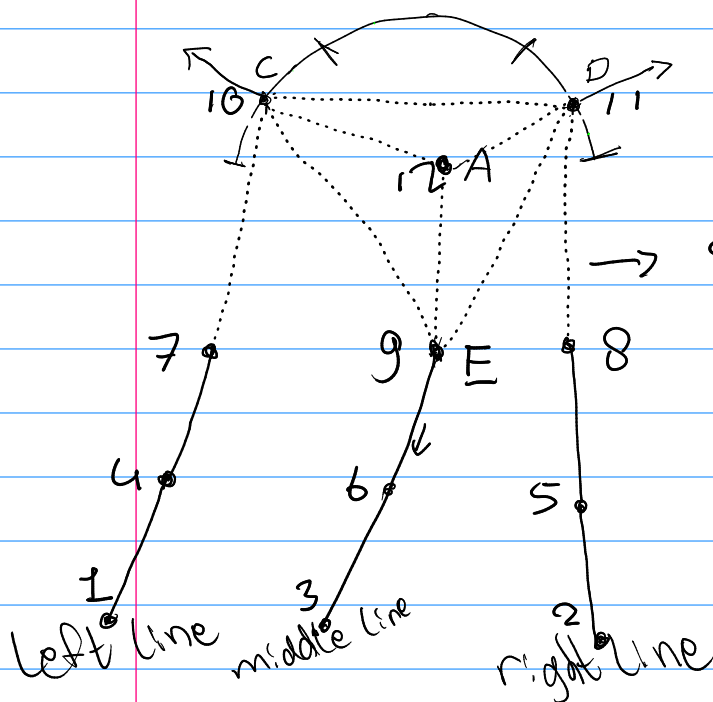
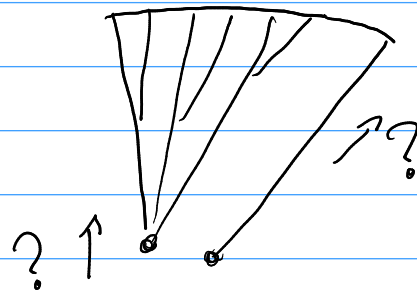


force on left wire is difficult to model

can assume lift is divided between power and steering lines with a constant

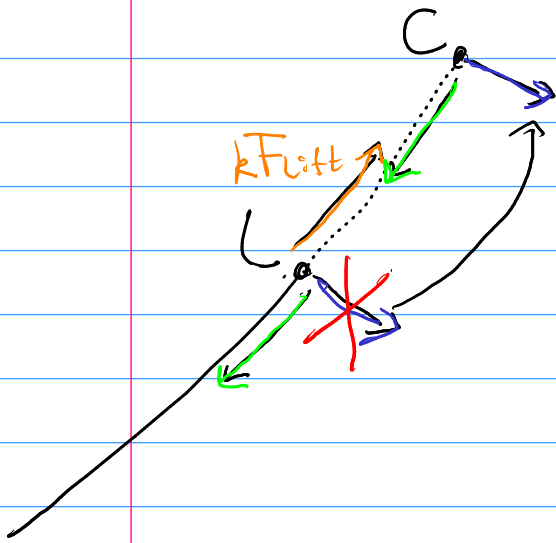


→ steering tether connection

(motor, left, right)

$m, L, r$   
are all on the same line of the last  $m$  segment  
 $L$  and  $r$  are connected to  $m$  after the right distance is calculated

# steering tether connection



$$F_L = F_g + F_d + F_{tether} + k \cdot F_{lift, -z}$$

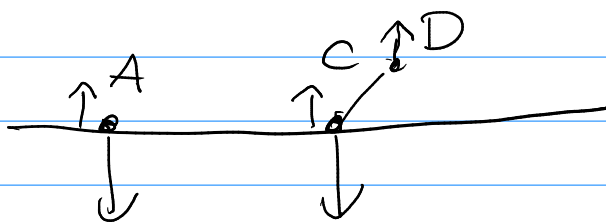
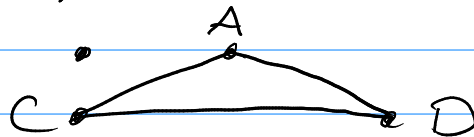
$$F_C = F_L - F_L$$

