1. (a) Compare the work done for a process from P_1 to P_2 under isothermal, adiabatic and polytropic processes. Which process does more work? Why?
   (b) A piston-cylinder device, with a set of stops on the top, initially contains 10kg of air [C_p = 1.0 kJ/(kg °C)] at 350 kPa and 300°C. Heat is now transferred to the air, and the piston rises until it hits the stops, at which point the volume is three times the initial volume. More heat is transferred until the pressure inside the cylinder is doubled. Please determine the work done, the amount of heat transfer and the entropy change for this process.
   (c) Show the process on a p-v diagram. What kind of the thermodynamic process it may undergo. (20%)

2. (a) Does the temperature in the Clausius inequality relation have to be absolute temperature? Why?
   (b) A pendulum 3 m long consists of a 10 kg mass at the end of a thread. The pendulum is held in a horizontal position on a warm day (300K). It is released, it swings, and it eventually comes to rest. Please calculate (1) $\Delta U_{pendulum}$ (2) $\Delta U_{surroundings}$ (3) ΔU_{total} (4) $\Delta S_{pendulum}$ (5) $\Delta S_{surroundings}$ (6) ΔS_{total} (15%)

3. A well-insulated, thin-walled, counter-flow heat exchanger is to be used to cool oil [C_p = 2.20 kJ/(kg °C)] from 200 °C to 40 °C at a rate of 3kg/s by water [C_p = 4.18 kJ/(kg °C)] that enters at 20 °C at a rate of 2 kg/s. The diameter of the tube is 2.5cm, and its length is 10 m. Please calculate (a) the rate of heat transfer and (b) the rate of exergy destruction in the heat exchanger. (15%)

(背面仍有題目,請繼續作答)

Prob. 4 (17%) Using T-s diagram, please (1) explain the assumptions for an ideal Rankine cycle, and (2) indicate the paths and purposes for superheat, reheat, and regenerative modifications of the cycle.

Prob. 5 (17%) Explain why the back work ratio of vapor power cycles is much lower than that of gas turbine cycles, and why the gas turbine cycles can still possess thermal efficiencies equivalent or even higher than that of vapor power cycles.

Prob. 6 (16%) Please illustrate the physical meanings (basic analogies) of the two equations

$$\begin{bmatrix} \textit{exergy transfer} \\ \textit{accompanying heat} \end{bmatrix} = \int_1^2 \left(1 - \frac{T_0}{T_b}\right) \delta Q$$

and $$\begin{bmatrix} \textit{exergy transfer} \\ \textit{accompanying work} \end{bmatrix} = [W - p_0(V_2 - V_1)]$$

for the exergy analysis, where Q is the amount of energy by heat interaction across the system's boundary and V is the volume of the system.