AEM 668: Lecture 1
Advanced Dynamics of Flight
Introduction and Vector Kinematics

Instructor: Dr. Jinwei Shen

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Roadmap

1. Kinematics and Dynamics of Aircraft Motion
   - Introduction
   - Vector Kinematics
   - Matrix Analysis of Kinematics
   - Numerical Integration: Runge-Kutta
   - Attitude Propagation
   - Earth-based Frames

2. Modeling the Aircraft
3. Modeling, Design and Simulation Tools
4. Aircraft Dynamics and Classical Control Design
5. Modern Control Techniques
1 Advanced Dynamics of Flight

- Essence of Aeronautical Engineering
  - Study of the motion – the flight – of the vehicle
  - Flight motion defines the aircraft performance
  - Study of the complete vehicle, not a component
  - Multidisciplinary: aeronautical disciplines fit together

- Multidisciplinary
  - Mechanics
  - Aerodynamics
  - System Dynamics
  - Control Design

- Undergraduate Flight Dynamics and Control (FDC)
  - Materials familiar
  - Greater depth or level of abstraction
  - Emphasis on theory and math
  - Advance on simulation (programming)
  - Review key concepts if no undergraduate FDC
2 Syllabus

- Description
  - Analysis of the rigid body dynamic motions of an aircraft
  - Response of an airplane to actuation of controls
  - Introduction to automatic control and stability
  - Introduction to vehicle simulation by digital computer


- MATLAB programming
- Grade: Homework(4) 40%, Midterm 30%; Final 30%
- Piazza (collective learning)
- Lecture schedule and notes
- A small aircraft model or toy helpful (allowed in exams)
3 Equations of Motion (EOM)

- Equation of Motion will be of the form

- Solution by numerical integration
4 Vector Kinematics

4.1 Intro

- Frame of Reference
  - Frame subscript: lower case
  - Point subscript: upper case
- Inertial Frame:
  - Neither accelerating nor rotating
  - Strictly, none exists; Some seem close
  - Newtonian mechanics only valid in an inertial frame
- Vector
  - Ordered array of numbers; Any length (dimension)
  - 3D vector for Newtonian mechanics in Euclidean space
  - Notation: with an over-arrow
- Coordinates: Actual measures used to describe vector (frames)
4.2 Notation

4.3 Derivative of a vector
4.4 Direction Cosines (DC)

- Descriptions in a coordinate

- Vector: a length and direction (3 DC)

- DC: unit vector in the direction of $\vec{r}$ in $F_a$
Next lecture (SL 1.2)

- Vector Kinematics (Cont’ed)