$$res1 = \text{norm}(V_C - V_L)$$

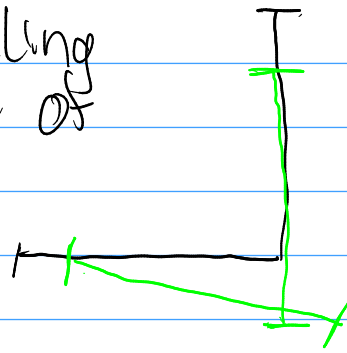
$\Rightarrow$  L should never move relative to C

$$res2 = \text{norm}(a_C - a_L)$$

improvement: divide  $F_{tether}$  over A, C and D



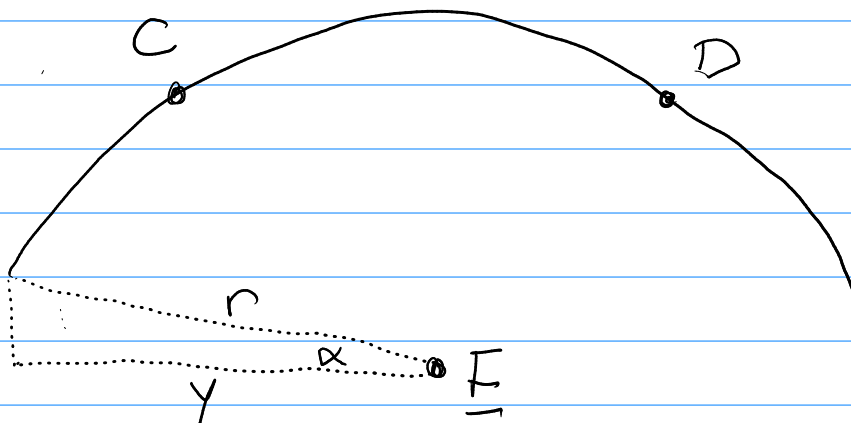
movement of trailing  
edge  $\approx$  movement of  
L or r



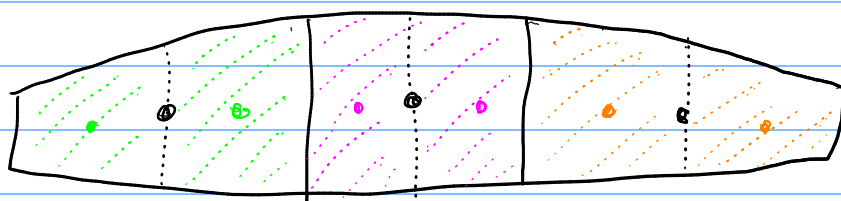
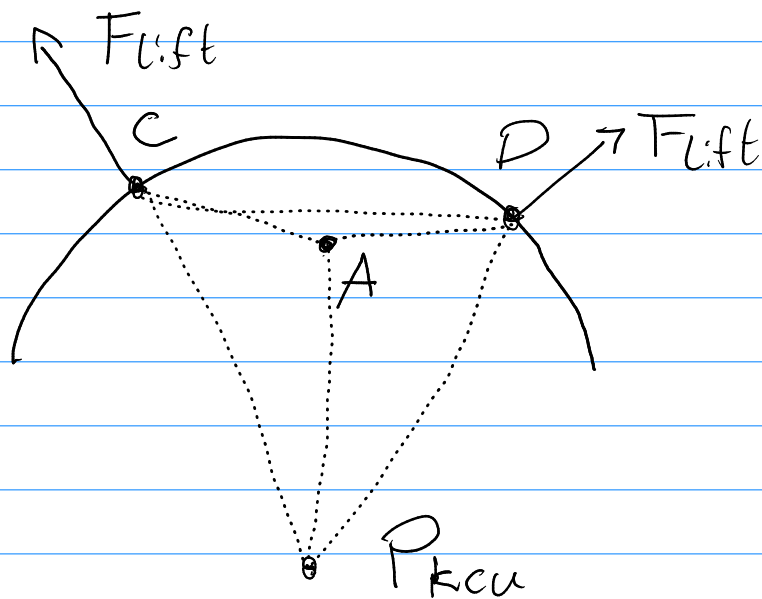
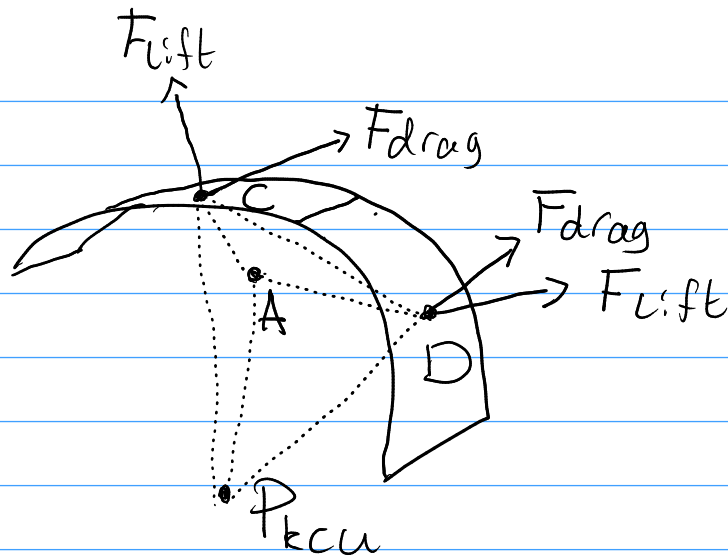
want to have lift dependent  
of this distance, not angle

