Homework – Week #9 | **ME 200 – Thermodynamics I** | Due by 11:59 p.m. EDT
Submit on Gradescope | | on March 20, 2023

Textbook Reading 5.1-5.9, 6.1, 6.2

You should show all appropriate reservoirs and depict the relevant energy flows (heat transfer and work) between them, through power cycle/refrigeration cycle/heat pump cycle, with correct directions as system diagrams for HW-22 and HW-23.

HW – 22(i)

Consider three different power cycles each receiving 1000 kJ energy input by heat transfer from a reservoir at 500 K. Cycle A rejects 600 kJ by heat transfer to a reservoir at 200 K, cycle B rejects 600 kJ by heat transfer to a reservoir at 300 K, and cycle C rejects 600 kJ by heat transfer to a reservoir at 400 K.

Determine if each power cycle is irreversible or reversible or impossible. Explain why.

HW – 22(ii)

A power cycle receives heat transfer from a hot reservoir and heat transfer at the rate of 10 kW occurs from the power cycle to a reservoir at 300 K. All the power produced by the power cycle is used for operating a reversible heat pump at steady state. The heat pump operates between reservoirs at 270 K and 300 K. There is heat transfer at the rate of 150 kW from the heat pump to the reservoir at 300 K.

(a) Find the thermal efficiency of the power cycle, in %.
(b) Determine the required hot reservoir temperature if the power cycle is reversible, in K.

HW – 23(i)

A heat pump cycle operates continuously over a week at steady state to heat a space that is at a constant temperature of 23°C. The heat pump receives energy by heat transfer from a ground source at 5°C while discharging energy by heat transfer to the space at a constant rate of 120,000 kJ/hr. The heat pump consumes 700 kW-hr of electricity over the week and the cost of electricity is $0.15/kW-hr.

(a) Determine the total heat transfer into the heat pump from the ground source, in kJ.
(b) Calculate the coefficient of performance of the heat pump.
(c) Find the cost of operating the heat pump for one week, in $.
(d) Determine the ratio of the actual to maximum coefficient of performance of the heat pump.

HW – 23(ii)

Two irreversible refrigeration cycles operating at steady state are arranged in series. Cycle A removes energy by heat transfer at the rate of 450 W from a cold space at -20°C and has a coefficient of performance of 2.5. Energy by heat transfer rejected from cycle A is supplied to cycle B which operates with a power input of 250 W. Cycle B rejects energy by heat transfer to the environment at 20°C.

(a) Calculate the power input of cycle A, in W.
(b) Find the coefficient of performance of cycle B.
(c) Determine the rate of heat transfer to the environment, in W.

HW – 24(i) (See HW – 8(i))

Complete the following table for propane. You do not need to include system diagram, assumptions, and basic equations for this problem.

State	*P*, bar	*T*, °C	*v*, m^3/kg	*s*, kJ/kg-K	*x*	Phase
a		20			1	
b		20		1.2066		
c	1	40				
d	10		0.0019393			

HW – 24(ii)

Determine whether the following statements are true or false with appropriate justification. You do not need to include system diagram, assumptions, and basic equations for this problem.

(a) An ideal gas expanding isothermally in a frictionless piston-cylinder system and producing work equal to heat transfer violates the second law of thermodynamics.
(b) A throttling process is internally reversible.
(c) A reversible power cycle with a thermal efficiency of 100% violates the first law of thermodynamics.
(d) A reversible power cycle with a thermal efficiency of 100% violates the second law of thermodynamics.