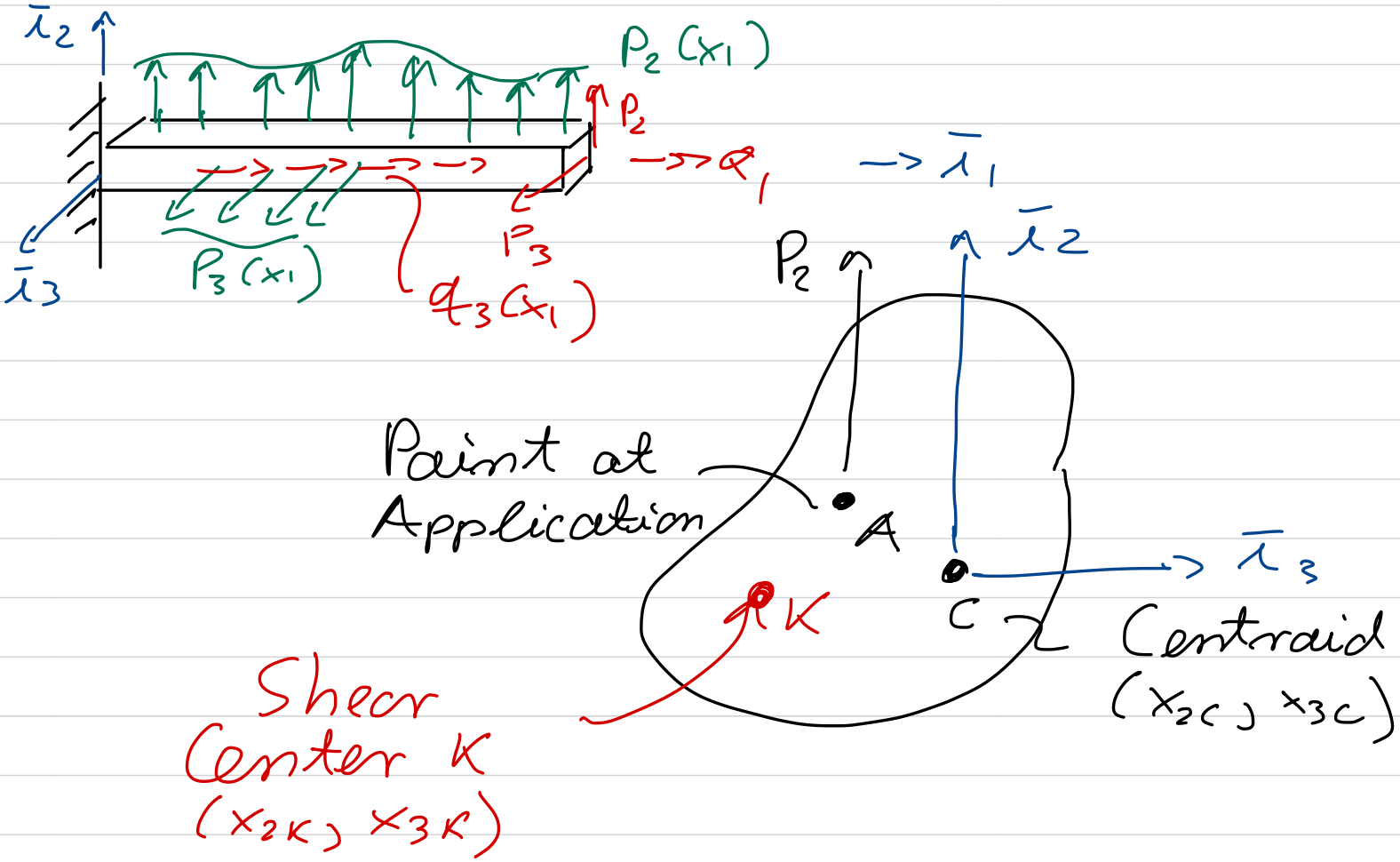
Coupled Bending - Torsion



* If the transverse loads are not applied at the shear center, they may be replaced by an equal load at K plus a torque

Ex: $P_2(x_1)$ applied at A

=

$P_2(x_1)$ @ K + $q_1(x_1) = (x_{3K} - x_{3A})\vec{P}_2(x_1)$

Procedure

1) Compute the location of the centroid C (x_{2C}, x_{3C}).

2) Compute the centroidal stiffnesses.

3) Compute the location of the shear center K (x_{2K}, x_{3K}).

4) Compute the torsional stiffness.

5) Solve the axial problem.

