**Flight Dynamics & Control**

**Aircraft Dynamics Assessment and Autopilot Design Exercise**

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| Group Number | 07 | Student CIDs | 02488088  02200298  02464991  02376386  02383703  02402843 |

**Answer the following questions within the space provided using 11pt Arial. Make sure tables and figures are properly formatted and readable. Marks will be deducted for bad formatting.**

Define the conditions under which your tests were conducted. A single altitude, flight speed and loading should have been used for all computations and tests

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| --- | --- | --- | --- |
| Flight Speed (IAS), kt | **190** | Payload weight, lbs | **500** |
| Altitude, ft | **9000** | Fuel weight, lbs | **2400** |
|  |  | CG offset, inch | **0** |

**Q1.** Provide dimensional values for the following inertial properties, stability and control derivatives computed.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| , kg m2 | 47049.99 | , kg m2 | 128216.8 | , kg m2 | 169200.7 |
| , kg m2 | 86.69 | , m | 10.1282 |  |  |
| , Ns/m |  | , Ns/m |  | , Ns |  |
| , Ns/m |  | , Ns/m |  | , Ns |  |
| , Ns/rad |  | , Ns/rad |  | , Ns/m rad |  |
| , Ns2/m |  | , Ns2/m |  | , Ns2 |  |
| , N/rad |  | , N/rad |  | , Nm/rad |  |
| , N |  | , N |  | , Nm |  |

Note that in the table above are the throttle derivatives given per % throttle.

**(10% of marks)**

**Q2.** Present your simulation and experimental findings for the aircraft’s open-loop response by plotting the variation of the most relevant states of the phugoid, SPPO, roll subsidence, spiral and Dutch Roll modes. Present them side-by-side and scale the magnitude of your computational results as to allow a direct comparison with the experimental cases. *(Provide plots only)*

**EXPERIMENTAL SIMULATION**

|  |
| --- |
| Phugoid |
| SPPO |
| Roll Subsidence |
| Dutch Roll |
| Spiral |

**(10% of marks)**

**Q3.** Provide your computed and experimentally derived values for the eigenvalues of each dynamic mode

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Experimental Period, s | Exp Time-to- half/double amplitude, s | Experimental Eigenvalue | Theoretical Eigenvalue | Reduced-order model Eigenvalue |
| Phugoid |  |  |  |  |  |
| SPPO |  |  |  |  |  |
| Roll Subsidence |  |  |  |  |  |
| Dutch Roll |  |  |  |  |  |
| Spiral |  |  |  |  |  |

**(10% of marks)**

**Q4.** Discuss the quality of your predictions compared to your experimental findings. What might the source of any discrepancies between your computed values and those observed during flight testing be? *Briefly* highlight any issued that may have impacted your experimental values.

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**(20% of marks)**

**Q5.** Briefly describe the approach your group took when tuning your controller. What scenarios did you consider and what were your tuning targets (for example rise time, settling time).

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**(5% of marks)**

**Q6.** Provide your PID gains for each of the three controllers your designed. Remember that gains are dimensional and here define the percentage input per degree or knot of measured error.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Proportional Gain | Integral Gain | Derivative Gain |
| Roll |  |  |  |
| Climb Angle |  |  |  |
| Speed |  |  |  |

**(5% of marks)**

**Q7.** Present your simulation and experimental findings for your initial autopilot’s closed-loop performance by plotting the variation of the most relevant states. Present them side-by-side, using equivalent perturbations and scale the magnitude of your computational results as to allow a direct comparison with the experimental test cases. *(Provide plots only)*

**EXPERIMENTAL SIMULATION**

|  |
| --- |
| Roll Controller |
| Climb Angle Controller |
| Speed Controller |

**(10% of marks)**

**Q8.** For each of your controllers briefly describe how you re-tuned their gains based on the responses observed during your testing. Provide the final tunned gains. Present a plot of the final performance of your final standalone controllers to a step change in the setpoint.

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| --- |
| Roll Controller |
| Climb Angle Controller |
| Speed Controller |

**(15% of marks)**

**Q9.** How well did the control gains tuned using your theoretical model perform during flight testing? What might the source of any observed differences in their performance be?

|  |
| --- |
|  |

**(10% of marks)**

**Q10.** Plot your combined pitch and velocity autopilot’s response to a change in the climb angle setpoint. Did you have to adjust the gains to ensure satisfactory performance?

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|  |

**(5% of marks)**