SELECTED TOPICS
In Aerospace Engineering

EDITOR

ERWIN SULAEMAN

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EMAIL: iiumprinting@yahoo.com

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A non linear model

9.1. Introduction

In this chapter, the orientation and position of the aircraft motion based on the non linear model is described before developing the aircraft equation of motion. The equation is first derived in the form of Euler's force and moment equations of motions. The full equations of motion include also the effect of spinning rotors.

9.2. Orientation and Position of the Airplane

The position and orientation of the airplane are given relative to the Earth-fixed frame F_E. The CG has position vector $\mathbf{r}_c$, with coordinates (x_E, y_E, z_E).

The orientation of the airplane is given by a series of three consecutive rotations known as the Euler angles. The airplane is imagined first to be oriented such that its axes are parallel to those of F_E, hence its position is $Cx_1\, y_1\, z_1$. Then the following rotations are applied:

1. A rotation ψ about oz_1, carrying the axes to $Cx_2\, y_2\, z_2$.
2. A rotation θ about oy_2, carrying the axes to $Cx_3\, y_3\, z_3$
3. A rotation ϕ about ox_3 carrying the axes to $Cx_3 y_3 zd_3$

where the ranges are limited to

$$\begin{aligned} &-\pi \le \psi < \pi \ \text{ or } \ 0 \le \psi \le 2\pi \\ &-\frac{\pi}{2} \le \theta \le \frac{\pi}{2} \\ &-\pi \le \phi < \pi \ \text{ or } \ 0 \le \phi \le 2\pi \end{aligned} \tag{9.1}$$

In a vertical climb or dive,