Homework#5

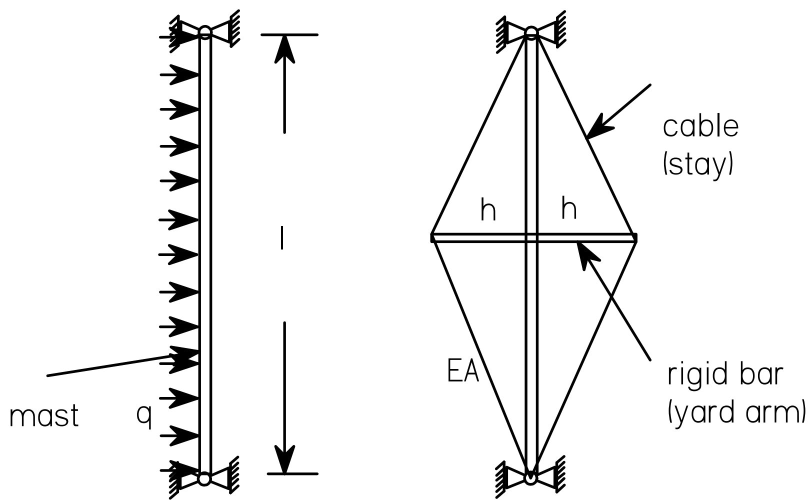
Given: November 19, 2002 Due: November 27, 2002
if doing Case Study, select one of these two from Gere
If not doing Case Study, do both of these plus extra problem on next page
Due Dec 5 (last assignment due date)

1. Problem 3.3-8 in Gere's book page 253.

2. Problem 3.4-2 in Gere's book page 256.

Problem 1

Assume that a tubular mast of a small sailing boat is modeled as a pin-pin supported elastic beam. The beam is of length l, cross-sectional radius R, and has a bending rigidity EI. The beam is subjected to a uniformly distributed load of intensity q, representing the wind load on the main sail.



In order to increase the stiffness of the system, the mast is reinforced by four stays (cables), as shown in the sketch above. The stays are held apart by two rigid bars (yard arms) of the length h each. The axial rigidity of the stays is denoted EA. Note that the cables and rigid bars are in the same plane as the distributed load q.

a. Derive the expression for the stiffness of the system $K = \frac{ql}{w_o}$ assuming a classical beam theory and infinitesimal deflection where w_o is the mid-span deflection of the beam.

b. Determine the magnitude of the mid-span deflection and the corresponding load at which the cable will yield.

c. Find the maximum stresses in the beam at the point when the cable yields.

Hints: a) 1) determine relationship between wo and (q*l and interface force P) in beam (mast) by superposition
2) find strain in cable in terms of wo, h, and l; - neglect terms in w_o^2 and use $(1+x)^{1/2} \sim 1 + x/2$ for small x.
3) use energy equation in cable to relate wo and P $(\partial \Pi / \partial w_o = 0)$
4) substitute in 1) and solve for ql/wo.
b) relate force at yield in cable to interface force (geometry) and using 3) above: solve for wo.
c)assume mast radius R, superpose axial force (geometry from cable) and bending stress from maximum moment at yield (P = Py from b).