PROBLEM 5.10-12 THE T-BEAM SHOWN IN THE FIGURE HAS CROSS-SECTIONAL DIMENSIONS AS FOLLOWS: $b = 220\,mm$, $t = 15\,mm$, $h = 300\,mm$, AND $h_1 = 275\,mm$. THE BEAM IS SUBJECTED TO A SHEAR FORCE $V = 70\,kN$. DETERMINE THE MAXIMUM SHEAR STRESS τ_{max} IN THE WEB OF THE BEAM.

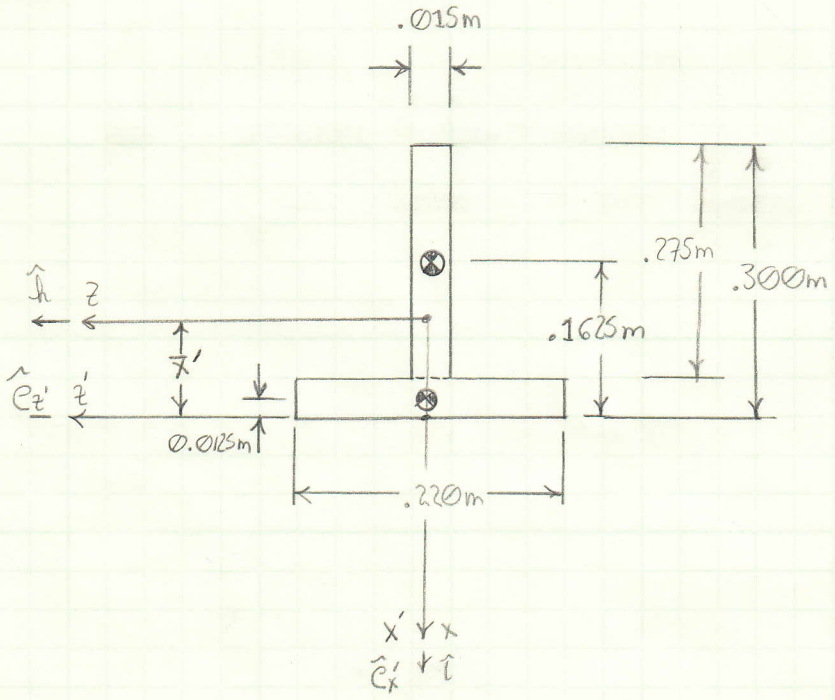
GIVEN:

CONSTRAINTS
1) T-BEAM $b = 220mm$, $t = 15mm$, $h = 300mm$, $h_1 = 275mm$
2) SHEAR LOAD $70\,kN$

ASSUMPTIONS
1) SMALL DISPLACEMENTS
2) LINEAR ELASTIC MATERIAL RESPONSE

FIND:
1) THE MAXIMUM SHEAR STRESS IN THE WEB OF THE BEAM

DIAGRAM:



MECHANICS:

TO FIND THE MAXIMUM SHEAR STRESS, FIRST THE LOCATION OF THE CENTROID MUST BE LOCATED

$$\bar{X}' = \frac{\Sigma \bar{X}_i' A_i}{A} = \frac{0.1625m \cdot .015m \cdot .275m + .0125m \cdot .025m \cdot .220m}{.015m \cdot .275m + .025m \cdot .220m}$$

$$= 0.07679m \quad (1)$$

THE MOMENT OF INERTIA FOR THE CROSS-SECTION ABOUT THE CENTROIDAL AXIS CAN NOW BE CALCULATED

$$I = \left[\frac{1}{12}(.015m)(.275m)^3 + (.015m)(.275m)(.1625m - .07679m)^2\right]$$
$$+ \left[\frac{1}{12}(.220m)(.025m)^3 + (.220m)(.025m)(.07679m - .0125m)^2\right]$$

$$= 79.32(10^{-6})\,m^4 \quad (2)$$

SINCE THE MAXIMUM SHEAR STRESS IS LOCATED AT THE NEUTRAL AXIS, THE MAXIMUM SHEAR STRESS CAN NOW BE COMPUTED AS

$$\tau = \frac{V \cdot Q}{I \cdot t} = \frac{70(10^3)\,N \cdot (.1116m)(.2232m)(.015m)}{(79.32)(10^{-6})m^4 \cdot .015m}$$

$$= 21.98(10^6)\frac{N}{m^2} = \boxed{22.0\ MPa}$$

SUMMARY

THE LOCATION OF THE CENTROID PLAYS A CRITICAL ROLE IN THE SOLUTION TO THIS PROBLEM. ONCE THE CENTROID IS LOCATED, THE MINIMUM MOMENT OF INERTIA IS COMPUTED, THE NEUTRAL AXIS IS LOCATED, AND THE LOCATION OF THE MAXIMUM SHEAR STRESS IS KNOWN.