The test will be closed book, closed note. The test will involve several homework-style problems + definitions and explanations. You will need a calculator to do the test, but no other electronic devices are permitted. The honor code is in effect. The following material will be tested. Note that nozzles will figure prominently in the test! Don't forget to bring a calculator and blank paper to the test. You are also permitted to prepare and bring to the test a formula sheet/review notes covering one 11x8 sheet of paper.

**Introduction and Thermodynamics**
Know and understand the definition of isentropic compressibility. Know the definition of Mach number in terms of the scales of the forces, as well as in terms of the flow and sound speed. Be able to sketch accurately the flow past an airfoil as it develops with Mach number, including the configurations of any waves and sonic lines. Know the definitions of the various compressible flow regimes. Know the equation of state for a perfect gas, and where it comes from and what it assumes. Know the meaning of the first law of thermodynamics. Know the definitions of enthalpy and entropy, of $C_p$ and $C_v$, as well as their units. Be able to state the 2nd law of thermo (in math and words). Be able to state precisely what is meant by a thermally perfect gas and a calorically perfect gas, pressure work, heat, specific heats. Know precisely the meaning of adiabatic, reversible and isentropic processes. Be able to identify based when a real world flow is isentropic or adiabatic, and when it is not, and why. Know where the relations $p/\rho = \text{constant}$ and $R = C_p - C_v$ come from and what assumptions they imply. Be able to identify the assumptions implicit (and those not implicit) in all the thermodynamic results we use.

**Derivation of the governing equations.**
Know (in words) and understand the fundamental laws. Be able to define the Lagrangian and Eulerian perspectives. Be able to state qualitatively the steps taken in deriving the fundamental laws and why they are taken. Know the assumptions made in deriving each equation. Be able to state precisely what the Reynolds transport theorem does. Understand the terms in the Eulerian forms of the equations of motion

**1D steady flow**
Know, precisely, what is meant by 1D flow, and when this assumption is valid. Know the algebraic form of the governing equations that apply to 1D flow ($puA = \text{const.}$, $h + u^2/2 = \text{const.}$ and $p + pu^2 = \text{const.}$) and be able to state precisely the assumptions that each one implies. Know how the equation for the speed of sound ($a^2 = \gamma RT$) is obtained from these equations. Know the significance of the momentum equation in 1D isentropic flow and 1D constant area flow, and how to use it to calculate the force exerted by a flow. Know the various forms of the energy equation in terms of stagnation or critical properties (including $A^*$), and when precisely these are valid. Know precisely the role of the various stagnation and critical quantities, the forms of the energy equation that use them, and when they are constant. Know qualitatively how all flow properties vary as a function of streamtube or duct area in isentropic flow. Be able to state precisely what is meant by choked flow. Understand fully the operation of converging and converging-diverging nozzles (including typical pressure and Mach number distributions in them) and precisely what is meant by the design condition, overexpanded, underexpanded and choked flow, shock in nozzle etc. Be able to compute the flow in a given nozzle, and be able to solve the full range of converging and converging-diverging nozzle problems, except for the shock in nozzle case. Be able to compute the range of back pressures that will produce subsonic flow, choked flow, the design condition, underexpanded flow and that bracket the combined pressure ranges for over expanded and shock in nozzle flow.

**Normal shock waves**
Be able to state the various properties of shock waves. Be able to state the origin of the Rankine Hugoniot relations. Know what happens to the Mach number, all the flow variables, thermo variables, stagnation and critical properties across a normal shock (do they go up, down or stay same). Know why shocks cannot accelerate flows from subsonic to supersonic speed.

**Homeworks, class examples and Tables**
Know how to do the homeworks (1 and 2) and the class examples and variations under test conditions. *Some of the test questions are likely to be quite similar to class examples or homeworks.* Solutions to the homeworks will be posted on the web. Know how to use the NACA 1135 tables to perform all isentropic flow calculations.