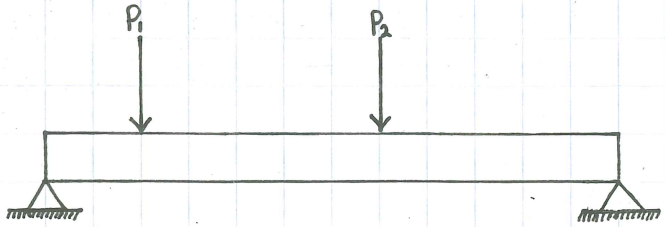
CIVI02 - STRUCTURES and MATERIALS

Topic: Big Question - What is the horizontal component of force in a suspension bridge?

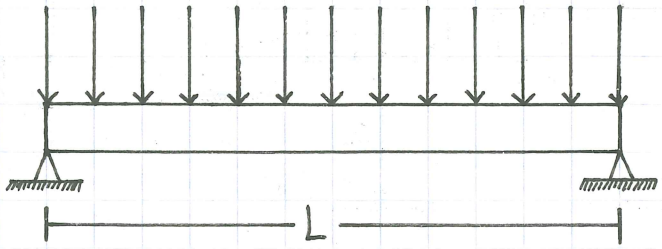
② Distributed Loads:

a) Point Loads



$$\text{Total Load} = \sum P_i$$

b) Uniformly Distributed Load (UDL)



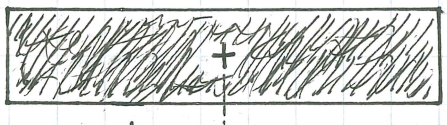
$W = \frac{kN}{m}$

$$\text{Total Load} = W \cdot L = W$$

Moments with UDL

Moment = Total Load × Distance to Centroid of Body Diagram

Loading Diagram

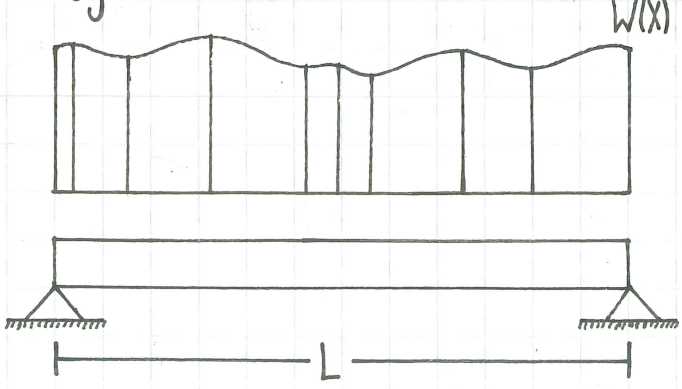


Point of Rotation

$d = \frac{L}{2}$

$$\text{Moment} = \underbrace{(W \cdot L)}_{\text{Total Force}} \cdot \underbrace{\frac{L}{2}}_{\text{Moment Arm or Lever Arm}}$$

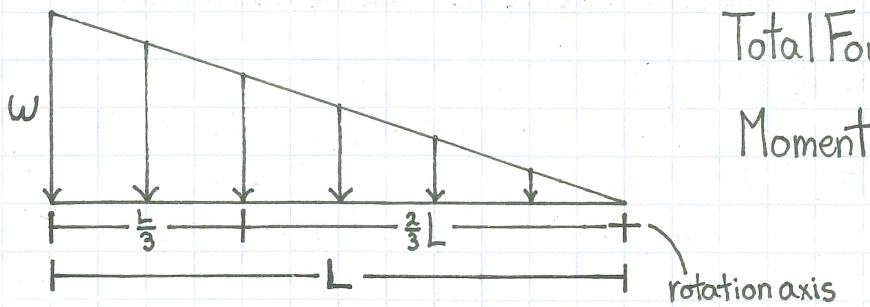
Or by calculus:



