, anticipate the following steps:

i. Equilibrium analysis
ii. Deflection analysis (for finding external reactions in indeterminate structures)
iii. Internal resultant analysis (including shear force/bending moment diagrams)
iv. Location and description of the critical state of stress
v. Mohr's circle for the critical state of stress
vi. Failure analysis using the maximum shear stress theory

SOLUTION

Equilibrium analysis



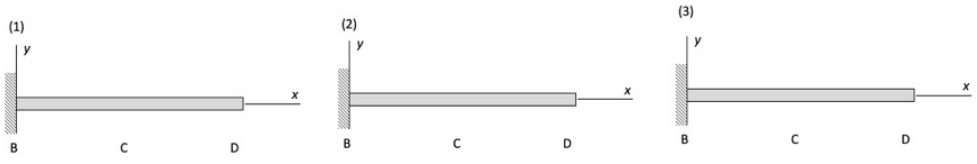


Deflection analysis – using three different methods

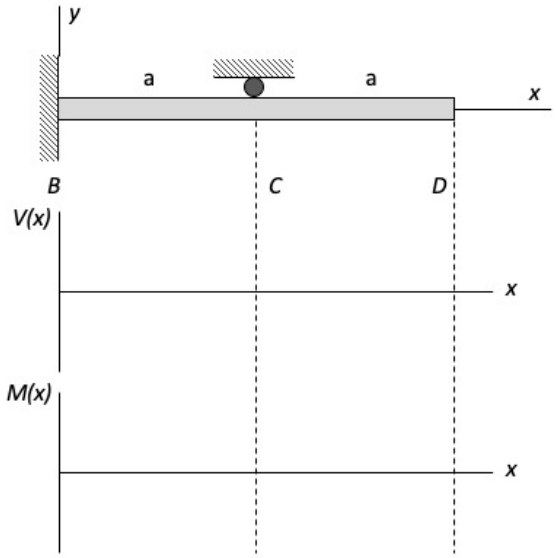
Method #1: 2nd – order integration

Method #2: Castigliano's 2nd theorem (ignoring shear effects)

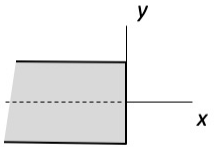
Method #3: Superposition

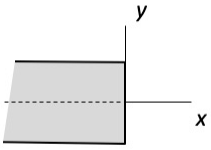


Shear force/bending moment diagrams

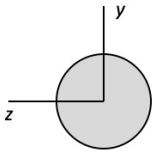


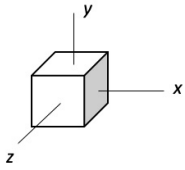
Critical state of stress on top or bottom surface

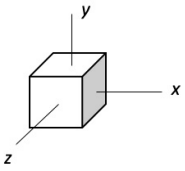




Mohr's circle (will be the same for both a and b)







Failure analysis