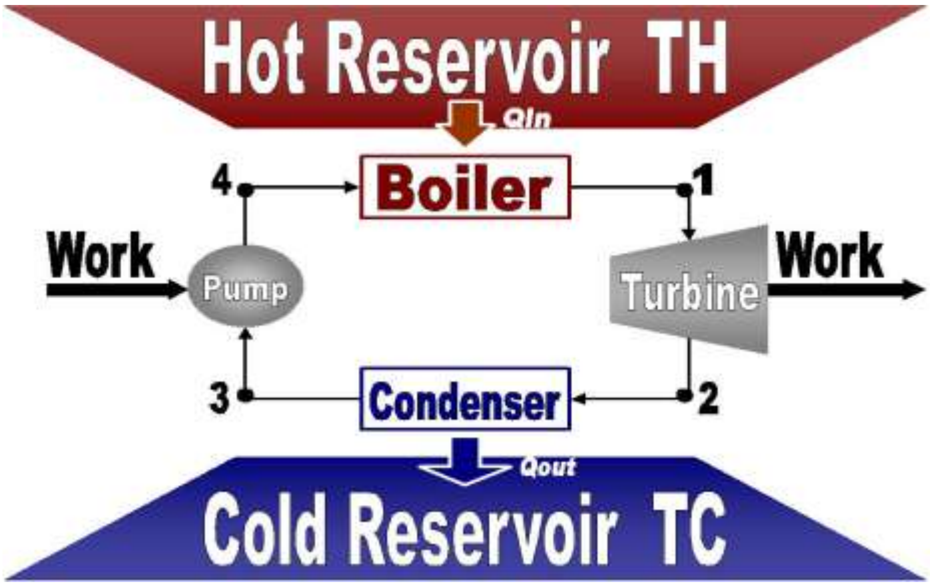
Thermodynamics: Homework A – Set 7
Jennifer West (2004)

Problem 1



Water is the working fluid in a Carnot vapor power cycle. Saturated liquid enters the boiler at a pressure of 18 MPa, and saturated vapor enters the turbine. The condenser pressure is 6 kPa. The flow through the system is **M** kg/s.

M = 1 kg/s

Question 1 of 4:
What is the thermal efficiency (%) of this Carnot cycle?

A. 5.03%
B. 50.9%
C. 101.2%
D. 13.7%
E. 69.6%

Question 2 of 4:
What is the back work ration (%)?

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Question 3 of 4:
What is the net work of cycle in kW?

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Question 4 of 4:
What is the amount of heat transfer from the working fluid passing through the condenser, in kJ/s?

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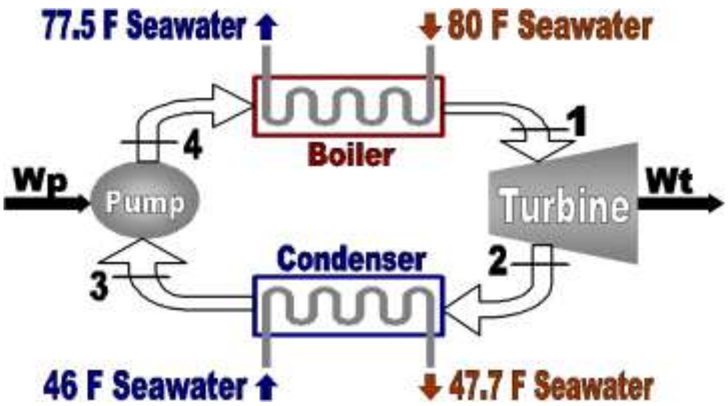
Problem 2



At a particular location in the ocean, the temperature near the surface is 80 °F, and the temperature at a depth of 1500 ft is 46 °F. A power plant based on the Rankine cycle, with ammonia as the working fluid, has been proposed to utilize this naturally occurring temperature gradient to produce electrical power. The power to be developed by the turbine is **Wt** Btu/h. A schematic is illustrated to the left. For simplicity, the properties of seawater can be taken as those of pure water with c = 1.0 Btu/(lbm*R).

Wr = 8.2 x 10^8 Btu/h

Question 1 of 5:
What is the thermal efficiency (%) of a reversible power cycle operating between thermal reservoirs at 80 and 46^{o}F?

A. 1.00%
B. 6.30%
C. 17.6%
D. 39.4%
E. 73.1%

Question 2 of 5:
Estimate the thermal efficiency (%) of the proposed cycle.

