# Linear Algebra in Aerospace Engineering

Dawson Beatty

March 6, 2016

## Rotations

One of the main applications of linear algebra within Aerospace engineering is the use of rotation matrices. Rotation matrices can be used to describe the roll, pitch, and yaw of a spacecraft, which represent rotation about the $x$, $y$, and $z$ axes respectively.

**Roll:**

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

**Pitch:**

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

**Yaw:**

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

## Statics

Statics also makes use of the principles of linear algebra. The whole idea of statics is taking the sum of the forces in the $x$ and $y$ directions– as well as the net torque– to be zero.

$$\sum F_x = 0 \qquad \sum F_y = 0 \qquad \tau_{\text{net}} = 0$$

This usually involves identifying all the forces in the problem, and summing them up to zero. This is at it's heart a giant homogeneous linear algebra problem. It would also be *really* interesting to see if the solution to an engineering problem you found was guaranteed to be unique, or if there might be another solution that you're missing.

## Component Connections

Again this is not strictly an Aerospace engineering application, but more of an engineering application in general. When working with a large system, it's helpful to know which parts connect ot each other, and the distances between each of the components.

Problems like this can be solved by creating a matrix with one row and one column for each component, then putting a 1 for connections between components, and a 0 for components that don't connect. I was somewhat disheartened to see that we'd be skipping most of the sections dealing with problems like this, but I can always go back and learn it more on my own.

## Curve Mapping

It's also possible to use linear algebra for polynomial curve fitting, or fitting a curve to a specific set of points. There are limitless applications of this in every part of engineering.