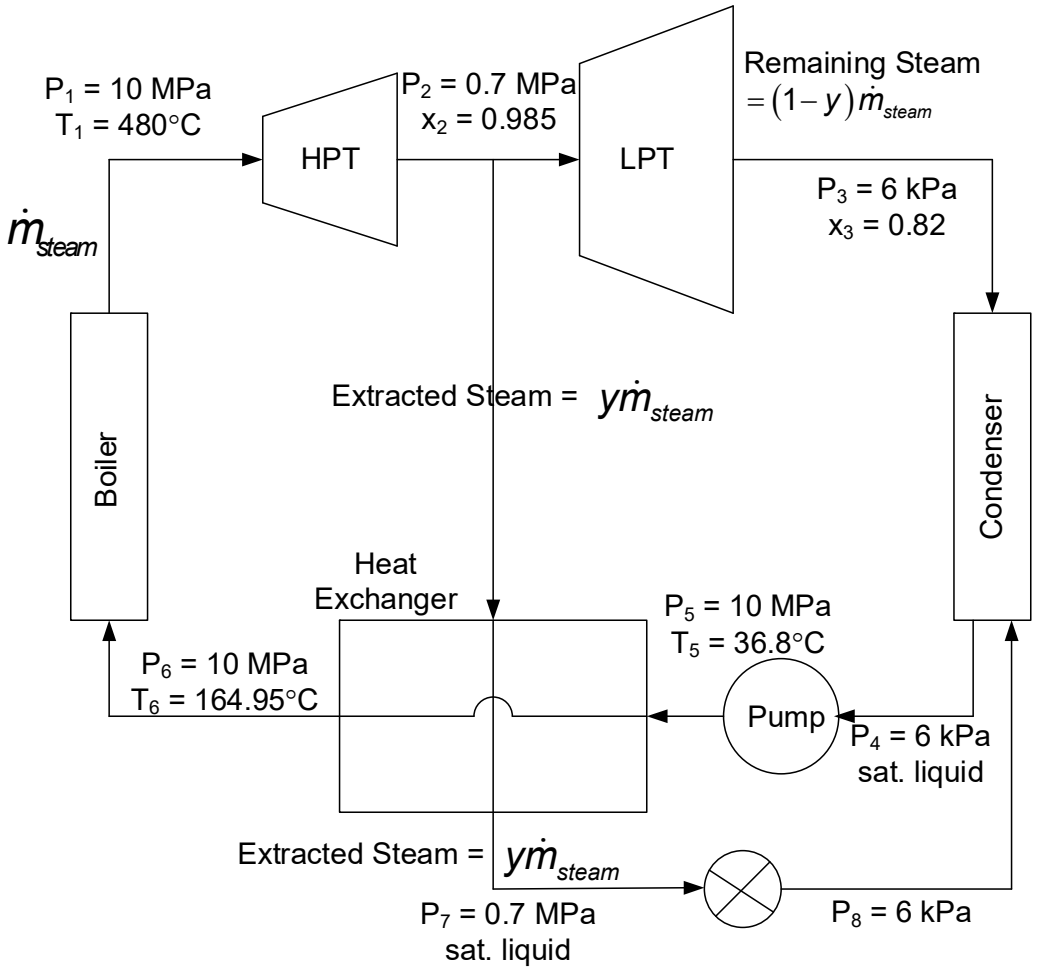
Textbook Reading: 2.6, 4.1-4.11

HW – 17

A power cycle operating steadily is shown below. The boiler (a heat exchanger to boil liquid water) produces steam at an absolute pressure of 10 MPa and a temperature of 480°C (State 1). Steam leaving the boiler enters a high-pressure turbine (HPT) and expands to an absolute pressure of 0.7 MPa and a quality of 98.5% (State 2). A fraction of the steam (y) is extracted at State 2 and the remaining fraction of the steam (1 – y) at State 2 expands in a low-pressure turbine (LPT) to an absolute pressure of 6 kPa and a quality of 82% (State 3). Steam leaving the LPT is cooled in a condenser and exits as saturated liquid at an absolute pressure of 6 kPa (State 4). Saturated liquid water leaving from the condenser is pumped to an absolute pressure of 10 MPa and a temperature of 36.8°C (State 5) in a pump. Liquid leaving the pump (State 5) is heated using the extracted steam (State 2) in a rigid and well-insulated heat exchanger to an absolute pressure of 10 MPa and a temperature of 164.95°C (State 6) and is supplied to the boiler. Extracted steam (State 2) exits the heat exchanger as saturated liquid at an absolute pressure of 0.7 MPa (State 7) and is throttled to an absolute pressure of 6 kPa (State 8) feeding into the condenser. Assume that both turbines and pump are adiabatic.



(a) Determine the fraction of steam (y) extracted at State 2.
(b) Find specific work (per unit mass flow rate leaving the boiler) for the HPT and LPT, in kJ/kg.
(c) Calculate specific work (per unit mass flow rate leaving the boiler) for the pump, in kJ/kg.
(d) Find specific heat transfer for the boiler, in kJ/kg.
(e) Calculate specific heat transfer (per unit mass flow rate leaving the boiler) for the condenser, in kJ/kg.

HW – 18(i) (See HW – 17)

HW-18(i) is based on HW-17. You do not need to repeat the analysis from the previous problem and you can use any needed results.

(a) Calculate thermal efficiency of the cycle only using the net specific work and heat transfer into the cycle (values calculated in HW-17(b), (c), and (d)), in %.
(b) Find thermal efficiency of the cycle only using the net specific heat transfer and heat transfer into the cycle (values calculated in HW-17(d) and (e)), in %.

HW – 18(ii)

A gas contained inside a closed piston-cylinder device undergoes a cycle consisting of the following three processes.

Process 1-2: Constant pressure
Process 2-3: Constant volume cooling
Process 3-1: Compression during which PV = constant

State	P (bar)	V (m^3)	U (kJ)
1	10	0.5	200
2	10	1.0	400
3	5	1.0	200

(a) Draw a P-V diagram showing the three processes. Label states and identify process directions with arrows.
(b) Find the work for each process, in kJ.
(c) Calculate the heat transfer for each process, in kJ.
(d) Determine the thermal efficiency of the cycle, in %.