1. Define the isentropic efficiency for a compressible flow turbine and compressor.

2. An axial flow air compressor is designed to provide an overall pressure ratio of 8 to 1. At inlet and outlet the stagnation temperatures are 310K and 590K, respectively. Determine the overall isentropic efficiency and the polytropic efficiency for the compressor. Assume that γ for air is 1.4.

3. For a perfect gas expanding through an adiabatic turbine, show that:

   (a) $\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\eta_p \frac{\gamma-1}{\gamma}}$

   (b) $\eta_t = \frac{1-\left(\frac{p_2}{p_1}\right)^{\eta_p \frac{\gamma-1}{\gamma}}}{1-\left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}}}$

4. An axial flow turbine has a small stage efficiency of 86%, an overall pressure ratio of 4.5 to 1 and a mean value of γ equal to 1.333. Calculate the overall turbine efficiency (or isentropic efficiency).

5. Air is expanded in a multi-stage axial flow turbine, the pressure drop across each stage being very small. Assuming that air behaves as a perfect gas with ratio of specific heats γ, derive pressure-temperature relationships for the following processes:

   (a) reversible adiabatic expansion;

   (b) irreversible adiabatic expansion, with small stage efficiency η_p ;

   (c) reversible expansion in which the heat loss in each stage is a constant fraction k of the enthalpy drop in that stage;

   (d) reversible expansion in which the heat loss is proportional to the absolute temperature T. Sketch the first three processes on a T, s diagram.