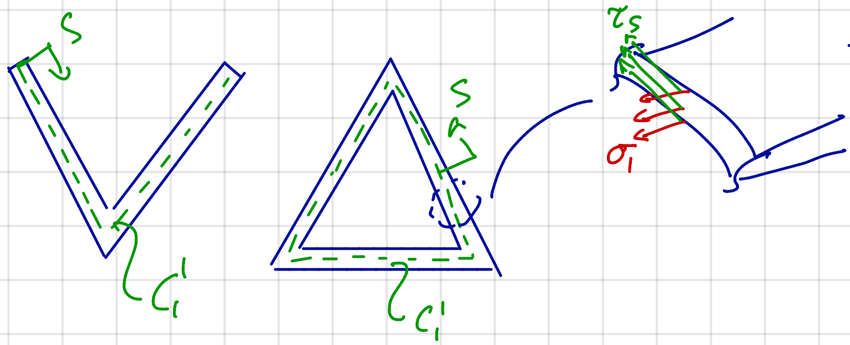
Summary: Bending & Shear at thin-walled beams.
Shear Center.



* Stresses are uniformly distributed

$n = \sigma_1 \cdot t$ – Axial flow

$f = \tau_s \cdot t$ – Shear flow

Axial Stress flow

$$n = E \cdot t(s) \left[\frac{N_1(x_1)}{S} - \frac{x_2 H_{23}^c - x_3 H_{33}^c}{\Delta H} M_2(x_1) - \frac{x_2 H_{22}^c - x_3 H_{23}^c}{\Delta H} M_3(x_1) \right]$$

Shear Stress Flow

Value at f(s) at s=0.

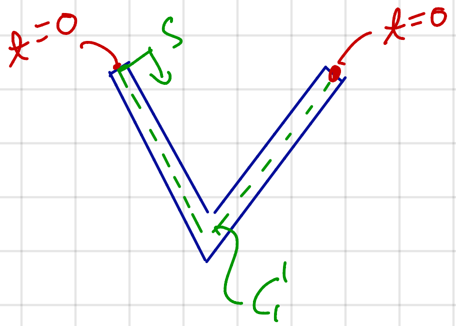
$$f(s) = C + \frac{Q_3(s) H_{23}^c - Q_2(s) H_{33}^c}{\Delta H} V_3(x_1) - \frac{Q_3(s) H_{22}^c - Q_3(s) H_{23}^c}{\Delta H} V_2(x_1)$$

$$Q_2(s) = \int_0^{s} E t x_3 \, ds$$

$$Q_3(s) = \int_0^{s} E t x_2 \, ds$$

* Given V_2 & V_3 as well as the geometry and material properties, we can solve for f(s).

Open Section

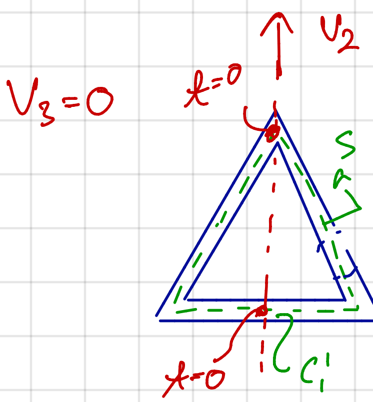


* Shear flow is zero at the end points at C_1'

→ Use this to solve for the integration constant C in $t(s)$.

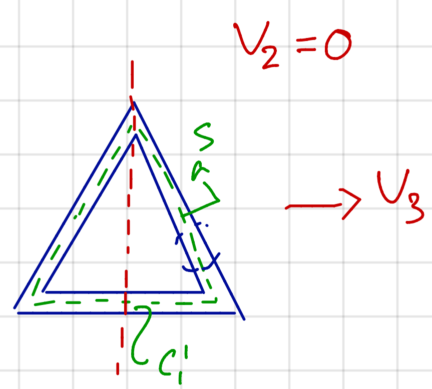
Closed Section

a) Symmetry



If the geometry has a symmetry plane and the load is applied about the sym. plane, then the shear flow is zero at the sym. plane.

b) Not Symmetric



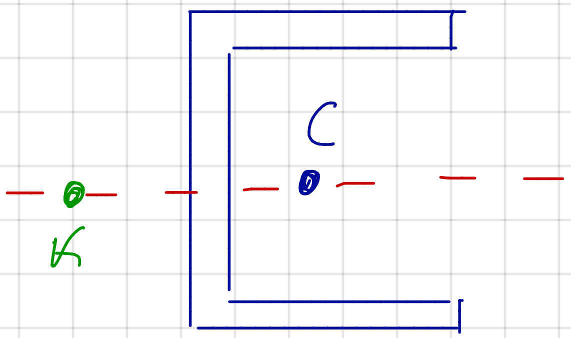
* Make a cut and solve

$$t(s) = t_0(s) + t_c$$

$$t_c = - \frac{\int_{C_1'} \frac{t_0(s)}{Gt} ds}{\int_{C_1'} \frac{ds}{Gt}}$$

Shear Center

* The cross-section bends without twisting, if and only if the transverse loads are applied at the Shear Center.
* If there is a (geometric) symmetry plane, the shear center must be on it.



Find K through

$$M_{1K} = \int_{C_1'} t\,\tau_K\,ds = 0$$

Alternatively, if we know M_1 about another point (say A) we may solve

$$M_{1A} = \underbrace{(x_{2K} - x_{2A})}_{\text{Distance between A \& K in } \bar{\imath}_2 \text{ direction}} V_3 - \underbrace{(x_{3K} - x_{3A})}_{\text{Distance between A \& K in the } \bar{\imath}_3 \text{ direction}} V_2$$

Procedure

1) Apply a V_3 $(V_2 = 0)$ solve for x_{2K}
2) Apply a V_2 $(V_3 = 0)$ solve for x_{3K}