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Question 3 of 5:
Estimate the net power output of the plant, in Btu/h, if the pumps used to circulate seawater through the evaporator and condenser heat exchangers require a total power input of 2.55 x 10^8 Btu/h.

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Question 4 of 5:
Determine the seawater flow rate through the condenser, in lb/h.

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Question 5 of 5:
Determine the seawater flow rate through the boiler, in lb/h.

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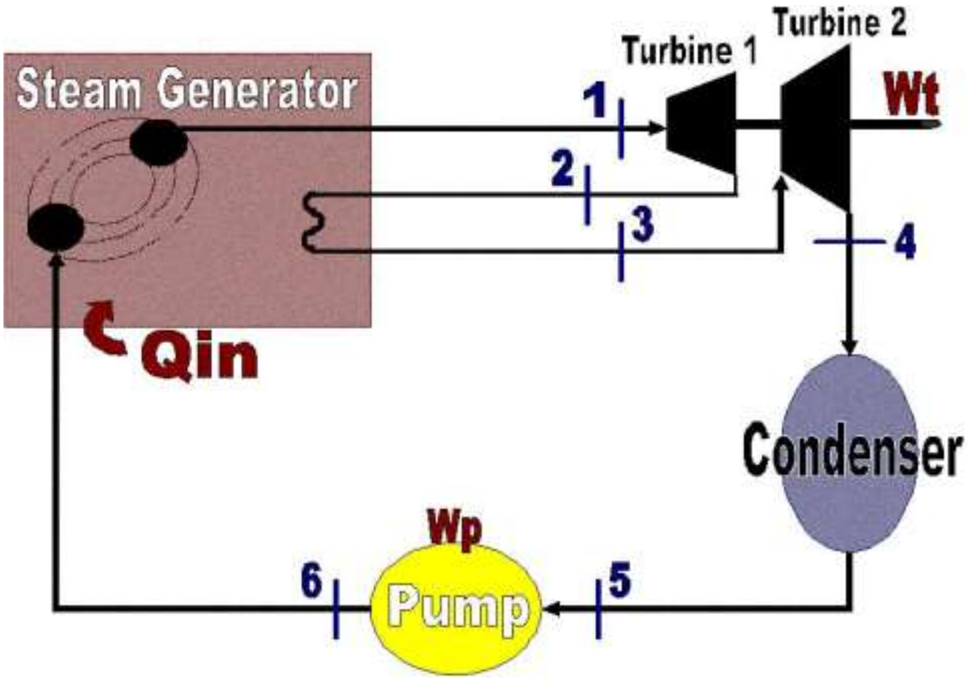
Problem 3



M kg/s of steam at 10 MPa, 600 °C enters the first stage turbine of an Ideal Rankine cycle with reheat. The steam leaving the reheat section of the steam generator is at 500 °C, and the condenser pressure is 6 kPa. The quality of the exit at the second stage turbine is 90 %.

M = 1.0 kg/s

Question 1 of 3:
What is the specific enthalpy (kJ/kg) at point 6, just after the pump?

A. 161.59 kJ/kg
B. 3472.3 kJ/kg
C. 3625.3 kJ/kg
D. 403.51 kJ/kg
E. 3040.5 kJ/kg

Question 2 of 3:
Determine the cycle thermal efficiency (%).

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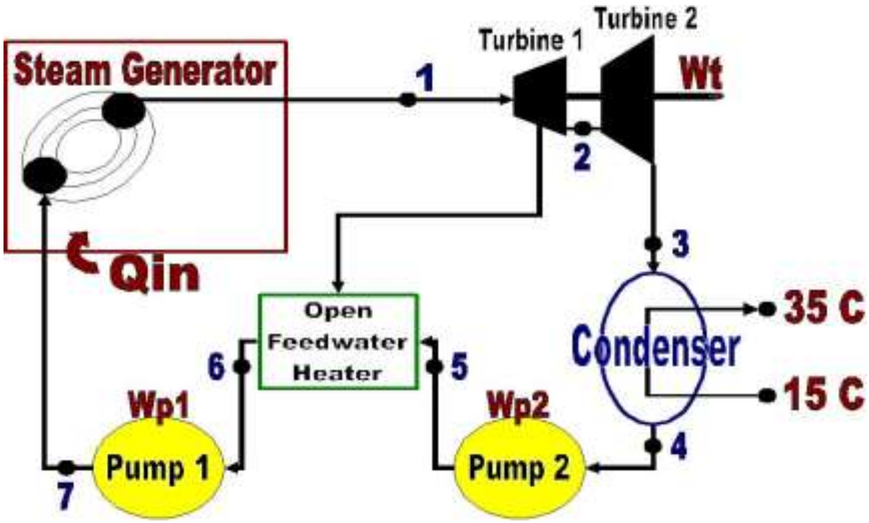
Problem 4



