5 Control Volume Theorems

- 5.1 Physical laws expressed in terms of a *material volume* (a closed system that consists always of the same material particles): law of mass conservation, equation of motion, first law of thermodynamics, second law of thermodynamics.
- 5.2 The Reynolds transformation, which allows the physical laws that apply to material volumes to be expressed in terms an arbitrarily specified *control volume* (an open system with a completely arbitrarily specified boundary).
- 5.3 The mass conservation law applied to a control volume. Examples involving various control volume choices for a given problem.
- 5.4 The linear momentum equation (Newton's law of motion in control volume form). Various examples, steady and unsteady, including a fuel-laden space rocket accelerating to speed, transient flows involving phase change (and the reaction stress that causes), examples from hydraulics and surface waves, determining drag from a wake profile, etc.
- 5.5 The angular momentum theorem (a moment of Newton's law, expressed in control volume form. Various examples, ranging from lawn sprinklers and centrifugal pumps to the spin-up of bathtub vortices and tornadoes.
- 5.6 The energy equation (first law of thermodynamics) in control volume form. Examples.

Read: Fay: Chapt. 5

Sonin: "Fundamental Laws of Motion for Particles, Material Volumes, and Control Volumes," 2000, Handout.

Problems: Shapiro & Sonin 5.1, 5.5, 5.10, 5.11, 5.13, 5.16, 5.18, 5.22 5.24, 5.27, 5.29, 5.30, 5.33.