



AeroClub Summer Project
**Indian Institute of Space Science and
Technology**
Introduction to Systems Engineering (Code: IDC111)

AE+AV
Fusion series
May 29, 2017

Deadline: 05/06/2017

Quiz 1

Maximum Marks: 200

1. You must be familiar with Frames of Reference, while learning Dynamics. Here is a list of frames that you will use in the ongoing project. Explanations are provided in detail.

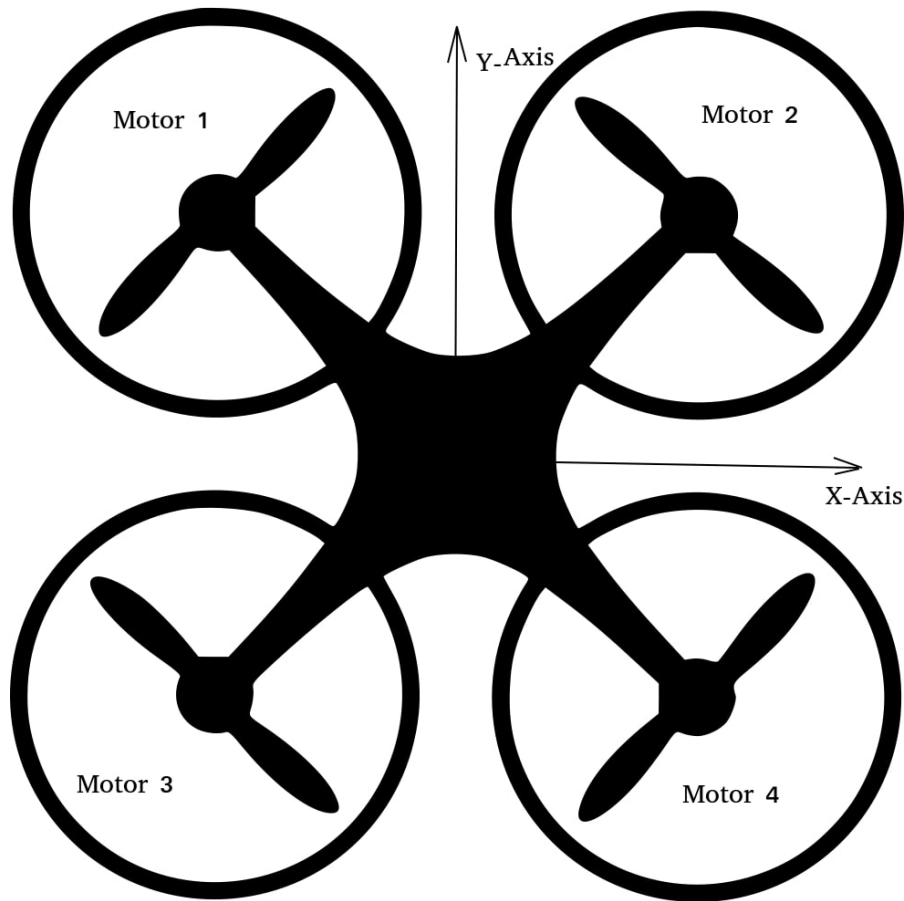
- **Inertial:** This is our ground reference frame. Assume this fixed to the ground
- **Body Inertial:** This is the frame fixed on the centre of mass of the UAV but its orientation is same as Inertial frame
- **Rolled:** Let the Body Inertial frame be rolled by ϕ then it is the Rolled frame
- **Pitched:** Let the rolled frame be pitched by θ then it is the pitched frame
- **Fixed:** This is the frame fixed on the COM of the UAV and its orientation is that of the UAV's

You need to draw the frames figuratively describing where each frame is located. And also provide transformation matrices for each of the following transformations:

$$T_{Inertial}^{BodyInertial}, T_{BodyInertial}^{Rolled}, T_{Rolled}^{Pitched}, T_{Pitched}^{Fixed}, T_{Inertial}^{Fixed}$$

P.S. - In the above Question T_{Frame2}^{Frame1} means a matrix that which when multiplied with co-ordinates of Frame 2 will give us the co-ordinates of same point in frame 1. For example let's say $[a \ b \ c]^t = T_{Frame2}^{Frame1} [x \ y \ z]^t$. Here 't' means Transpose and 'T' is the transformation matrix and a,b,c are co-ordinates in Frame 1 and x,y,z in frame 2.

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2.

The above figure contains four motors named motor 1, motor 2, motor 3, motor 4 and the given frame as shown is a 'X' frame of reference and the same frame when rotated by 45 deg becomes a '+' (plus) frame of reference. Answer the following on basis of the above answer the following:-

- Can you explain the nomenclature X and +?
- Can you comment about the sense of rotation of all the 4 motors, i.e. which of them rotate clockwise and which anticlockwise?
- What if all the motors rotated in the same sense?
- Given your all possible listing to Q2.2 can you say how the X and + frame will affect the dynamics?
- What are your views on a H type frame? Draw and explain in detail.
- Can you comment the effect of a shift in Centre of Gravity from the Geometric centre, given all 4 motors have the same thrust values and all motor arms are the same? How do we tackle this situation

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3. Here is an example operation attached on how the motor goes from a position to a different, <https://drive.google.com/open?id=0B2kPro7Md9VTZTVRN0I1dW5xZms>
Referr to slides 19-22

First state which motor has what sense of rotation, show the Inertial and Body Inertial frame on the graph and then ,Can you jot down the similiar changes in motor thrusts step by step for the following manoeuvres:-

- From (0,0,0) to (0,y,z)
- From (0,0,0) to (x,y,z)
- From (0,0,0) to (x,y,0)
- Comment on how do we cause yaw in our UAV?
- Which is better to move from (0,0) to (x,y) in the same plane: make a yaw and move forward or to roll and pitch up?

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4. This is more of a data mining assignment. You may use the internet to maximum for this purpose. Read up on P.I.D. control on any system. Familiarize yourself with the nomenclature of 'error', 'correction' and 'overshoot' etc.

Write the fundamental equation of PID control system in a Differential Equation. Explain all the variables. Let us assume that x be the desired value of a certain parameter, y be the observed value of a certain parameter and e will be the error($x-y$), in the differential equation you wrote explain how various constants regulate the condition? What is tuning of these constants? Now substitute one of these constants as 0 there will be 3 cases, they will be PD control, PI control and ID control, can you graph the output measured value for P.I.D. control, P.I. control, I.D. control and P.D. control?

P.S. :- This is the essence of module 2. This is the brainstorming question, think and apply your brain in the most analytical way possible.

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5. Give short answers of the following questions.

1. Static system vs Dynamic System?
2. Control requirement in case of Quad?
3. Is control as essential in fixed wing as in a Quad?
4. Can you comment on the relation of stability and control, how does one change with respect to other?
5. Is fixed wing's stability due to structure?
6. Are Quads not as stable as fixed wings? Why?
7. How do you think we can implement a Control System in a Quad? Your idea is required.
8. Can you tell if feedback is good for control or bad?
9. Do you want a grace of 2 mark?

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