Water is the working fluid in an Ideal Rankine cycle. Superheated vapor enters the turbine at 8 MPa, 480 C. The condenser pressure is 8 kPa The net power output of the cycle is $\mathbf{W_{cycle}}$ MW. There is also an open feedwater heater operating at 0.7 MPa. Saturated liquid exits this feedwater heater at 0.7 MPa.

Problem from Fundamentals of Engineering Thermodynamics, 5th Ed. by Michael J. Moran and Howard N. Shapiro. John Wiley & Sons, Inc. 2004.

W_{cycle} = 100 MW

Question 1 of 4:
What is the fraction of flow extracted at location 2?

A. 0.2036
B. 0.5169
C. 0.1013
D. 0.7654
E. 0.9815

Question 2 of 4:
What is the rate of heat transfer, in kW, to the working fluid passing through the steam generator?

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Question 3 of 4:
What is the thermal efficiency of the process, expressed as a percentage?

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Question 4 of 4:
What is the mass flow rate, in kg/h, of the condenser cooler water if cooling water enters at 15^{o}C and leaves at 35^{o}C?

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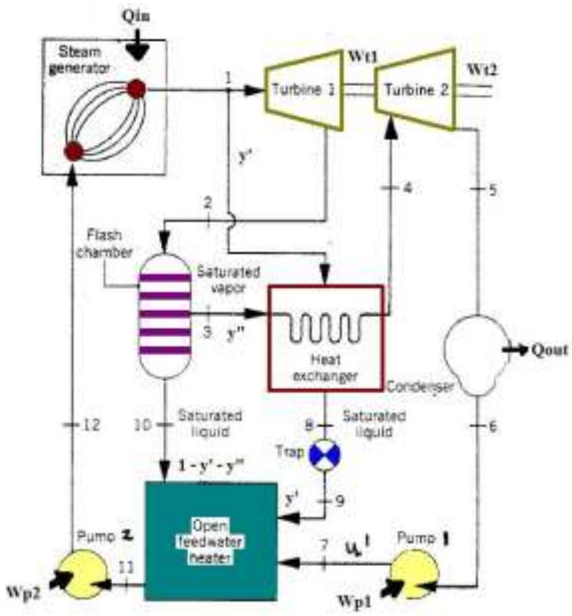
Problem 5



The adjacent figure illustrates a vapor power cycle with reheat and regeneration. The steam generator produces a vapor at 1000 psi, 800 °F. Some of this steam expands through the first turbine stage to 100 psi and the remainder is directed to the heat exchanger. The steam exiting the first turbine stage enters the flash chamber. Saturated liquid and saturated vapor at 100 psi exit the flash chamber as separate streams. The vapor is reheated in the heat exchanger to 530 °F before entering the second turbine stage. The open feedwater heater operates at 100 psi, and the condenser pressure is 1 psi. Each turbine stage has an isentropic efficiency of 88 % and the pumps operate isentropically. The net power output is $\mathbf{W_{cycle}}$ Btu/h.

Problem from Fundamentals of Engineering Thermodynamics, 5th Ed. by Michael J. Moran and Howard N. Shapiro. John Wiley & Sons, Inc. 2004.

W_{cycle}= 5 x 109 Btu/h

Question 1 of 4:
What is the specific enthalpy, in kJ/kg, of the stream at state 5?

A. 1294.2 kJ/kg
B. 1002.5 kJ/kg
C. 958.41 kJ/kg
D. 1379.6 kJ/kg
E. 298.60 kJ/kg

Question 2 of 4:
What is the mass flow rate through the steam generator, in lb/h?

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Question 3 of 4:
What is the thermal efficiency, expressed as a percentage, of the cycle?

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Question 4 of 4:
What is the rate of heat transfer to the cooling water passing through the condenser, in Btu/h?

