ASEN 2002: Aerodynamics Experimental Laboratory 2 Equation Sheet

ASEN 2002: Introduction to Thermodynamics and Aerodynamics
University of Colorado at Boulder

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Coefficient of Pressure:

$$C_p = \frac{p - p_\infty}{\frac{1}{2}\rho_\infty V_\infty^2} = \frac{p - p_\infty}{q_\infty} \tag{1}$$

$$C_p = 1 - \frac{V^2}{V_\infty^2} \tag{2}$$

Coefficient of Lift

$$C_L = \frac{L}{\frac{1}{2}\rho_\infty V_\infty^2 S} = \frac{L}{q_\infty S} \tag{3}$$

Coefficient of Drag

$$C_D = \frac{D}{\frac{1}{2}\rho_\infty V_\infty^2 S} = \frac{D}{q_\infty S} \tag{4}$$

Planform Area

$$S = c \cdot b \tag{5}$$

Sectional Coefficient of Lift

$$C_l = \frac{l}{\frac{1}{2}\rho_\infty V_\infty^2 c} = \frac{l}{q_\infty c} \tag{6}$$

Sectional Coefficient of Drag

$$C_d = \frac{d}{\frac{1}{2}\rho_\infty V_\infty^2 c} = \frac{d}{q_\infty c} \tag{7}$$

The normal force over the i^{th} segment of the airfoil

$$n_i = -\frac{1}{2}(p_i + p_{i+1}) cos\theta \Delta s_i \tag{8}$$

Simplified ...

$$n_i = -\frac{1}{2}(p_i + p_{i+1}) \Delta x_i \tag{9}$$

Axial force

$$a_i = \frac{1}{2}(p_i + p_{i+1}) sin\theta \Delta s_i \tag{10}$$

Normal force

$$a_i = \frac{1}{2}(p_i + p_{i+1}) \Delta y_i \tag{11}$$

Total axial and normal forces

$$n = -\sum_{n=1}^{n} \frac{1}{2}(p_i + p_{i+1}) \Delta x_i \tag{12}$$

$$a = -\sum_{n=1}^{n} \frac{1}{2}(p_i + p_{i+1}) \Delta y_i \tag{13}$$

Note that $\Delta x_i = x_{i+1} - x_i$ and $\Delta y_i = y_{i+1} - y_i$.

Normal Force

$$C_n \equiv \frac{n}{\frac{1}{2}\rho_\infty V_\infty^2 c} = -\sum_{i=1}^{n} \frac{1}{2}\left(\frac{p_i - p_\infty}{\frac{1}{2}\rho_\infty V_\infty^2} + \frac{p_{i+1} - p_\infty}{\frac{1}{2}\rho_\infty V_\infty^2}\right)\frac{\Delta x_i}{c} - \frac{p_\infty}{\frac{1}{2}\rho_\infty V_\infty^2 c}\sum_{i=1}^{n}\Delta x_i \tag{14}$$

employing simplifications...

$$C_n = -\sum_{i=1}^{n} \frac{1}{2}(C_{p_i} + C_{p_{i+1}})\frac{\Delta x_i}{c} \tag{15}$$

$$C_a = \sum_{i=1}^{n} \frac{1}{2}(C_{p_i} + C_{p_{i+1}})\frac{\Delta y_i}{c} \tag{16}$$

Exact normal and axial force coefficients

$$C_n = -\oint C_p \frac{dx}{c} \tag{17}$$

$$C_a = \oint C_p \frac{dy}{c} \tag{18}$$

Lift and Drag coefficients

$$C_l = C_n cos\alpha - C_a sin\alpha \tag{19}$$

$$C_d = C_n sin\alpha + C_a cos\alpha \tag{20}$$