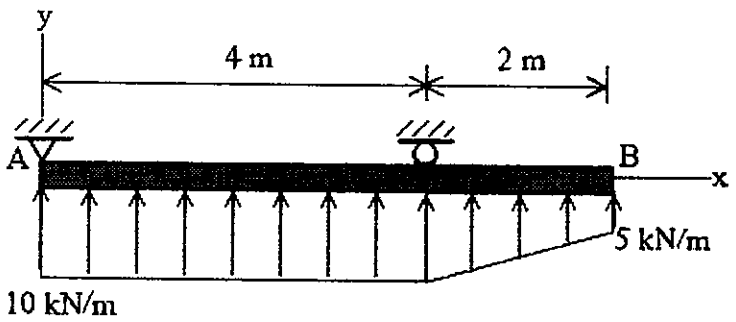
Problem 1 (25%)

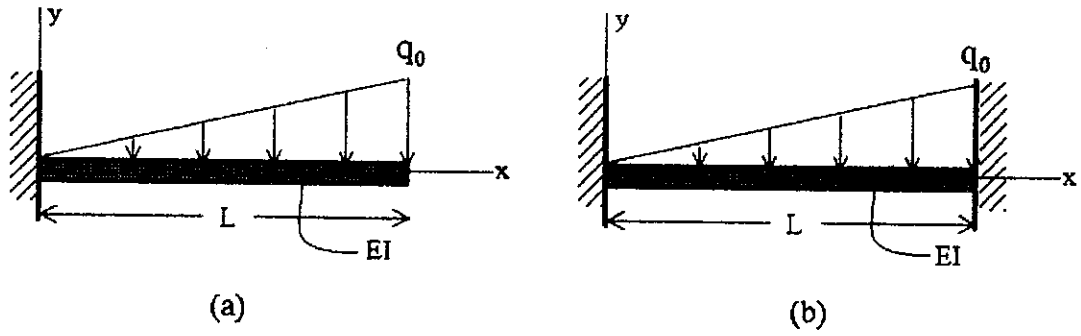
A tie beam (AB) subjected to a distributed load is shown below. Derive the equations of shear force and bending moment for this beam. Plot the shear force and bending moment diagrams and clearly mark all critical ordinates.



Problem 2 (25%)

A cantilever beam (a) and a fixed-fixed beam (b) are shown below.

(i) (20%) Use the fourth-order differential equation to derive the equations of the deflection curve for both the cantilever beam and the fixed-fixed beam. All the coefficients must be determined.
(ii) (5%) Find the maximum deflection for the fixed-fixed beam. (Partial credits would be given if the calculation process is correctly outlined.)



(a) A cantilever beam; (b) a fixed-fixed beam

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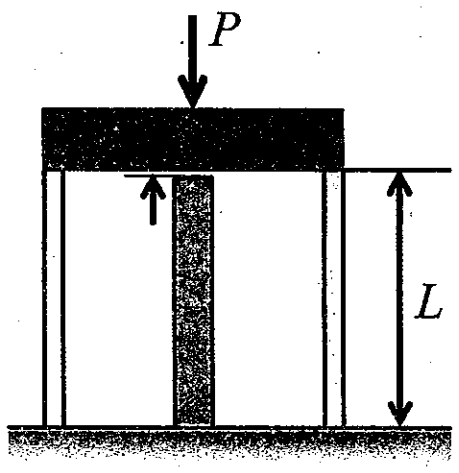
Problem 3 (25%)

A rigid plate is supported by three columns, each having Young's modulus E and length L. Three columns have different cross-sections. Two outer ones have cross-section A and the cross-section of the inner one is $4A$. Before the force P is applied, the middle column is shorter than the outer columns by an amount of Δ (Δ is much smaller than L). Answer the following questions:

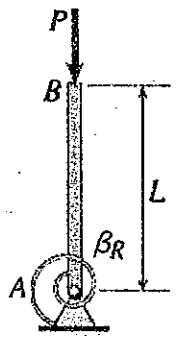
(i) (5%) Determine the force P_c at which the rigid plate just touches the middle column.
(ii) (10%) When $P > P_c$, determine internal forces and stresses in the three columns.
(iii) (10%) When $P > P_c$, determine the displacement of the rigid plate.



Problem 4 (25%)

Answer the following questions about the critical load of a column subjected to vertical loading.

(i) Analyze the theoretical critical loads of a vertically loaded 1-m square column of L = 10 m with pinned connections and linearly elastic springs under the following three conditions.



(a) (5%) The column is rigid; the spring stiffness β_R = 340 MN-m/rad.
(b) (10%) Young's modulus of the column E = 28 GPa; β_R = 340 MN-m/rad.
(c) (5%) Young's modulus of the column E = 28 GPa; $\beta_R = \infty$.

(ii) (5%) According to the above analyses, comment on the influences of the column and spring stiffnesses on the critical load.

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