to find drag coefficients:

- 1 test kite and measure angles
- 2 manually change coefficients until they are right in sim

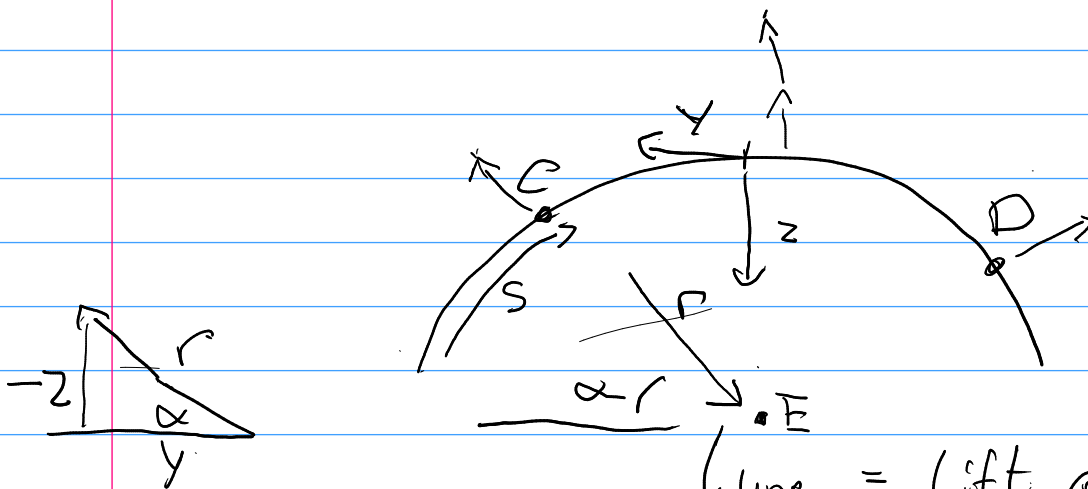


remove point B



- mass
- force
- force on mass =  $\Sigma$  force

should work as long as the dyhedral is not accounted for?

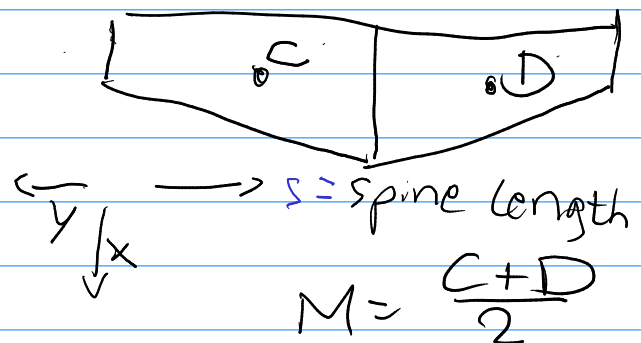


$L_{line}$  = lift on a line with length  $m$

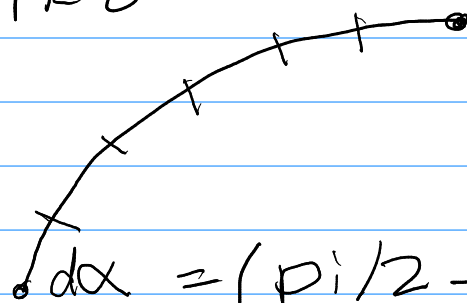
$$L_{Cx} = \int_0^{\frac{1}{2}w} L_{line,s} \cdot ds$$

