Handout Problems:

H6.1 (Chapter 9 - Lift)
An aircraft has a weight of 150,000 lbf. The wing has a planform area of 1650 ft², a span of 108 ft, and a span efficiency factor of 0.92. Assume steady level flight at an altitude of 30,000 ft and speed of 350 mph. Using airfoil data given in Fig. 9.36 of textbook, determine the following:

a. required thrust [lbf] and power [hp] (assume No flaps configuration)
b. minimum take-off speed \( V_o = 1.2V_{stall} \) at sea-level [mph]
c. recalculate b. using Trailing edge slotted flap [mph]
d. recalculate c. at Denver airport [mph]

H6.2 (Thermodynamics review)
Consider an ideal gas with constant specific heats, \( c_p, c_v \) and gas constant, \( R \). The specific volume is \( v = 1/\rho \) and the specific entropy is \( s \). Starting with the \( Tds \) equations (valid for pure, simple compressible substances),

\[
Tds = du + pdv, \quad Tds = dh - vdp
\]

a. Derive the following property relations:

\[
s_2 - s_1 = c_v \ln \frac{T_2}{T_1} + R \ln \frac{v_2}{v_1}, \quad s_2 - s_1 = c_p \ln \frac{T_2}{T_1} - R \ln \frac{p_2}{p_1}
\]

b. Show that the following relations are valid for an isentropic process (where \( k = c_p/c_v \)):

\[
\frac{T_2}{T_1} = \left( \frac{p_2}{p_1} \right)^{\frac{k-1}{k}}, \quad \frac{T_2}{T_1} = \left( \frac{p_2}{p_1} \right)^{\frac{k-1}{k}}, \quad \frac{p_2}{p_1} = \left( \frac{p_2}{p_1} \right)^{k}
\]

c. Using above results and \( T - s \) diagram, show that a constant pressure process where \( T_2 < T_1 \) corresponds to \( s_2 < s_1 \).
d. Using above results and \( T - s \) diagram, show that an isentropic process where \( p_2 > p_1 \) corresponds to \( T_2 > T_1 \).

H6.3 (Thermodynamics review)
Air enters a duct at 130 kPa and 25°C and exits at 150 kPa and 30°C. Assume steady flow and ideal gas with constant specific heats.

a. Evaluate the entropy change, \( s_2 - s_1 \) (kJ/kg K).
b. Plot states 1 and 2 on a \( T - s \) diagram. Be sure to indicate and label all relevant property values including constant pressure lines.
c. Consider the flow to be inviscid. Apply second law of thermodynamics (entropy balance) and determine if heat transfer is occurring. If so, is it heating or cooling? Explain.