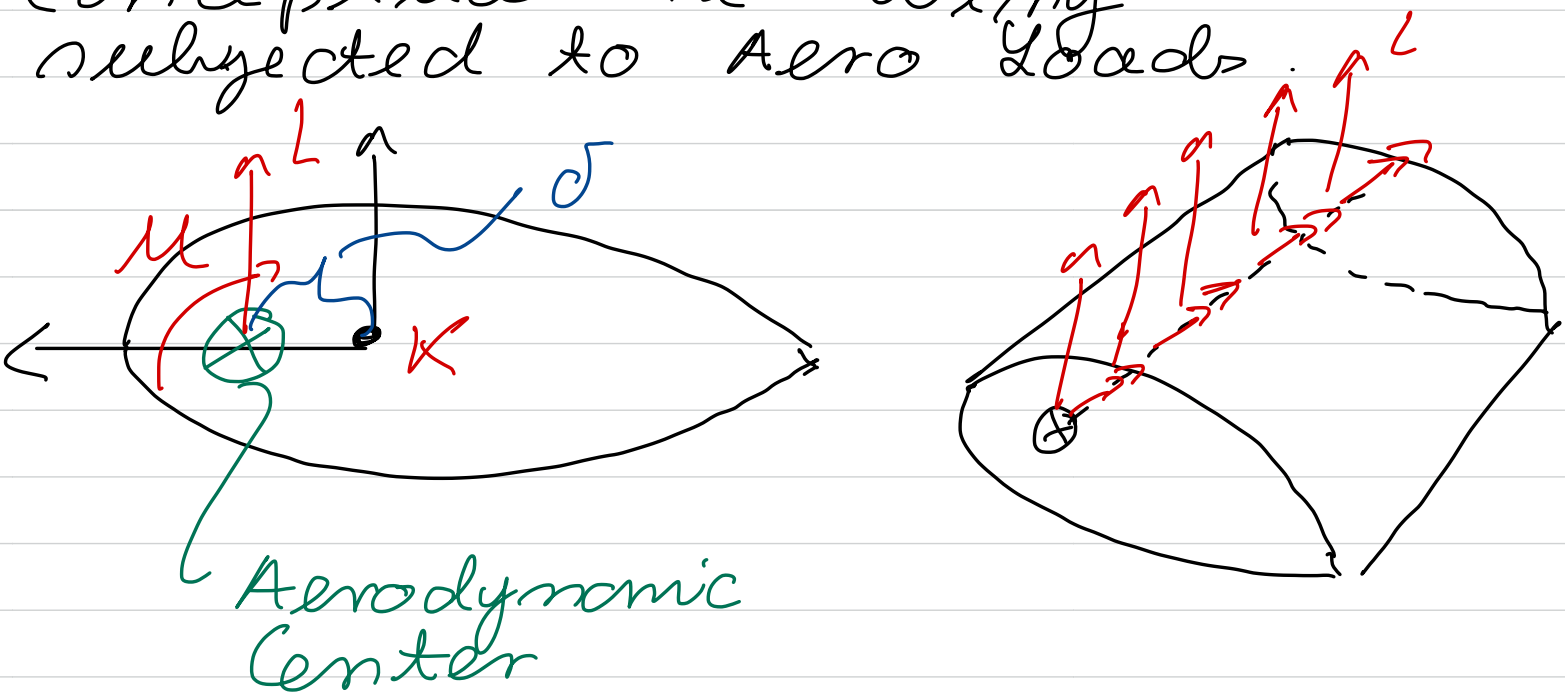
6) Solve the bending problem

7) Solve the torsional problem.

$$\frac{d}{dx_1}\left[H_{11}\frac{d\phi_1}{dx_1}\right] = -\left[q_1(x_1) + (x_{2A} - x_{2K})\,p_3(x_1) - (x_{3A} - x_{2K})\,p_2(x_1)\right]$$

Subject to B.C.s.

Conceptual Ex: Wing subjected to Aero Loads.



$L \rightarrow$ lift per unit span

$M \rightarrow$ Aerodynamic moment per unit span.

$$\frac{d^2}{dx_1^2}\left(H_{22}^{c}\frac{d^2 u_3}{dx_1^2}\right) = L$$

$$\frac{d}{dx_1}\left(H_{11}\frac{d\phi_1}{dx_1}\right) = -(M + \sigma L)$$

* For sym airfoil, $M = 0$ but we still have twisting

* L depends on $\phi_1(x_1)$, which depends on L!

↳ Aeroelasticity!