AERO 315
EQUATIONS

Fluid Mechanics

$$dP = -\rho\, g\, dh \qquad dP = -\rho\, V\, dV \qquad \tau_w = \mu\left(\frac{dV}{dy}\right)_{y=0} \qquad P_2 - P_1 = -\rho_l\, g(h_2 - h_1)$$

Viscous Flow

$$Re_x = \frac{\rho_\infty V_\infty x}{\mu_\infty} \qquad Re_c = \frac{\rho_\infty V_\infty \bar{c}}{\mu_\infty} \qquad Re_{x_{crit}} = \frac{\rho_\infty V_\infty x_{crit}}{\mu_\infty}$$

Airfoils & Finite Wings

$$C_D = c_d + C_{D_i} \qquad C_{D_i} = k\, C_L^2 \qquad k = \frac{1}{\pi e AR}$$

* use charts or various other methods to find this e (efficiency factor) / fudge factor.

$$C_L = C_{L_\alpha}(\alpha - \alpha_{L=0}) \qquad C_{L_\alpha} = \frac{c_{l_\alpha}}{\left[1 + \left(\frac{57.3^\circ\, c_{l_\alpha}}{\pi\, e\, AR}\right)\right]} \qquad V = \sqrt{\frac{2W}{\rho S C_L}} \qquad V_{stall} = \sqrt{\frac{2W}{\rho S C_{L_{max}}}}$$

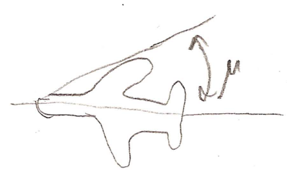
ICE-T

$$V_C = V_i + \Delta V_P \qquad V_e = f \cdot V_C \qquad V = V_e\sqrt{\frac{\rho_{SL}}{\rho_{ALT}}} = V_e\sqrt{\frac{P_{SL}\, T_{ALT}}{P_{ALT}\, T_{SL}}} \qquad \vec{V}_G = \vec{V} + \vec{V}_W$$

Mach Effects

$$a = \sqrt{\gamma R T} \qquad \sin\mu = \frac{1}{M}$$

$M = \frac{1}{\sin \mu}$



Stability & Control

$$\bar{x} = \frac{x}{\bar{c}} \qquad SM = \bar{x}_n - \bar{x}_{cg} = -\frac{C_{M_\alpha}}{C_{L_\alpha}}$$

Performance

$$n \equiv \frac{L}{W} \qquad V = \sqrt{\frac{2nW}{\rho S C_L}} \qquad V_{stall} = \sqrt{\frac{2\, n\, W}{\rho S\, C_{L_{max}}}} \qquad V^* = \sqrt{\frac{2\, n_{max}\, W}{\rho S\, C_{L_{max}}}}$$

$$c_{t_{ALT}} = c_{t_{SL}}\sqrt{\frac{T_{ALT}}{T_{SL}}} = c_{t_{SL}}\left(\frac{a_{ALT}}{a_{SL}}\right)$$

$$T_{A_{ALT}} = T_{A_{SL}}\left(\frac{\rho_{ALT}}{\rho_{SL}}\right) \text{ (dry)} \qquad T_{A_{ALT}} = T_{A_{SL}}\left(\frac{\rho_{ALT}}{\rho_{SL}}\right)(1 + 0.7M) \text{ (wet)}$$

$$\frac{L}{D} = \frac{W}{D} = \frac{W}{T_R} \qquad D_{min} = 2\, W\sqrt{k\, C_{D_o}} \qquad \left.\frac{L}{D}\right)_{max} = \frac{1}{2\sqrt{k\, C_{D_o}}}$$

Glides

$$\gamma = \tan^{-1}\left(\frac{1}{\frac{L}{D}}\right) = \sin^{-1}\left(\frac{D}{W}\right) = \cos^{-1}\left(\frac{L}{W}\right) \qquad R = h\left(\frac{L}{D}\right) \qquad ROD = \frac{P_R}{W} = V\sin\gamma$$

Climbs

$$\sin\gamma = \frac{T_x}{W} \qquad ROC = \frac{P_x}{W}$$

Cruise

$$R = \frac{\Delta W_f}{c_t\left(\frac{D}{V}\right)_{ave}} \qquad R = \frac{1}{c_t}\sqrt{\frac{8}{\rho S}}\left(\frac{\sqrt{C_L}}{C_D}\right)\left(\sqrt{W_1} - \sqrt{W_2}\right)$$

$$E = \frac{\Delta W_f}{c_t\, D_{ave}} \qquad E = \left(\frac{1}{c_t}\right)\left(\frac{C_L}{C_D}\right)\ln\left(\frac{W_1}{W_2}\right)$$

Take Off / Landing

$$s_{TO} = \frac{1.44 W_{TO}^{\;2}}{\rho S C_{L_{max}} g\left[T - D - \mu(W_{TO} - L)\right]_{0.7V_{TO}}} \qquad V_{TO} = 1.2 V_{stall}$$

$$s_{TO} = \frac{1.44 W_{TO}^{\;2}}{\rho S C_{L_{max}} g T} \quad \text{(thrust >> retarding forces)}$$

$$s_L = \frac{1.69\, W_L^{\;2}}{\rho S C_{L_{max}} g\left[D + \mu(W_L - L)\right]_{0.7V_L}} \qquad V_L = 1.3 V_{stall}$$

Steady Level Turn

$$n = \frac{1}{\cos\phi} \qquad r = \frac{V^2}{g\sqrt{n^2 - 1}} \qquad \omega = \frac{g\sqrt{n^2 - 1}}{V}$$

Pull-up (instantaneous, bottom of loop)

$$r = \frac{V^2}{g(n-1)} \qquad \omega = \frac{g(n-1)}{V}$$

Pull-down (instantaneous, top of loop)

$$r = \frac{V^2}{g(n+1)} \qquad \omega = \frac{g(n+1)}{V}$$

Energy Height & Specific Excess Energy

$$H_e = E_s = h + \frac{V^2}{2g} \qquad P_s = \dot{E}_s = \frac{dh}{dt} + \frac{V}{g}\frac{dV}{dt} = V\left(\frac{T - D}{W}\right) = \frac{P_x}{W}$$