NAME:
AERO 360
Examination 1
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1. Write the x momentum equation in *non-conservative form* for a fluid which is (10)

- one-dimensional
- unsteady
- incompressible
- viscous
- Newtonian

2. For compressible flow with no heat transfer or viscous forces, the *unsteady three-dimensional* energy equation in terms of entropy is

$$\rho \frac{ds}{dt} = 0$$

Use the mass conservation equation, definition of the material derivative, and minor manipulations to cast this version of the energy equation in *conservative form.* (10)

3. Air, assumed calorically perfect ($c_p = 1,004.5 \frac{J}{kg\ K}$) and ideal ($R = 287 \frac{J}{kg\ K}$), flows steadily in a constant area ($A = 0.01\ m^2$) circular duct with an entrance pressure, temperature, and velocity of $P_1 = 300,000\ Pa$, $T_1 = 500\ K$, $u_1 = 100\ \frac{m}{s}$. The duct has a length of $10\ m$. The duct wall (and consequently the flowing fluid inside) is maintained at a *constant temperature* of $500\ K$. Frictional effects give rise to a pressure drop so that at the end of the duct, the static pressure is measured to be $P_2 = 200,000\ Pa$.

a) What is the mass flow rate? (10)

b) What is the Mach number at the entrance? (10)

c) What is the Mach number at the exit? (10)

d) What is the entropy change $s_2 - s_1$? (10)

e) What is the change in stagnation pressure $P_{o2} - P_{o1}$? (5)

f) What is the wall heat flux q_w? (5)

4. Steam with a static pressure and temperature of $P_1 = 1.0\ MPa$, $T_1 = 500°C$ flows in a duct with a velocity of $u_1 = 1,000\ \frac{m}{s}$. What is the stagnation pressure P_o? (For this problem, you *must* use the steam tables; linear interpolations *or* intelligent estimates are acceptable here in determining P_o). (20)

5. Derive the Maxwell relation that corresponds to the Gibbs relation below (10)

$$de = Tds - Pdv$$