Trim State - $V_E^E = 5\,m/s$ $\psi = 0$ rad

$$\dot{X} = \begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \\ \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \\ \dot{u} \\ \dot{v} \\ \dot{w} \\ \dot{p} \\ \dot{q} \\ \dot{r} \end{bmatrix}$$

$\dot{V} = 0 \rightarrow \Sigma F = 0 = [0, F\cos\phi, F\sin\phi] = [0, -D, mg]$

$=$

Since $\phi = \theta = \psi = 0 \rightarrow V = \dot{y} = 5\,m/s$

$$X = \begin{bmatrix} x \\ y \\ z \\ \phi \\ \theta \\ \psi \\ u \\ v \\ w \\ p \\ q \\ r \end{bmatrix} = \begin{bmatrix} 0 \\ 5t \\ 0 \\ 2.15 \\ 0 \\ 0 \\ 0 \\ 4.995 \\ 0.19 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$f_i = \frac{mg}{4}$

$D = \rho V_a^2 = 1.6^3 \cdot [0\ 5\ 0]^2 = 2.5 \cdot 1.6^{-2}$

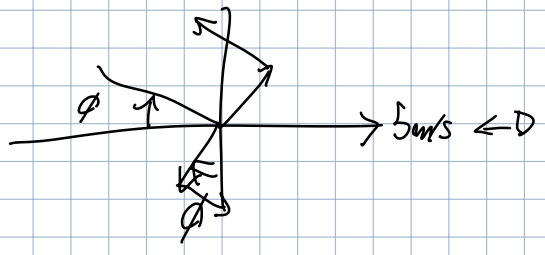
$0 = \cancel{ma_x} - \cancel{mqw} + mg\cancel{\cos\theta}\sin\phi + Y/m$

$g\sin\phi - \frac{Y}{m} \rightarrow 9.8\sin\phi = \frac{0.025}{0.068} = 0.368$

$\phi = 2.15°$

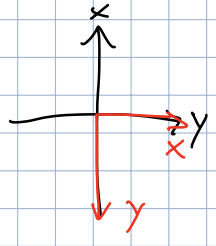
$x = z = 0 \quad y = 5\,m/s$

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.999 & 0.038 \\ 0 & 0.032 & 0.999 \end{bmatrix} \begin{bmatrix} 0 \\ 5 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 4.995 \\ 0.19 \end{bmatrix} m/s$$



Trim State - $V_E^E = 5\,m/s$ $\psi = 90° = \pi/2$ rad

$\psi = 90° \rightarrow \begin{bmatrix} \dot{x}_E \\ \dot{y}_E \\ \dot{z}_E \end{bmatrix} = R_E^B \begin{bmatrix} u^E \\ v^E \\ w^E \end{bmatrix}$



$$X = \begin{bmatrix} x \\ y \\ z \\ \phi \\ \theta \\ \psi \\ u \\ v \\ w \\ p \\ q \\ r \end{bmatrix} = \begin{bmatrix} 5t \\ 0 \\ 0 \\ 0 \\ -2.15 \\ 0 \\ 4.995 \\ 0 \\ 0.19 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Trim State 1 ($V_E^E = 5$ m/s (east), $\Psi = 0$ deg)

$D = \nu V_a^2 = 10^{-3} \cdot [0\ 5\ 0]^2 = 2.5 \cdot 10^{-2}$

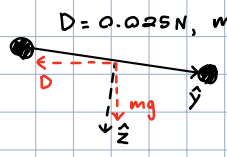
$\dot{V} = 0 = \sum F = [0, f\cos\phi, f\sin\phi] = [0, -D, mg]$

$0 = \cancel{pw^E} - \cancel{rv^E} + g\cancel{\cos\theta}\sin\phi + Y/m \rightarrow g\sin\phi = -Y/m$

$\phi = \sin^{-1}(Y/mg) = \sin^{-1}\left(-\frac{-0.025}{0.068 \cdot 9.8}\right) = 2.15^\circ$

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(2.15) & \sin(2.15) \\ 0 & -\sin(2.15) & \cos(2.15) \end{bmatrix} \begin{bmatrix} 0 \\ 5 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 4.995 \\ -0.19 \end{bmatrix}$$

(R_B^E, V_E^E, V_B^E)



$f = \sqrt{0.025^2 + 0.6664^2} = 0.666369$

$X = [0\ \ 5t\ \ 0\ \ 2.15\ \ 0\ \ 0\ \ 0\ \ 4.995\ \ -0.19\ \ 0\ \ 0\ \ 0]$

$x\ \ y\ \ z\ \ \phi\ \ \theta\ \ \psi\ \ u\ \ v\ \ w\ \ p\ \ q\ \ r$

Trim State 2 ($V_E^E = 5$ m/s (east), $\Psi = 90$ deg)

★ only change is orientation

$$\begin{bmatrix} \cos(90) & \sin(90) & 0 \\ -\sin(90) & \cos(90) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 5 \\ 0 \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ 0 \end{bmatrix}$$

(R_B^E, V_E^E)

$X = [5t\ \ 0\ \ 0\ \ 0\ \ -2.15\ \ 90\ \ 4.995\ \ 0\ \ -0.19\ \ 0\ \ 0\ \ 0]$

$x\ \ y\ \ z\ \ \phi\ \ \theta\ \ \psi\ \ u\ \ v\ \ w\ \ p\ \ q\ \ r$