Welcome to ASEN 3728

Aircraft Dynamics!

Aeronautical Engineering

1. Aerodynamics
2. Structures / Materials
3. Propulsion
4. Dynamics + Control

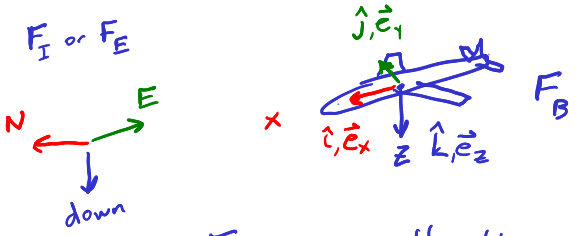
- Keep the pointy end forward
- Get the aircraft to where we want to go

+ Mathematical description of A/C behavior
  + computer simulation model
+ Design of A/C and Control Systems
  to effect desirable dynamics

Notation + Conventions

Body Coordinate System

vectors: $\vec{\ }$, $\hat{\ }$ (unit) or bold



Frame: collection of ≥ 3 points (distance between points is constant)

Inertial: translates with a constant velocity
└ Newton's laws valid

~~acceleration~~ ~~rotation~~

Coordinate System: 3 unit vectors that allow measurement

$\vec{V}_B^E$ ← if present, frame

"inertial velocity written in body coordinates"

↑ coordinate system

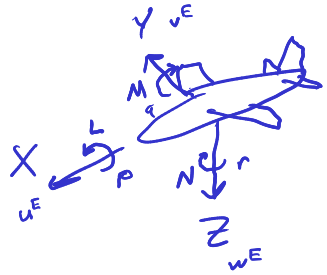
Forces and Moments

$$\vec{f} = X\hat{i} + Y\hat{j} + Z\hat{k}$$

$$\vec{f}_B = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

$$\vec{G} = L\hat{i} + M\hat{j} + N\hat{k}$$

$$\vec{G}_B = \begin{bmatrix} L \\ M \\ N \end{bmatrix}$$



$$\vec{V}^E = u^E\hat{i} + v^E\hat{j} + w^E\hat{k}$$

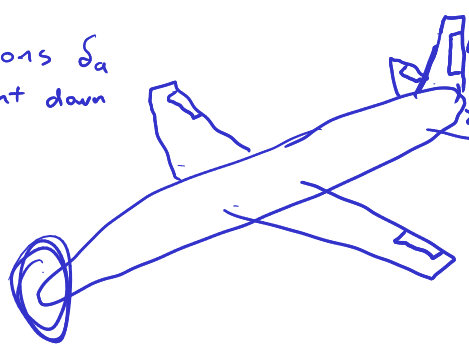
$$\vec{V}_B^E = \begin{bmatrix} u^E \\ v^E \\ w^E \end{bmatrix}$$

$$V_g = |V_B^E| = \sqrt{u^{E^2} + v^{E^2} + w^{E^2}}$$

$$\vec{\omega}^E = p\hat{i} + q\hat{j} + r\hat{k}$$

$$\vec{\omega}_B^E = \begin{bmatrix} p \\ q \\ r \end{bmatrix}$$

Control Surfaces



Ailerons δ_a

$+\delta_a$ = right down

$+\delta_a \rightsquigarrow -L$

Rudder

$+\delta_r$ = toward $-y$ direction

$+\delta_r \rightsquigarrow -N$, Y

Elevator

$+\delta_e$ = down

$+\delta_e \rightsquigarrow -M$ $-Z$

Throttle: δ_t

$+\delta_t \rightsquigarrow +X$ force

no moment

Wind

(not gravity)

Aerodynamic Forces + Moments are functions of the A/C velocity w.r.t. the air

$$\vec{V}^E = \vec{V} + \vec{W}$$

$\vec{V}$: air-relative; $\vec{W}$: wind

When no wind $\vec{V}^E = \vec{V}$

$$\vec{V}_B = \begin{bmatrix} u \\ v \\ w \end{bmatrix}$$

Wind Angles

$$u = V\cos\beta\cos\alpha$$
$$v = V\sin\beta$$
$$w = V\cos\beta\sin\alpha$$

angle of attack α

$\alpha \equiv \tan^{-1}\frac{w}{u}$

sideslip angle β

$\beta \equiv \sin^{-1}\frac{v}{V}$