THE UNIVERSITY OF TEXAS AT AUSTIN
Department of Aerospace Engineering and Engineering Mechanics

ASE 367K FLIGHT DYNAMICS
Fall 2024

HOMEWORK 4
Due: 2024-09-27 at 11:59pm via Canvas

Problem 1

Answer the following questions related to yaw stability and control:

a. Determine the side-wash angle and the maximum deflection angle of the rudder of the Boeing 747-200 if the aircraft is designed to land (at any weight) in crosswind of up to 40 knots and the area of the rudder is 30% of the area of the vertical stabilizer.

b. Determine the sizes of the rudder and the vertical stabilizer assuming this is the limiting operating condition for the rudder.

N.B. You may assume that the minimum landing speed of the 747-200 is 120 knots; the derivative coefficients C_{n_β} and $C_{n_{\delta_r}}$ that are provided in the table below for M = 0.25 at sea level are valid for all low-speed, near sea-level operations; $C_{n_{\beta_f}}$ and C_{n_β} are approximately equal; l_f is approximately 150 ft.; $C_{L_{\alpha_f}}$ is approximately 3 per radian; the wing sweep angle is 35 degrees; $\frac{S_f}{S} = 0.15$; $z_w/d = 0.5$; and $AR_w = 7.5$.

Transport aircraft: Boeing 747

Longitudinal	C_L	C_D	C_{L_α}	C_{D_α}	C_{m_α}	$C_{L_{\dot\alpha}}$	$C_{m_{\dot\alpha}}$	C_{L_q}	C_{m_q}	C_{L_M}	C_{D_M}	C_{m_M}	$C_{L_{\delta_e}}$	$C_{m_{\delta_e}}$
M = 0.25 Sea level	1.11	0.102	5.70	0.66	−1.26	6.7	−3.2	5.4	−20.8	−0.81	0.0	0.27	0.338	−1.34
M = 0.90 40,000 ft	0.5	0.042	5.5	0.47	−1.6	0.006	−9.0	6.58	−25.0	0.2	0.25	−0.10	0.3	−1.2

Lateral	C_{y_β}	C_{l_β}	C_{n_β}	C_{l_p}	C_{n_p}	C_{l_r}	C_{n_r}	$C_{l_{\delta_a}}$	$C_{n_{\delta_a}}$	$C_{y_{\delta_r}}$	$C_{l_{\delta_r}}$	$C_{n_{\delta_r}}$
M = 0.25 Sea level	−0.96	−0.221	0.150	−0.45	−0.121	0.101	−0.30	0.0461	0.0064	0.175	0.007	−0.109
M = 0.90 40,000 ft	−0.85	−0.10	0.20	−0.30	0.20	0.20	−0.325	0.014	0.003	0.075	0.005	−0.09

Note: All derivatives are per radian.

You may also assume that $\eta_f\left(1+\frac{\partial\sigma}{\partial\beta}\right)$, the combined effects of the tail efficiency and sidewash in the expression $C_{n_{\beta_f}} = V_V \eta_f C_{L_{\alpha_f}}\left(1+\frac{\partial\sigma}{\partial\beta}\right)$ can be estimated using:

$$\eta_f\left(1+\frac{\partial\sigma}{\partial\beta}\right) = 0.724 + 3.06\frac{S_f/S}{1+\cos\Lambda_{c_w/4}} + 0.4\frac{z_w}{d} + 0.009AR_w$$

Problem 2

Answer the following questions related to roll stability and control:

a. Which of the following two statements is true?

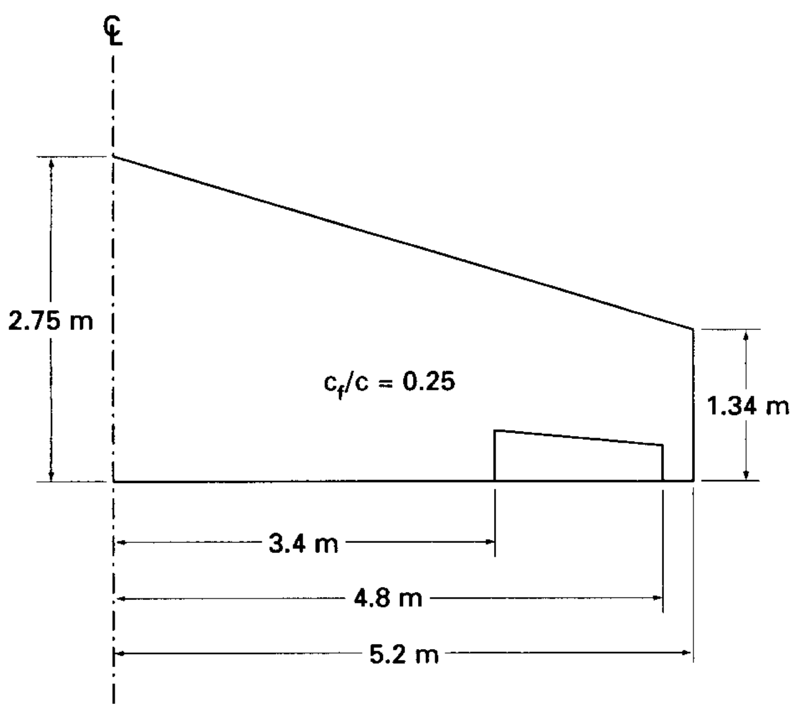
   i. When an aircraft is perturbed such that one wing is lowered relative to the other, dihedral causes the lower wing to increase its surface area relative to the airflow, thus increasing its lift. This acts to oppose the original roll motion.

   ii. When a disturbance causes an aircraft to roll away from its nominal straight and level position, the aircraft will sideslip in the direction of the wing that is going down. This creates an airflow component along the length of the wing from tip to root. The dihedral angle can be seen as presenting a positive angle of attack to this lateral flow, hence generating some additional lift. It is this lift, which restores the aircraft to its normal attitude

b. Explain using appropriate figures how wing sweep contributes to roll stability.

c. Derive an approximate expression (as a function of wing sweep angle) for the contribution of wing sweep to roll stability.

d. Suppose the wing planform below is incorporated into a low-wing aircraft design. Determine the wing dihedral angle necessary to produce a dihedral effect of $C_{l_\beta} = -0.1$ rad^{-1}. Neglect the fuselage interference on the wing dihedral contribution.



Problem 3

Starting with the equation for the thrust required T_R in level flight (as a function of mass, altitude, and true airspeed):

a. Derive (separately for jet and propeller aircraft) an expression for the instantaneous speed and to achieve maximum endurance.

b. Derive (separately for jet and propeller aircraft) an expression for the instantaneous speed to achieve maximum range.

c. Explain why the pitch of the aircraft must be reduced as a function of time, i.e., as fuel is consumed, to maintain a constant altitude and Mach number during cruise. Not sure about its relation to pitch

d. Explain why a cruise climb at a constant Mach number is better (from a fuel consumed per distance traveled) than cruising at a constant altitude and Mach number.