Problems of Ch2

September 22, 2024

Due: Oct 8th, 2024

2.1 Ask yourself in what direction does aerodynamic drag (by definition) act. Then write the appropriate scaler component of the vector momentum equation in this direction. The body force term for this case is the drag. Solve the equation for this drag.

2.2 Similarly, ask yourself in what direction does the lift act. Then write the appropriate scaler component of the vector equation in this direction. The body force term for this case is the lift; solve the equation for this lift.

2.3 When the National Advisory Committee for Aeronautics (NACA) measured the lift and drag on airfoil models in the 1930s and 1940s in their specially designed airfoil wind tunnel at the Langley Aeronautical Laboratory, they made wings that spanned the entire test section, with the wing tips butted against the two sidewalls of the tunnel. This was done to ensure that the flow over each airfoil section of the wing was essentially two-dimensional (no wing-tip effects). Such an arrangement prevented measuring the lift and drag with a force balance. Instead, using a Pitot tube, the NACA obtained the drag by measuring the velocity distribution behind the wing in a plane perpendicular to the plane of the wing, i.e., the Pitot tube, located a fixed distance downstream of the wing, traversed the height from the top to the bottom of the test section. Using a control volume approach, derive a formula for the drag per unit span on the model as a function of the integral of the measured velocity distribution. For simplicity, assume incompressible flow.

2.4 In the same tests described in problem 2.3, the NACA measured the lift per unit span by measuring the pressure distribution in the flow direction on the top and bottom walls of the wind tunnel. Using a control volume approach, derive a formula for the lift per unit span as a function of the integral of these pressure distributions.