Aeronautics Formula Sheet

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1 Aircraft Geometry

Wing taper ratio $\lambda = \frac{c_t}{c_r}$

Standard mean chord (SMC) $\bar{c} = \frac{S}{b}$

Aspect ratio (AR) $AR = \frac{b}{\bar{c}} = \frac{b^2}{S}$

Mean aerodynamic chord (MAC) $\bar{\bar{c}} = \frac{1}{S}\int_{-\frac{b}{2}}^{\frac{b}{2}} c^2(y)dy$

2 Lift & Airfoils

Lift $L = \frac{1}{2}\rho_\infty {V_\infty}^2 S C_L$

Reynolds number (Re) $Re = \frac{\rho V_\infty c}{\mu}$

Coefficient of Lift $C_L = \frac{L}{\frac{1}{2}\rho_\infty {V_\infty}^2 S}$

Coefficient of Drag $C_D = \frac{D}{\frac{1}{2}\rho_\infty {V_\infty}^2 S}$

Pitching Moment Coefficient $C_M = \frac{M}{\frac{1}{2}\rho_\infty {V_\infty}^2 Sc}$

Coefficient of Lift $C_L = a(\alpha - a_0)$

3 Drag

Coefficient of Drag (3D) $C_D = C_{D_0} + K{C_L}^2$

Coefficient of induced Drag (3D) $C_{Di} = \frac{{C_L}^2}{\pi e AR}$

Coefficient of Drag (3D) $C_D = C_{D_0} + \frac{{C_L}^2}{\pi e AR}$

4 Wave Drag & Pitching Moment

$C_{M_{ac}} = C_{M_0}$

aerodynamic center $\frac{x_{ac}}{c} = 0.25$

5 Standard Atmosphere

Equation of state $p = \rho R T$

Temperature $T = 288.15 - 6.5H$

Density Ratio in relation to sea level $\sigma = \frac{20 - H}{20 + H}$

Speed of sound $a = \sqrt{\gamma R T}$

6 Aircraft Performance in Straight & Level Flight

Equivalent air speed $V_E = V\sqrt{\frac{\rho}{\rho_0}} = V\sqrt{\sigma}$

Pitot-static tube $p_{pitot} - p_{static} = \frac{1}{2}\rho V^2$

Minimum Drag $C_{D_{min}} = 2C_{D0} = 2K{C_L}^2$

Minimum Drag Velocity $V_{MD} = \left(\frac{2W}{\rho S}\right)^{\frac{1}{2}}\left(\frac{K}{C_{D0}}\right)^{\frac{1}{4}}$

7 Variation of Power with Speed & Altitude

Power $P = TV = DV$

Minimum Power Coefficient of Drag $C_{D_{MP}} = C_{D0} + 3C_{D0} = 4C_{D0}$

Minimum Power Coefficient of Lift $C_{L_{MP}} = \sqrt{3C_{D0}/K}$

Minimum Power Velocity $V_{MD} = \left(\frac{2W}{\rho S}\right)^{\frac{1}{2}}\left(\frac{K}{3C_{D0}}\right)^{\frac{1}{4}}$

8 Climb & Glide

Gliding Lift $L = W\cos\theta$

Gliding Drag $D = W\sin\theta$

Climbing Lift $L = W\cos\theta$

Climbing $T - D = W\sin\theta$

9 Cruise

Thrust $T = kT_0\sigma^x$ $\quad x = 1$ for all altitudes except for $H > 11km$

10 Range & endurance Jet

Endurance $E = \frac{1}{fg}\frac{C_L}{C_D}\ln\left(\frac{W_1}{W_2}\right)$

Range $R = \frac{V}{fg}\frac{C_L}{C_D}\ln\left(\frac{W_1}{W_2}\right)$

11 Range & endurance Propeller driven AC

Endurance $E_{prop} = \frac{\eta}{fg}\frac{1}{V}\frac{C_L}{C_D}\ln\left(\frac{W_1}{W_2}\right)$

Range $R_{prop} = \frac{\eta}{fg}\frac{C_L}{C_D}\ln\left(\frac{W_1}{W_2}\right)$

12 Payload - Range

Initial Weight	$W_{intial} = W_{final} + Trip\ fuel\ weight$
Final Weight	$W_{final} = OEW + Payload + Reverse\ Fuel$
Range	$R = \frac{a}{fg}\left(M\frac{L}{D}\right)\ln\left(\frac{W_{intial}}{W_{final}}\right)$

13 Manoeuvring Flight

Load Factor	$n = \frac{L}{W}$
Corner Velocity	$V* = \sqrt{\frac{2n_{max}W}{\rho S C_{L\ max}}}$
Load Factor (wind gusts)	$n = \frac{\rho a_1 \upsilon}{2W/S}V + 1$

14 Banked Turns

Angle	$\cos\phi = \frac{1}{n}$
Turn Radius	$R = \frac{V^2}{g\sqrt{n^2-1}}$
Turn Rate	$\omega_t = \frac{g\sqrt{n^2-1}}{V}$

15 Magic Table

C_L/C_D relation	Maximized when	C_L	C_D	Relates to
$C_L^{\frac{3}{2}}/C_D$	$C_{D0} = \frac{1}{3}C_L^2$	$\sqrt{\frac{3C_{D0}}{K}}$	$4C_{D0}$	Min Power, Min Sink Rate, Max Prop Endurance
C_L/C_D	$C_{D0} = KC_L^2$	$\sqrt{\frac{C_{D0}}{K}}$	$2C_{D0}$	Min drag, Min glide angle Max prop range, Max jet endurance
$C_L^{\frac{1}{2}}/C_D$	$C_{D0} = 3KC_L^2$	$\sqrt{\frac{C_{D0}}{3K}}$	$\frac{4}{3}C_{D0}$	Max Jet Range