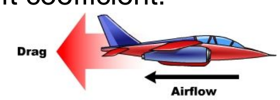
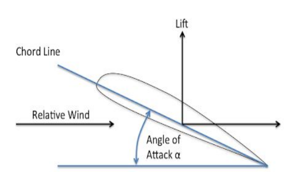
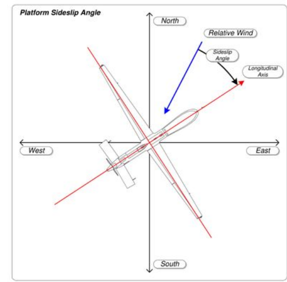
Force Coefficients

Coefficient	Coefficient Name	Definition	Relative Information
C_L	Lift	Effectiveness of the airfoil to produce lift	Determined by the wings, fuselage, and horizontal tail. It varies with Mach and alpha.
C_D	Drag	The aerodynamic force that opposes an aircraft's motion through the air.	Generally presented as a function of the lift coefficient. 
C_Y	Sideforce	Force in the Y direction of the body.	Created by sideslipping motion (Beta not equal to 0) and rudder deflection.

Moment Coefficients

Coefficient	Coefficient Name	Definition	Relative Information
C_l	Rolling Moment	The rotational moment about the longitudinal axis.	
C_m	Pitching Moment	The rotational moment about the y axis.	
C_n	Yawing Moment	The rotational moment about the z-axis.	

Coefficient	Coefficient Name	Definition	Relative Information
α	Angle of Attack	The angle the chord line makes with the freestream velocity vector.	

β	Sideslip Angle	The aerodynamic state where an aircraft is moving somewhat sideways as well as forward relative to the oncoming airflow or relative wind.	

Dimensionless Force Coefficient Equations

Coefficient	Equation	Relative Information
C_L	$C_L = \frac{C_L}{\bar{q}S}$ For small airfoils $C_L = 2\pi\alpha$	Wind-axis q bar = dynamic pressure S = wing planform area CL = lifting force α = angle of attack
C_D	$C_D = \frac{C_D}{\bar{q}S}$	Wind-axis q bar = dynamic pressure S = wing planform area CD = Drag force
C_Y	$C_Y = \frac{C_C}{\bar{q}S}$	Wind-axis q bar = dynamic pressure S = wing planform area CC = sideforce

Dimensionless Moment Coefficient Equations

Coefficient	Equation	Relative Information
C_l	$l_w = \frac{R_M}{\bar{q}Sb_{ref}}$	Wind-axis q bar = dynamic pressure S = wing planform area RM = Rolling Moment Bref = wingspan
C_m	$m_w = \frac{P_M}{\bar{q}S\bar{c}}$	Wind-axis q bar = dynamic pressure S = wing planform area PM = Pitching Moment

		c bar = mean aerodynamic chord
C_n	$n_w = \frac{Y_m}{\bar{q} S b_{ref}}$	Wind-axis q bar = dynamic pressure S = wing planform area YM = Yawing Moment Bref = wingspan

Coefficient	Equation	Relative Information
α	$-\pi < \alpha < \pi$	Measured with the limits of -pi to pi because it is being measured or estimated on the z-axis.
β	$-\frac{\pi}{2} \leq \beta \leq \frac{\pi}{2}$	The sideslip angle does not have an equation but is measured with the two limits seen to the left. This is being measured on the y-axis.

Dimensionless Force Coefficient Equations

Coefficient	Equation	Measurement
C_L	$C_L = \frac{C_L}{\bar{q} S}$ For small airfoils $C_L = 2\pi\alpha$	Coefficient of Lift can be determined as the angle of attack varies. My current understanding is, for a small plane with a reliable pitot tube, you may get a reasonable estimation of the angle of attack. https://courses.cit.cornell.edu/mae5070/Caughey_2011_04.pdf
C_D	$C_D = \frac{C_D}{\bar{q} S}$	

C_Y	$C_Y = \frac{C_C}{\bar{q}S}$	

“The second important method of measuring aerodynamic coefficients is through *flight test*. In this case *trimmed coefficients* are measured by using the control surfaces to make perturbations from the trimmed steady-state flight condition (Maine and Iliffe, 1980). The typical results are curves of a coefficient plotted against Mach, with altitude as a parameter, for a specified aircraft weight and cm position. The dependence on altitude comes about through the variation of alpha with altitude for a given Mach number, through aeroelastic effects changing with dynamic pressure and, possibly, through Reynolds number effects.”

The above information is pulled directly from the textbook. While this tells us that we need to flight test the system, it does not tell us how this should be conducted. There are several equations in the subsequent sections pertaining to the aerodynamic coefficients as a function of aoa and sideslip, but these equations are not drawn out. They are in the form CL(alpha,beta). Further research is needed to determine the flight tests. **This is to be done in week 3 of February.**

The textbook offers four ways to determine the AC’s. The first way described in the text is wind tunnel testing. This would be the easiest way to determine the coefficients, but it is expensive and most likely not worth the return on investment. The second way to determine the coefficients is flight testing. This is the way I believe we can determine the coefficients. The third way the text offers to determine the coefficients is through a computational model. Finally, the text suggests the last way to determine the AC’s is through CFD (computational fluid dynamics) computer code.

In lieu of defining a flight test, I have included an article that discusses how a flight test may work. I have included it here for reference. I think this is valuable information for the instrumentation team. This article will also help us define tests to find the moments of inertia.