$$L_c = \begin{bmatrix} L_{c,z} \\ L_{c,y} \end{bmatrix}$$

$$L_{line} = \frac{1}{2} \rho v$$



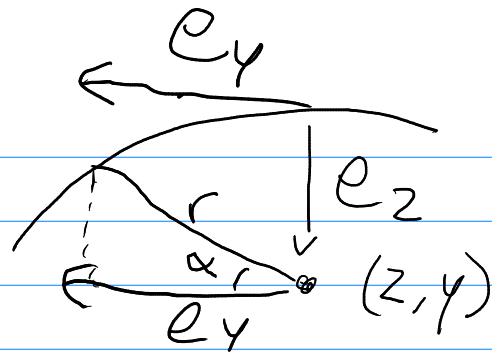
$$n=6$$



$$d\alpha = (\pi/2 - \alpha_0) / n$$

$$L = \sum_{i=0}^n \frac{dL}{d\alpha} (d\alpha/2 + d\alpha \cdot i + \alpha_0) \cdot d\alpha$$

$$L_c = \int_{\alpha_0}^{\frac{1}{2}\pi} \frac{dL}{d\alpha} d\alpha$$



$$L = \frac{1}{2} \rho v_{a, \alpha}^2 A C_L(\alpha) \cdot e_r$$

$$e_r = \frac{E - F}{\|E - C\|}$$

$$F = E + e_y \cos \alpha r - e_z \sin \alpha r$$

$$v_a = v_{wind} - v_{kite}(\alpha)$$

F is any point on the kite

$$v_{kite}(\alpha) = \begin{bmatrix} v_{ex} \\ v_{ey} \\ v_{ez} \end{bmatrix} \cdot [e_x \ e_y \ e_z]$$

$$= \begin{bmatrix} \frac{v_{ex} - v_{Dx}}{y_c - y_D} \cdot (y - y_D) + v_{Dx} \\ v_{Ey} \\ v_{Ez} \end{bmatrix} [e_x \ e_y \ e_z]$$

$$v_{ex} = v_c \cdot e_x$$

$$y = \cos \alpha r$$

$$-z = \sin \alpha r$$

$$= \begin{bmatrix} \frac{v_{ex} - v_{Dx}}{y_c - y_D} (\cos \alpha r - y_D) + v_{Dx} \\ v_{Ey} \\ v_{Ez} \end{bmatrix} [e_x \ e_y \ e_z]$$

$$L = \left( t + \frac{m-t}{0.5w} s \right) \begin{array}{|c|c|} \hline t & L \\ \hline \end{array} \begin{array}{|c|} \hline m \\ \hline \end{array}$$

$s \quad \Delta s = 0 \text{ for a line}$

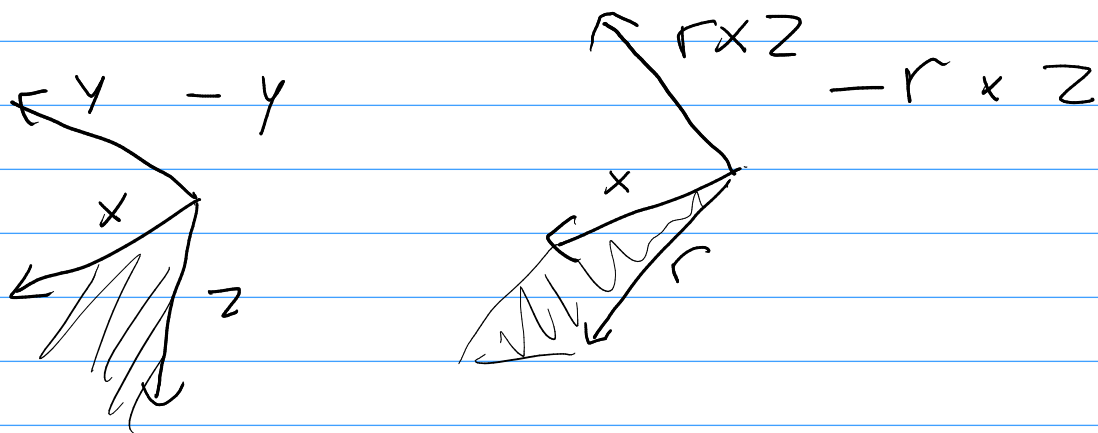
$$L(\alpha) = \frac{1}{2} \rho v_{a, \alpha}^2 S \left( t + \frac{m-t}{0.5w} s \right) C_L(\alpha) e_r$$

