1.(25%) Define or describe the following:

(a) Quasi-equilibrium process
(b) Critical state
(c) Generalized compressibility chart
(d) Joule-Thomson coefficient
(e) Clausius inequality

2.(25%) Starting from the basic laws of thermodynamics,

(a) show that the reversible steady flow mechanical work is $-\int v\,dp$, when the changes of kinetic and potential energy can be neglected..Where v and p denote the volume and pressure,respectively.

(b) derive the Bernoulli's equation for an incompressible flow in a duct or a pipe.

3. (30%)

...ar automotive engine ...esign, the cylinder contains ... a pressure of 5×10^5 N/m² and a temperature of 1600 K at the end of the power stroke just prior to the opening of the exhaust valve. If the atmosphere is at a pressure of 10^5 N/m² and a temperature of 300 K, calculate the maximum useful work transfer that could be extracted from each kg of this "waste" gas. Assume that the gas can be modeled as an ideal gas with $R = 0.287$ kJ/kgK and $c_v = 0.716$ kJ/kgK.

4. (20%)

Sketch the paths followed on the T–s diagram by each of the following reversible processes in an ideal gas. The important aspects of the paths are the slope dT/ds and the curvature of the path.

(a) Constant temperature
(b) Constant volume
(c) Constant pressure
(d) Constant entropy
(e) Constant internal energy

5. A metallic wire of initial length L_o and cross-section area A is stretched. Assuming elastic behavior, determine the work done in terms of the modulus of elasticity (E) and the strain (ϵ). (10%)

6. Show the first law of thermodynamics for the steady-state, steady-flow process and the uniform-state, uniform-flow process. Explain the physical meaning. (10%)