$$\text{Total Load} = \int_0^L W(x)\,dx$$

$$\text{Moment} = \int_0^L W(x) \times dx$$

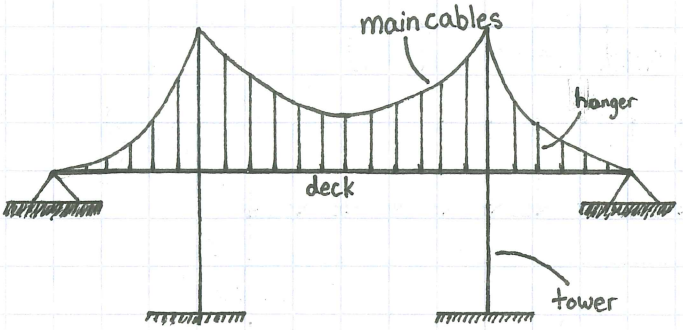
Example 2

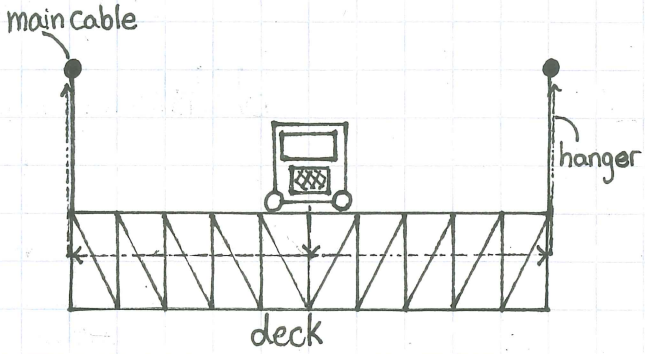


$$\text{Total Force} = \frac{L \cdot w}{2}$$

$$\text{Moment} = +\frac{wL}{2}\cdot\frac{2L}{3} = \frac{wL^2}{3}$$

Suspension Bridges

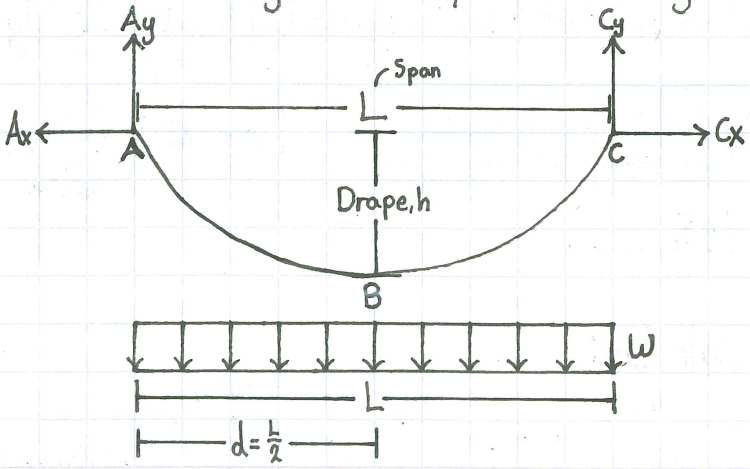




Load Paths

Car (or other load) → Deck → Hanger → Cables → Tower → Ground

③ Structural Analysis of Suspension Bridge



Solve for Ay, Cy

$$\Sigma F_y = 0 = A_y + C_y - w \cdot L$$

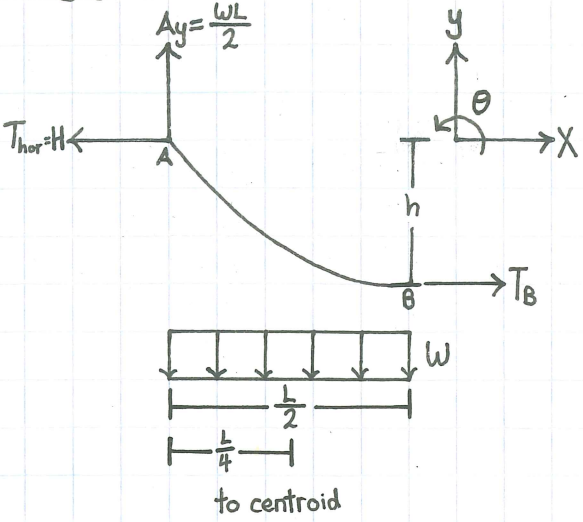
$$\Sigma M_A = 0$$

$$0 = -w \cdot L \cdot \frac{L}{2} + C_y \cdot L$$

$$C_y = \frac{wL}{2}$$

$$\Sigma F_y = 0 \quad A_y = \frac{wL}{2}$$

FBD for A → C



$\Sigma F_x = 0$

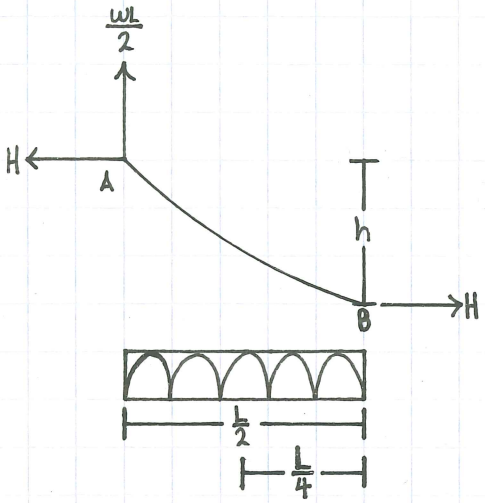
$0 = -T_{hor} + T_B, \; T_{hor} = H$

$0 = -H + T_B, \; T_B = H$

$\Sigma M_A = 0$

$0 = -\frac{wL}{2}\frac{L}{4} + T_B \cdot h \quad (T_B = H)$

$\boxed{H = \frac{wL^2}{8h}}$



$\Sigma M_B = 0$

$0 = -\frac{wL}{2}\frac{L}{2} + Hh + \frac{wL}{2}\frac{L}{4}$

$0 = -\frac{wL^2}{4} + \frac{wL^2}{8} + Hh$

$\frac{wL^2}{8} = Hh$

$\boxed{H = \frac{wL^2}{8h}}$

Golden Gate Bridge

$L = 1280\text{m}$

$h = 143\text{m}$

$w = 370\frac{\text{KN}}{\text{m}}$

$\frac{wL}{2} = 237\text{mN}$

$H = 530\text{mN} \longrightarrow 265\text{mN per Cable}$

Maximum Cable Force

$T_{max} = \sqrt{H^2 + \left(\frac{wL}{2}\right)^2}$

$= 580\text{mN} \longrightarrow 290\text{mN}$ per cable