Light Aircraft Structures
Torsion of Multi-Cell Closed Cross-sections

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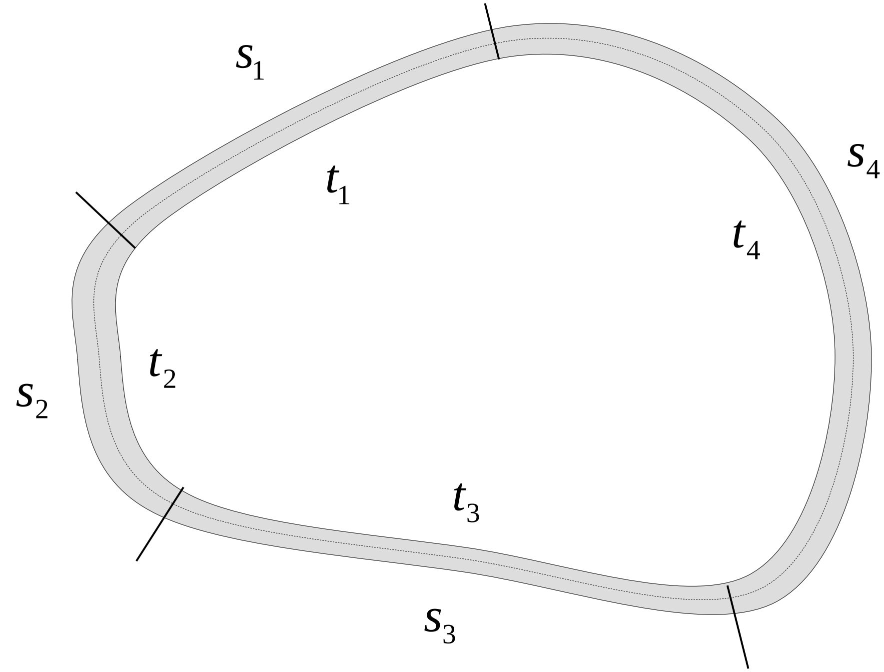
Discretising Line Integrals

- We have seen that a line integral around the cross-section can be converted into a summation of the contributions of multiple segments of constant thickness:



$$\oint_S \frac{\mathrm{d}s}{t} = \sum \left(\int_{s_i} \frac{\mathrm{d}s}{t_i} \right) = \sum \left(\frac{s_i}{t_i} \right)$$

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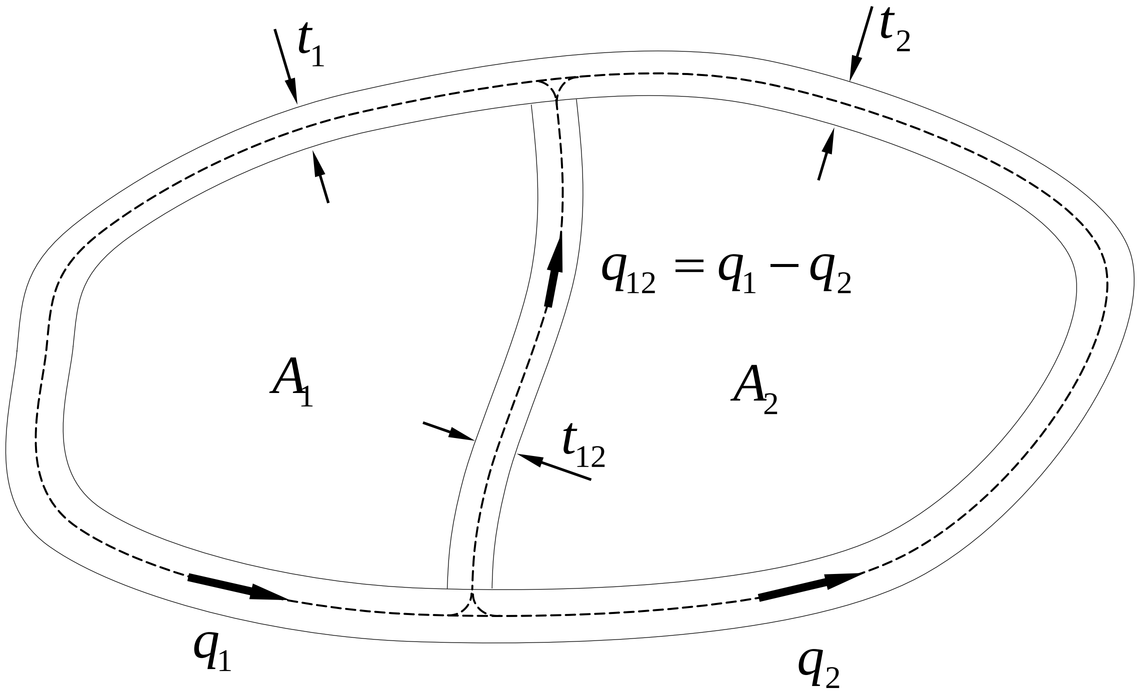
Multi-Cell Closed Sections