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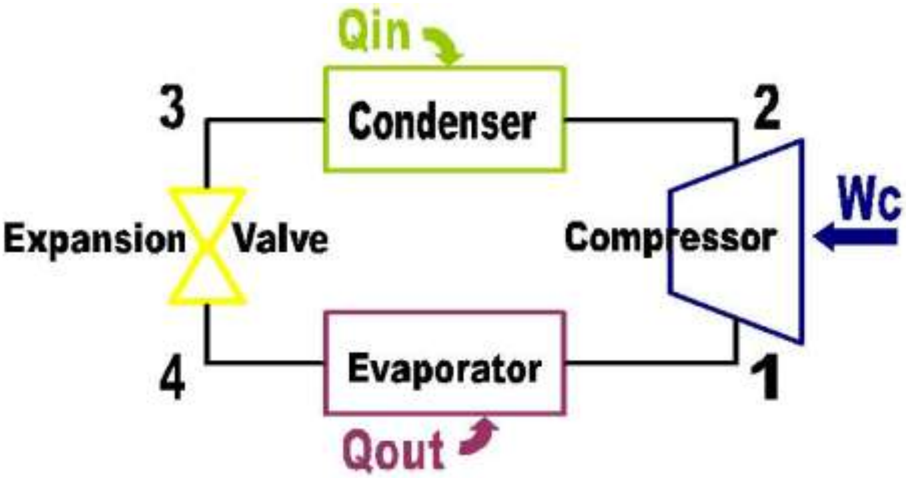
Problem 6



An ideal vapor-compression refrigeration cycle operates at steady-state with Refrigerant 134a as the working fluid. Saturated vapor enters the compressor at -10 °C and saturated liquid leaves the condenser at 28 °C. The mass flow rate of refrigerant is **M** kg/min.

Problem from Fundamentals of Engineering Thermodynamics, 5th Ed. by Michael J. Moran and Howard N. Shapiro. John Wiley & Sons, Inc. 2004.

M = 5 kg/min

Question 1 of 3:
What is the coefficient of performance for the process?

A. 3.62
B. 4.71
C. 5.75
D. 7.93
E. 9.46

Question 2 of 3:
What is the compressor power in kW?

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Question 3 of 3:
What is the refrigerating capacity, in tons?

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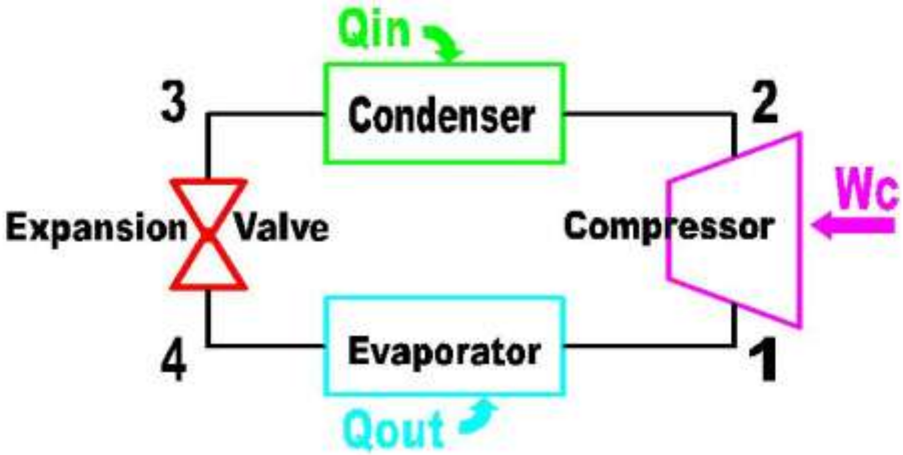
Problem 7



An ideal vapor-compression refrigeration cycle operates at steady-state with Refrigerant 134a as the working fluid. Saturated vapor enters the compressor at 1.6 bar and saturated liquid leaves the condenser at 32 °C. The process has an isentropic compressor efficiency of 80%. The mass flow rate of refrigerant is **M** kg/min.

Problem from Fundamentals of Engineering Thermodynamics, 5th Ed. by Michael J. Moran and Howard N. Shapiro. John Wiley & Sons, Inc. 2004.

M = 5 kg/min

Question 1 of 3:
What is the coefficient of performance for this process?

A. 1.017
B. 9.542
C. 6.510
D. 3.212
E. 7.459

Question 2 of 3:
What is the compressor power, in kW?

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Question 3 of 3:
What is the refrigerating capacity, in tons?

