Pitch Perfect: ME 2400 Project (Jan – May 2023)

Marks 30 (+5 bonus) Presentation Date: April 25th || Report Due Date : May 5th

Figure 1

A Boeing CH-47 Chinook is a tandem-rotor heavy-lift helicopter. It has two rotors in the front and back which allow it to be one of the heaviest lifting helicopters. Tandem Rotor helicopters like Chinook have a wide range of center of gravity, making them ideal as vertical takeoff cargo carriers. And since the rotors rotate in opposite directions to cancel out the counter-rotation, no tail rotor is necessary to stabilize the yaw. The challenge, however, lies in stabilizing the pitch. The two tandem rotors need to balance the lift dynamically to achieve the desired pitch.

Figure 2

Objective: Build a control algorithm that can balance the pitch of a tandem rotor helicopter by controlling its lift and demonstrate it using a simplified physical setup.

You are to build a simplified simulator of a Chinook helicopter that is supported at its center of mass but free to pivot (pitch up or down as represented in *Figure 3*). On the two ends of its body, you must mount two vertical rotors (motors with propellers) which will propel air downwards and balance the pitch of the setup. This should be a fully self contained unit except for power which s***hould be delivered externally (for safety)***. The length of

the helicopter's body is restricted to 400 mm. The goal is to only demonstrate pitch control. Hence the r*oll and yaw axes are locked*. Only pitch is left free.
Note: The choice to let the motors pivot on the body so as to remain vertical is up to you.

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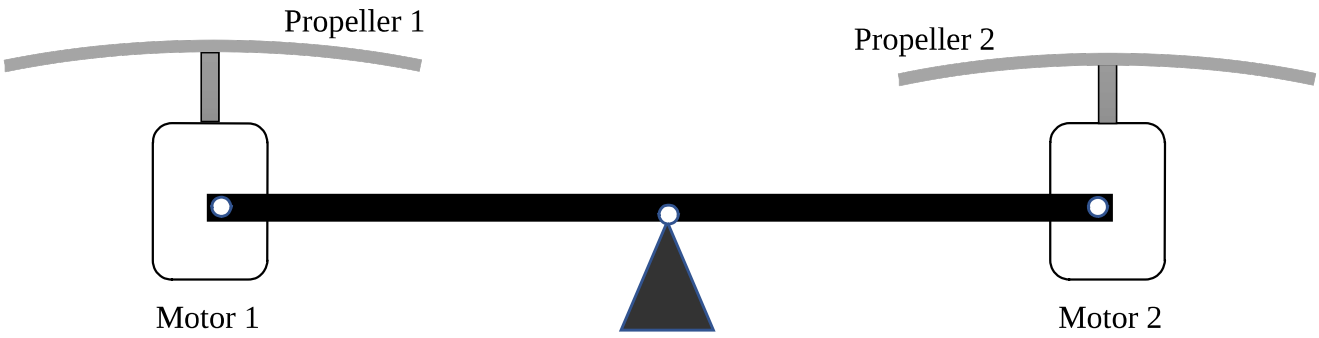

Figure 3

The helicopter will be tested on its ability to balance itself should an external load be applied to it such that its CG shifts away from the pivot point. (The load will be reasonable and dependent on the motor's torque).
Bonus: The setup is able to balance at any requested pitch angle (θ in *Figure 4*) within +30° to -30° and not just 0°.

