21-S-6-ZA-58 Solution

Question: The truss system shown is acted upon by a force F_1 N at point A, F_2 N at D, and P at C. If a m and b m, find the maximum force P that can be applied so that the force in each member does not exceed F_{max} N.

Solution:

We start by finding the reaction forces by taking the sum of forces and moments of the whole system.

$\Sigma F_x = A_x + G_x = 0 \Rightarrow A_x = -G_x$

$\Sigma F_y = F_2 - F_1 - P + A_y = 0 \Rightarrow A_y = F_1 + O - F_2$

$\Sigma M_A = aG_x + F_2 2b - 3bP = 0 \Rightarrow G_x = (-2bF_2 + 3bP)/a$

Then, we write the force in each member in terms of P using the method of joints.

A: $\Sigma F_x = -A_x + F_{AB} = 0 \Rightarrow A_x = F_{AB}$

B: $\Sigma F_x = F_{BC} sin\theta - F_{AB} = 0 \Rightarrow F_{BC} = F_{AB}/sin\theta$

$\Sigma F_y = F_{BD} - F_{BC} cos\theta = 0 \Rightarrow F_{BD} = F_{BC} cos\theta$

C: $\Sigma F_x = F_{CD} - F_{BC} sin\theta = 0 \Rightarrow F_{CD} = F_{BC} sin\theta$

$\Sigma F_y = -P + F_{BC} cos\theta \Rightarrow F_{BC} = P/cos\theta$

E: $\Sigma F_y = G_x - F_{DE} = 0 \Rightarrow F_{DE} = G_x$

We set the force in each member equal to the maximum allowable force and solve for P in each equation.

$P_{AB} = (F_2 2b - F_{max} a)/3b$

$P_{DE} = (aF_{max} + F_2 2b)/3b$

$P_{BC} = F_{max} cos\theta$

$P_{BD} = F_{max}$

$P_{CD} = F_{max}/tan\theta$

The maximum allowable P is the smallest P calculated above, as this will ensure the force in each member is at or below the maximum force.