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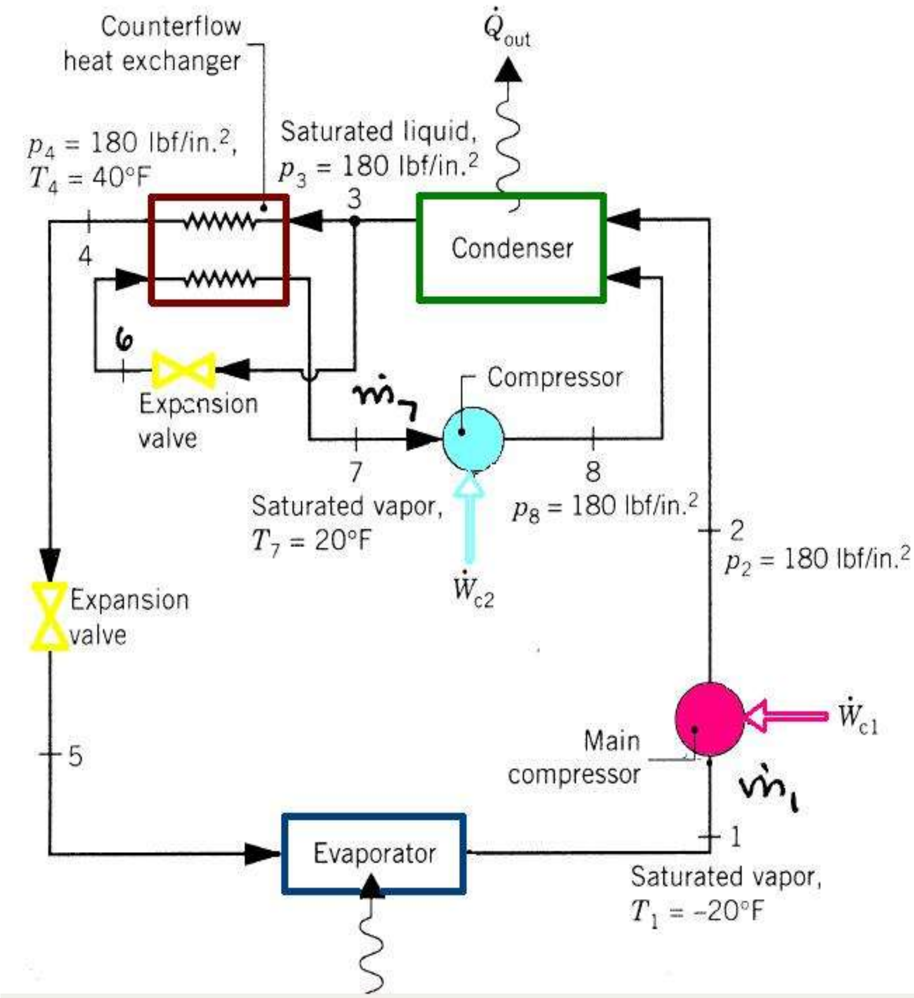
Problem 8



The figure shows a Refrigerant-22 vapor-compression refrigeration system with mechanical subcooling. A counterflow heat exchanger subcools a portion of the refrigerant leaving the condenser below the ambient temperature as follows: Saturated liquid exits the condenser at 180 psi. A portion of the flow exiting the condenser is diverted through an expansion valve and passes through the counterflow heat exchanger with no pressure drop, leaving as saturated vapor at 20 °F. The diverted flow is then compressed isentropically to 180 psi and reenters the condenser. The remainder of the flow exiting the condenser passes through the other side of the heat exchanger and exits at 40 °F, 180 psi. The evaporator has a capacity of **Qin** tons and produces – 20 °F saturated vapor at its exit. In the main compressor, the refrigerant is compressed isentropically to 180 psi.

Problem from Fundamentals of Engineering Thermodynamics, 5th Ed. by Michael J. Moran and Howard N. Shapiro. John Wiley & Sons, Inc. 2004.

Qin = 50 tons

Question 1 of 3:
What is the specific enthalpy of stream 8?

A. 118.54 Btu/lb
B. 35.95 Btu/lb
C. 102.50 Btu/lb
D. 21.66 Btu/lb
E. None of the above

Question 2 of 3:
What is the mass flow rate of stream 7, into the compressor, in lb/min?

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Question 3 of 3:
What is the coefficient of performance?

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