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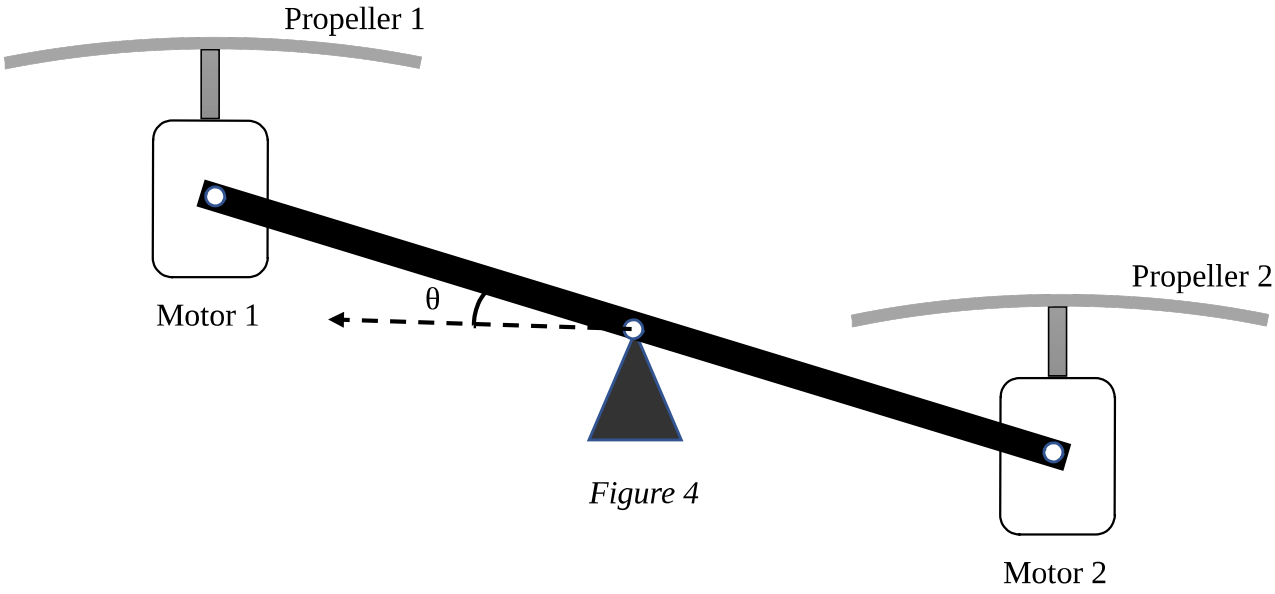

Figure 4

Suggested Project kit items: Motor (2), Tape, Jumper wires, Arduino UNO/ ESP32, Sensor – suitable one, Double sided tape, Bread Board, Propellers (2), USB cable, L293D / L298N (motor driver IC) , Wire stripper & cutter, Multimeter, Appropriate-Battery, body – design and fabricate out of wood, polycarbonate or other material.

Budget: Cannot exceed ***Rs. 2500*** (bills must be submitted along with report)

Project Assessment:

1. Required project report (in A4 sized pages) with the following contents: (a) Title, authors, roll numbers (b) Aims and objective (c) Chassis design and component placement (d) Controller design and tuning method used (e) Arduino programming (provide the program) (f) Conclusion (g) Team member contributions (h) Photos of your project building, team members, team-discussions, working model etc..
2. Working model demonstration: There will be a project demonstration day in an open space (location to be informed later) where all groups can show-case their working models.

a. Structure design and placement of components
b. Arduino programming (concise with plenty of comments, etc..)
c. Controller design (mode, tuning etc..)
d. Stable working demonstration – min. 5 seconds of balancing without large sways and swinging violently; bonus marks if it can respond to and correct external dynamic load disturbances.

Report outline (max 15 pages; appendices can be extra)

1. Executive summary/abstract
2. Introduction and Objective of project
3. Component list and sizing justifications
4. Mechanical design of the system – explain and justify design parameters used
5. Electronic circuit design
6. Controller design and Arduino program – what type of control, how did you tune, final parameter values
7. Control system block diagram and transfer function model; MATLAB Simulink model description
8. Results: video of system performing, response to disturbances
9. Conclusion and lessons learned
10. Photos of team working on the prototypes
11. Report must be formatted properly and look professional. Keep the following points in mind:
    a) Section numbering and sub-section numbering must be proper
    b) Figures/tables must be auto numbered with captions below the figure (Tables have captions above)
    c) All figures/tables must be cited in the text

References:

1. Lecture notes
2. Course textbook
3. www.instructables.com
4. www.arduino.cc
5. MATLAB Simulink documentation
6. MATLAB + Arduino documentation