$$s = \alpha r$$

$$\frac{dL}{d\alpha}(\alpha) = \frac{1}{2} \rho v_{a, \alpha}^2 r \left( t + \frac{m-t}{0.5w} \alpha r \right) C_L(\alpha) \cdot e_r$$

$$\frac{dL}{d\alpha} = \frac{1}{2} \rho v_{a, \alpha}^2 r \left( t + \frac{m-t}{0.5w} \alpha r \right) C_L(\alpha) \cdot e_r$$

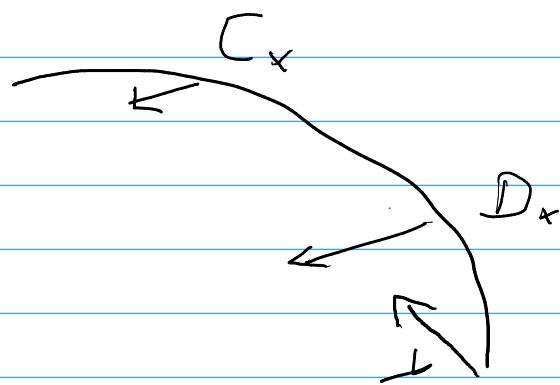
$$V_{a, \times r} = V_a - (V_a \cdot (e_r \times e_x))(e_r \times e_x)$$



