# ASEN 3128 LAB 2: Simulate EOM

         Assigned: Friday 5 February

         Due: Friday 19 February before Lab Section starts

## For all assignments students will work in groups of two to four students. Groups are determined by the instructors. A single assignment should be submitted for the group.

## OBJECTIVES

         Simulate the EOM for a quadrotor.

         Investigate the concepts of trim and static stability

## BACKGROUND

**Parrot mambo Minidrone**

In this lab assignment students will create a simulation of the full nonlinear equations of motion of the Parrot Mambo Minidrone. Smead Aerospace operates these minidrones in the Autonomous System Programming, Evaluation, and Networking (ASPEN) Lab, and we will be designing and implementing control laws for these minidrones in future lab assignments. A short video describing the drone can be found here:

<https://www.youtube.com/playlist?list=PLfIpWHYDHoWxHJ0fVvhWiATo1UsvypJmI>

**Quadrotor parameters**

These are the parameters for the Parrot Mambo Minidrone:

Quadrotor mass, *m*: 0.068 kg  
Radial distance from CG to propeller, *r*: 0.060 m  
Control moment coefficient, *km*: 0.0024 N\*m/(N)  
Body x-axis Moment of Inertia, *Ix*: 6.8E-5 kg\*m^2  
Body y-axis Moment of Inertia, *Iy*: 9.2E-5 kg\*m^2  
Body z-axis Moment of Inertia, *Iz*: 1.35E-4 kg\*m^2

Aerodynamic force coefficient **: 1E-3 N/(m/s)^2

Aerodynamic moment coefficient **: 2E-6 N\*m/(rad/s)^2

## PROBLEMS

1. Create a simulation of a quadrotor, including attitude dynamics and kinematics using the Euler angle attitude representation. Use the body frame representation of translational and angular velocities, corresponding to the book and class. Add control forces and moments from the rotors as discussed in class.
   1. Determine trim thrusts for the rotors for steady hovering flight. Simulate this trim state and verify that it produces equilibrium motion.
2. Add aerodynamic forces and moments due to drag to the simulation as discussed in class.
   1. Verify that this does not alter the trim state for steady hover.
   2. Determine the trim state and rotor thrust trim values for a constant velocity translation at 5 m/s East, while maintaining a yaw of 0 deg, and verify this in simulation.
   3. What changes in the trim state if a yaw of 90 deg is to be maintained instead while translating 5 m/s East? Verify this trim state in your simulation as well.
3. Is steady hovering flight stable for the quadrotor? Determine this through simulation, and through the behavior of the hardware demonstration system physically, and via plots of translation and rotation over time. A video of the Parrot Mambo flying with no control is available at the link below. A data file describing the behavior of the quadrotor in the video is provided with this lab assignment in Canvas.

<https://youtu.be/rcItTz1nSFs>.

## ASSIGNMENT

Submit a single file including all plots and code generated for the problems. Be sure to add titles to all figures that include both the problem number and a description of the plot, e.g. 2.c Output x versus Time. The assignment will be evaluated based on i.) correct answers; ii.) proper commenting and documenting of code; and iii.) the quality of the figures submitted (e.g. labeling, axis, etc).

All lab assignments should include the Team Participation table and should be completed and acknowledged by all team members. Description of the Team Participation table is provided in a separate document.