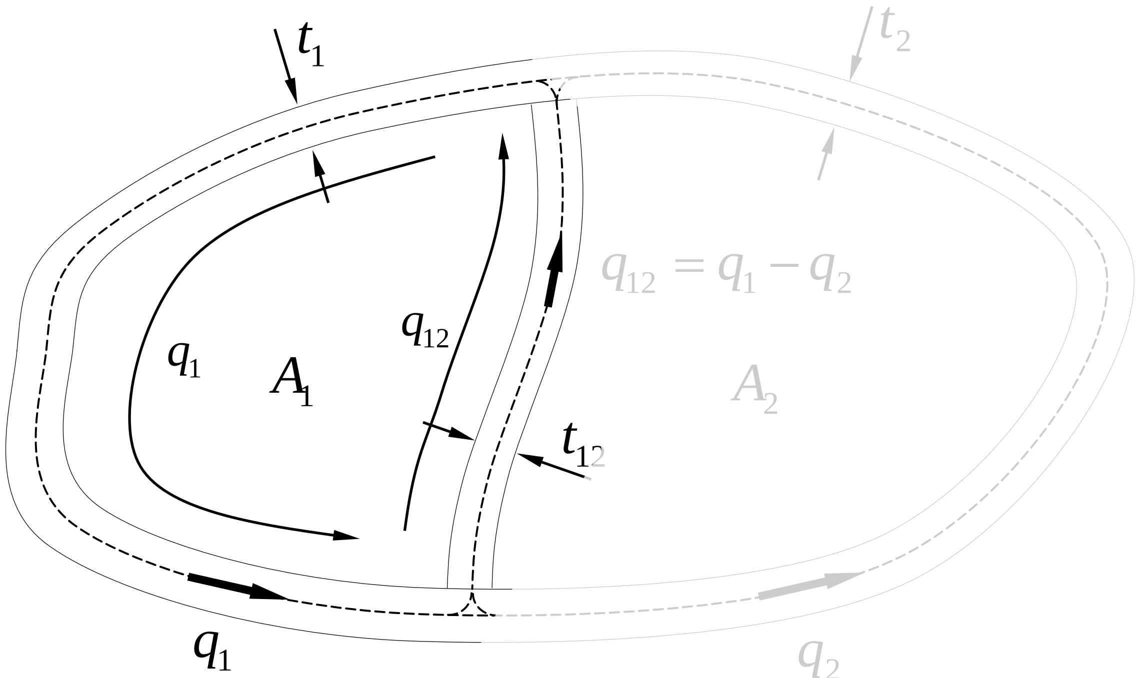
- In multi-cell sections the shear flow is constant only within individual cells

- Example:



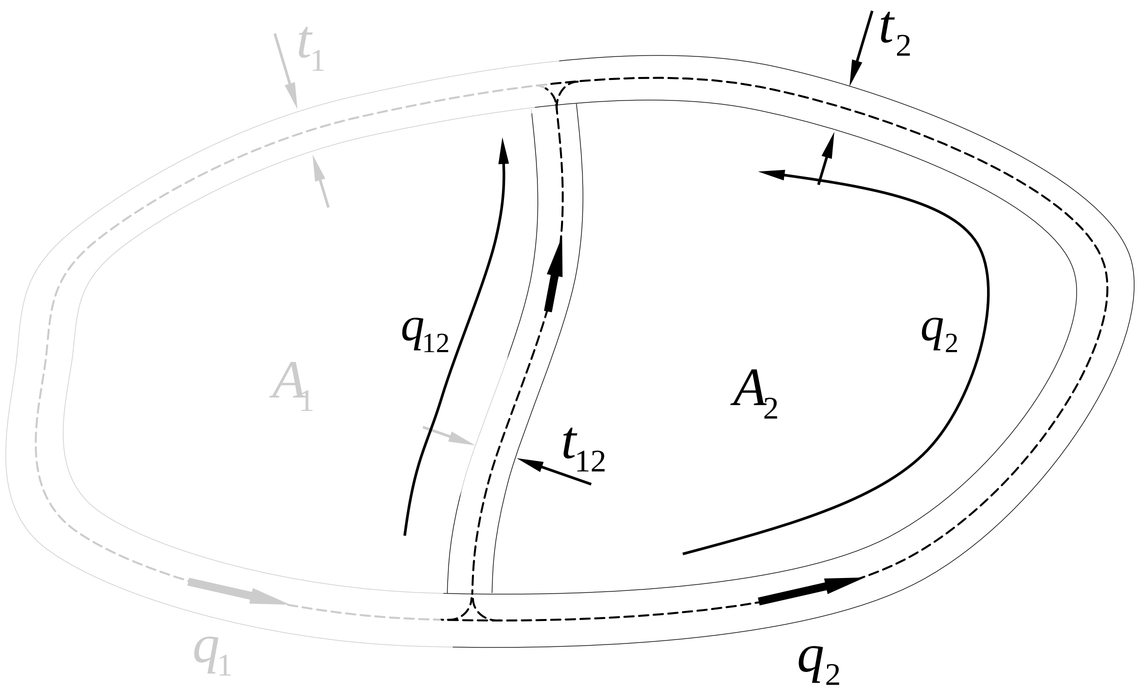
Multi-Cell Closed Sections

- Let us consider the cell on the left hand side:



$$\oint_1 \frac{q\,\mathrm{ds}}{t} = \int_A \frac{q_1\,\mathrm{ds}}{t_1} + \int_B \frac{q_{12}\,\mathrm{ds}}{t_{12}} = \oint_1 \frac{q_1\,\mathrm{ds}}{t_1} - \int_{12} \frac{q_2\,\mathrm{ds}}{t_{12}}$$

- Now the cell on the right hand side:



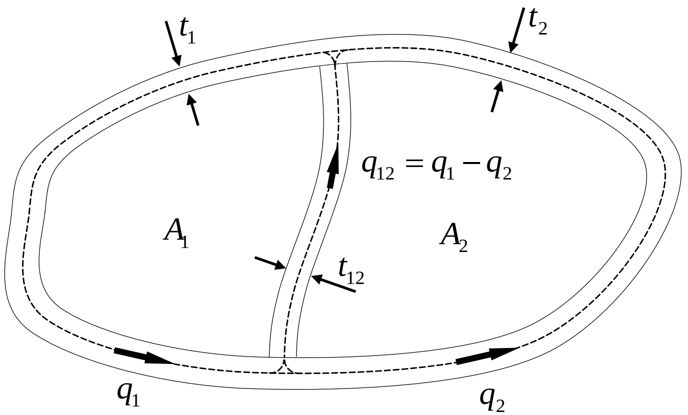
$$\oint_2 \frac{q\,\mathrm{d}s}{t} = \int_C \frac{q_2\,\mathrm{d}s}{t_2} + \int_B \frac{q_{12}\,\mathrm{d}s}{t_{12}} \quad = \oint_2 \frac{q_2\,\mathrm{d}s}{t_2} - \int_{12} \frac{q_1\,\mathrm{d}s}{t_{12}}$$

Multi-Cell Closed Sections

- For cross-sections with two cells we have finally:

$$\left(\frac{\theta}{L}\right)_1 = \frac{q_1}{2A_1G}\oint_1 \frac{ds}{t} - \frac{q_2}{2A_1G}\int_{12} \frac{ds}{t}$$

$$\left(\frac{\theta}{L}\right)_2 = \frac{q_2}{2A_2G}\oint_2 \frac{ds}{t} - \frac{q_1}{2A_2G}\int_{12} \frac{ds}{t}$$



- And since the twist rate is constant:

$$\left(\frac{\theta}{L}\right)_1 = \left(\frac{\theta}{L}\right)_2$$