$$V_a = V_{wind} - V_{kite}$$

$$V_{ex} = (V_e \cdot e_x)e_x$$

$$V_{kite}(\alpha) = V_x + V_y + V_z$$

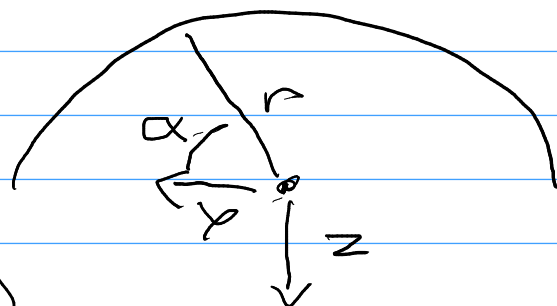


$$\text{Local: } y_L = \cos \alpha \cdot r$$

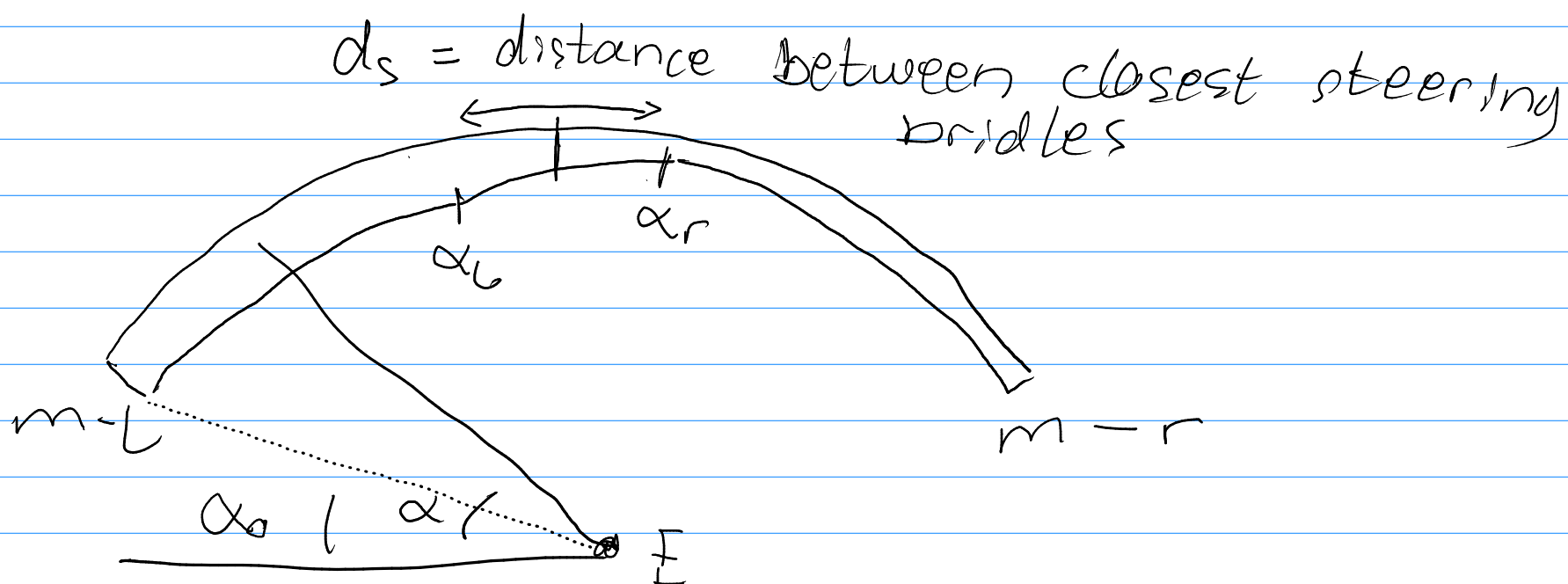
$$z_L = \sin \alpha \cdot r$$

$$y_{L,C} = \text{norm}(C-P)$$

$$y_{L,D} = -\text{norm}(D-P)$$



$$V_{kite}(\alpha) = \frac{V_{Cx} - V_{Dx}}{y_C - y_D} (y_L - y_{LD}) + V_{Dx} + V_{Ey} + V_{Ez}$$



$c_L$  is dependent of trailing edge displacement  $d$   
 $m, L, r$  middle left right line length

$$\alpha_0 = (\pi - w/r) / 2$$

$$d(\alpha) = \begin{cases} m-L & \text{if } \alpha < \alpha_L \\ m-r & \text{if } \alpha > \alpha_r \\ \frac{(m-r) - (m-L)}{\alpha_r - \alpha_L} (\alpha - \alpha_L) + (m-L) & \text{if } \alpha_L < \alpha < \alpha_r \end{cases}$$

