Indian Institute of Space Science and Technology

AE614/AE457 - Flight Dynamics and Control

May 5, 2026

End Semester

(Open Notes Exam)

Duration: 180 min **Maximum marks: 90**

- Please provide clear steps and expressions for the problems. Steps carry mark.
- State any assumptions you make and justify them.
- **Only hand-written notes are allowed. No photocopies or books allowed.**

? 1. A 2-seater aircraft has unstable spiral mode. As a designer, you have been asked to improve the spiral mode. You can use any and all means to make the aircraft stable in spiral mode. List and briefly explain all the methods that will make the spiral mode stable. [15]

2. Use the aircraft details given in the table for the below problem.
   (a) Derive the transfer functions of $\frac{\beta(s)}{\delta_r(s)}$ and $\frac{r(s)}{\delta_r(s)}$ using the Dutch-Roll approximation. [10]
   (b) Design a PI controller for $\frac{\beta(s)}{\delta_r(s)}$ such that the closed-loop system exhibits a maximum overshoot of 16% and a settling time of 2.5 s. [15]

3. Use the aircraft details given in the table for below problem.
   (a) Derive the state space mode for the bank angle (ϕ) and roll rate (p). [5]
   (b) Design a Full-State Feedback controller for ϕ such the closed loop system has a time period of 2.5 s and a settling time of 1.5 s. [15]

4. Derive the transfer function $\frac{h(s)}{\delta_e(s)}$. [Hint: Find the perturbation equation for h]. [15]

5. Please choose the correct answer and give proper detailed justification for your choice. **No justification, no marks.**
   (a) As the aircraft's longitudinal static stability increases, the natural frequency of the short-period mode also increases. (True/False) [5]
   (b) As I_y decreases, the Phugoid mode becomes more stable. (True/False) [5]
   (c) As the wing span increases, the roll mode becomes more stable. (True/False) [5]

Aircraft details

Aircraft Information

(a) *Geometric and Inertial Parameters*

Mean Aerodynamic Chord, $\bar{c}$	1.211 m
Wing Span, b	10.47 m
Wing Area, S	12.47 m^2
Mass, m	750 kg
Moment of Inertia, I_{xx}	873 $kg - m^2$
Moment of Inertia, I_{yy}	907 $kg - m^2$
Moment of Inertia, I_{zz}	1680 $kg - m^2$
Moment of Inertia, I_{xz}	1144 $kg - m^2$
Engine Thrust, T	1136 N
Trim speed, V_∞	55 m/s

(b) *Aerodynamic Derivatives*

$C_{D_0} = 0.036$	$C_{L_0} = 0.365$	$C_{m_0} = 0.05$
$C_{D_\alpha} = 0.061$	$C_{L_\alpha} = 4.98$	$C_{m_\alpha} = -0.59$
$e = 0.8$	$C_{L_q} = 27.3$	$C_{m_q} = -9.3$
$C_{L_{\delta_e}} = 0.26$	$C_{L_{\dot\alpha}} = 8.3$	$C_{m_{\dot\alpha}} = -4.3$
$C_{D_{\delta_e}} = 0.026$	$C_{L_{\delta_e}} = 0.26$	$C_{m_{\delta_e}} = -1.008$
$C_{Y_0} = -0.013$	$C_{l_0} = 0.0015$	$C_{n_0} = 0.001$
$C_{Y_\beta} = -0.431$	$C_{l_\beta} = -0.051$	$C_{n_\beta} = 0.071$
$C_{Y_p} = 0.269$	$C_{l_p} = -0.251$	$C_{n_p} = -0.045$
$C_{Y_r} = 0.433$	$C_{l_r} = 0.36$	$C_{n_r} = -0.091$
$C_{Y_{\delta_r}} = 0.15$	$C_{l_{\delta_r}} = 0.005$	$C_{n_{\delta_r}} = -0.049$
$C_{Y_{\delta_a}} = 0$	$C_{l_{\delta_a}} = -0.153$	$C_{n_{\delta_a}} = 0$

Formulae Sheet

$$\text{Maximum overshoot (\%)}, M_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$$

$$\text{Settling Time (s)}, T_s = \frac{4}{\zeta\omega_n}$$

$$\text{Time Period (s)}, T_P = \frac{2\pi}{\omega_n\sqrt{1-\zeta^2}}$$