EML 4421 Homework #3 due Feb 2

1. Show that by using energy equation $c_p T_O = c_p T + \frac{U^2}{2}$, one can obtain the following relationships for an isentropic 1-D acceleration process:
$\frac{T_O}{T} = \left[1 + \frac{\gamma - 1}{2} M^2\right], \frac{\rho_O}{\rho} = \left[1 + \frac{\gamma - 1}{2} M^2\right]^{1/(\gamma-1)}$, and $\frac{P_O}{P} = \left[1 + \frac{\gamma - 1}{2} M^2\right]^{\gamma/(\gamma-1)}$.

2. A pitot-static tube is usually being used to measure the air speed for an incompressible flow. If the compressibility effect is neglected, the following formula can be used to relate the velocity to the pressure difference between the stagnation and the local static pressures: $U = \sqrt{\frac{2(p_O - p)}{\rho}}$. Determine the error incurred in the estimation of the air speed by neglecting the compressibility effect as a function of the flow Mach number. Define the error as:
$\varepsilon = \left| \frac{\left(U_{actual} - U_{incompressible}\right)}{U_{actual}} \right|$. Plot ε as a function of the Mach number (for γ=1.4). Discuss your observation.