$$\alpha_L = \frac{1}{2}\pi - d_s/(2r)$$

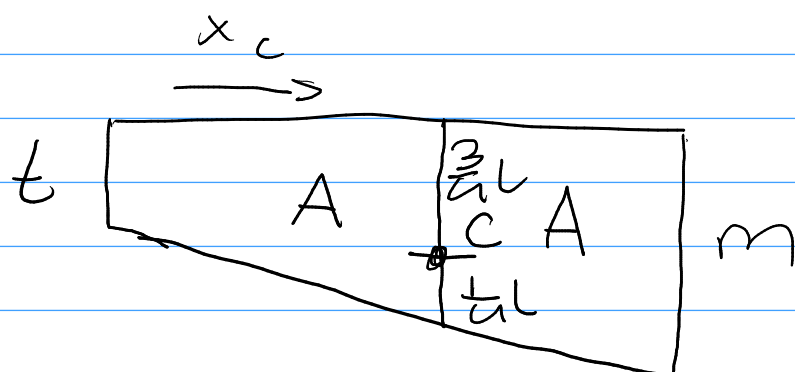
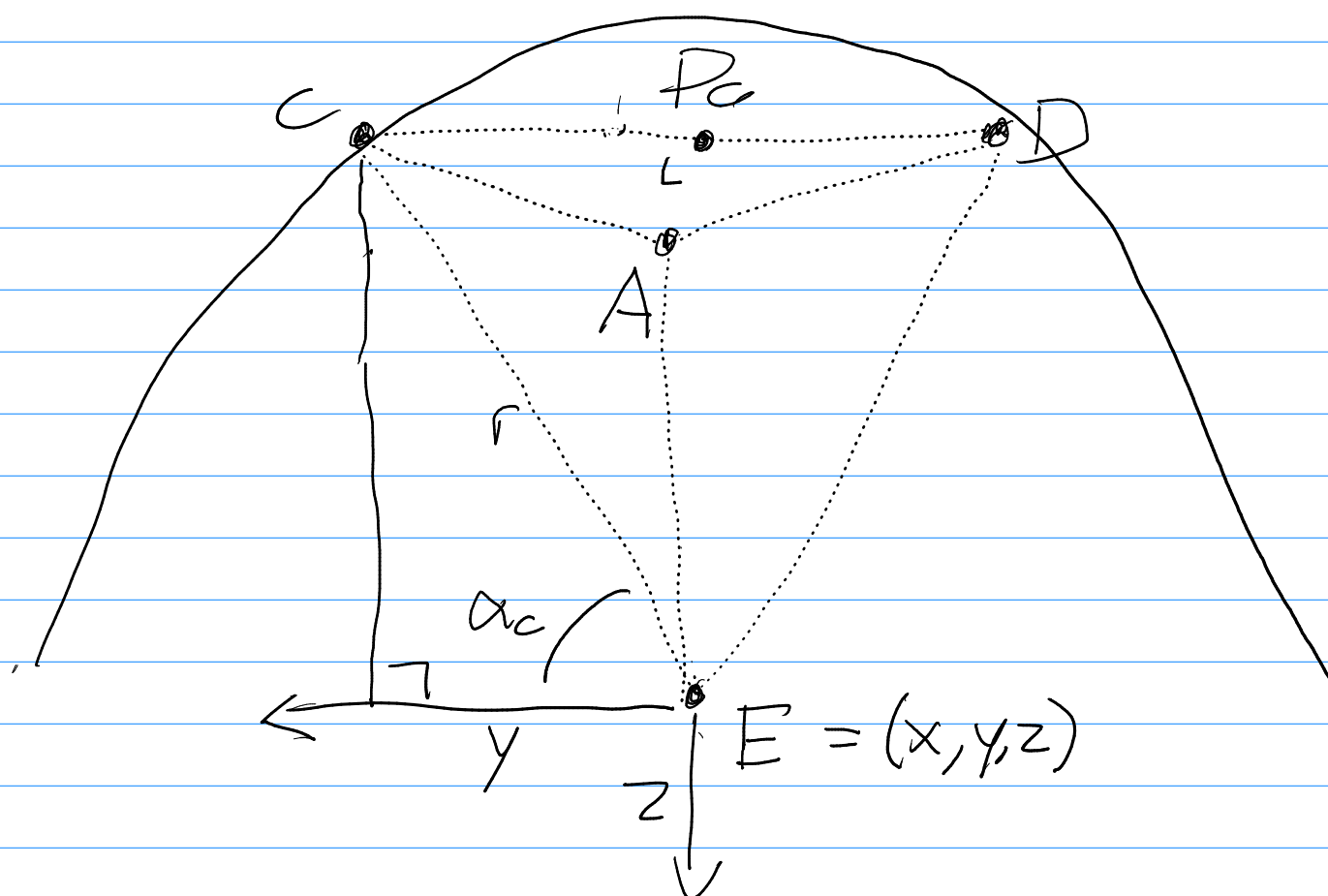
$$\alpha_r = \frac{1}{2}\pi + d_s/(2r)$$

$c_L(\alpha)$  where  $\alpha$  is the angle of attack

$$\alpha(d) = \tan^{-1} \left( \frac{d}{L} \right)$$

$$\alpha(v_x, r) = \pi - \arccos(\text{normalize}(v_x, r) \cdot x)$$





$$A = A \quad (\text{areas are equal})$$

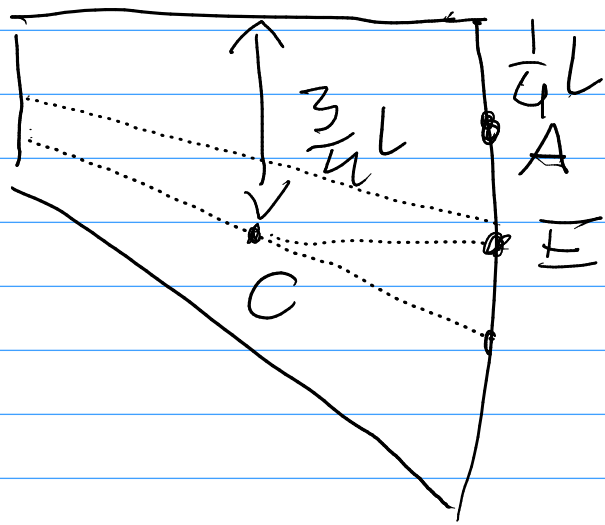
$$\frac{(L(\alpha_0) + L(\alpha_c))}{2} (\alpha_c - \alpha_0) =$$

$$\frac{(L(\alpha_c) + \frac{1}{2}\pi)}{2} (\frac{1}{2}\pi - \alpha_c)$$

$$x_c = \frac{w(-2t + \sqrt{2m^2 + 2t^2})}{4(m-t)}$$

$$\text{hvis } m=t \Rightarrow x_c = w/4$$

$$\alpha_c = \alpha_0 + x_c \cdot r$$



if  $\text{area} = k \cdot \text{mass}$   
 we want A at  
 $\frac{1}{4}$  length, C at  $\frac{3}{4} L$   
 (top)

and E at the same  
 ex as C

$$m_a = \frac{1}{2} m_{\text{kite}}$$

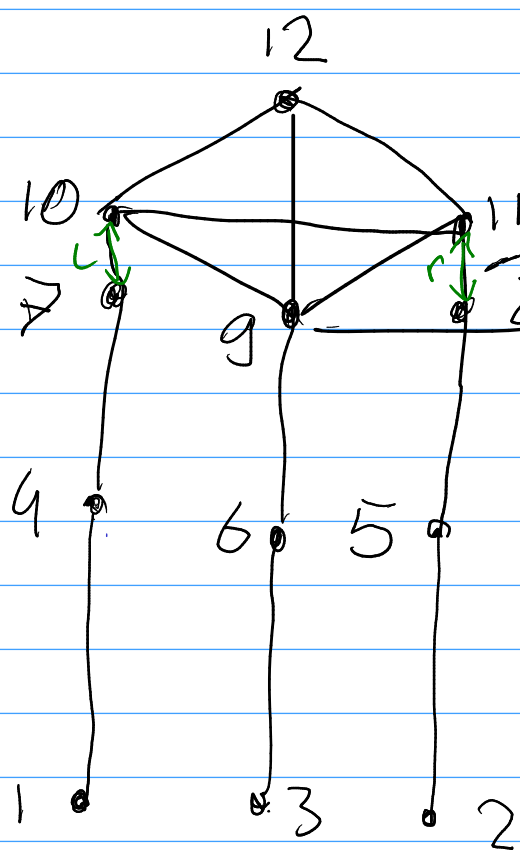
$$m_c = \frac{1}{4} m_{\text{kite}}$$

$$m_d = \frac{1}{4} m_{\text{kite}}$$

$$m_e = \text{tether weight}$$

points with 2 segments

points:  $3 \cdot \text{seg} + 4$

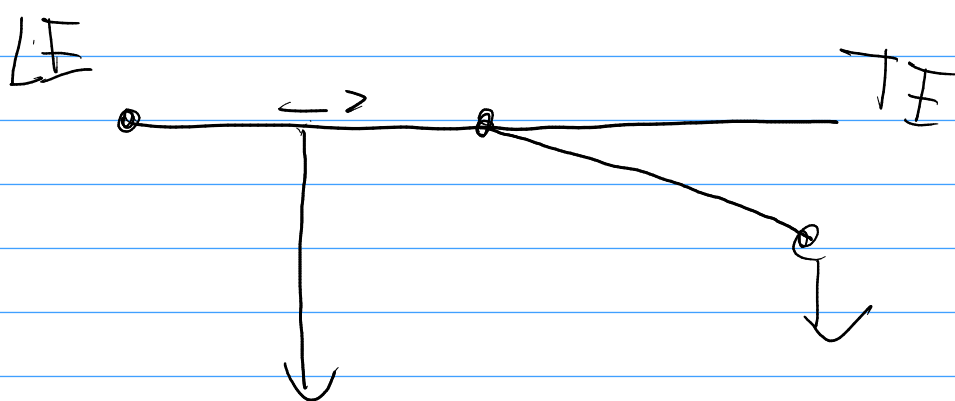


directly change pos  
Length so that  $F_{\text{tether}} = k \cdot \Delta L$   
segments:  $3 + 3$

$$\text{pos}[5] = \text{pos}[8] - \text{cr} \cdot l$$

$$\text{vel}[5] = \text{vel}[8]$$

$$\text{acc}[5] = \text{acc}[8]$$



$$k = 0, 1?$$

TF force should be small,  $k$  gets bigger with higher flap angle?

