Due: 3/29/2020 at 9:00 pm through Courseweb

MEMS 0051
Spring 2020
Midterm #2
3/27/2020

Name (Print): ____________________________

This exam contains 10 pages (including this cover page) and 4 problems. Check to see if any pages are missing. Enter all requested information on the top of this page, and put your initials and the date on the top of every page, in case the pages become separated. The following rules apply:

- You may use your notes, your book, EES and MATLAB. You may also use online thermodynamic property calculators, however EES is recommended.
- All work must be done on the test sheets. If you need more room, please note that you have added an additional sheet. Number that additional sheet, initial and date.
- If you use EES for determination of properties, please note so. However, if the values are wrong, you will receive no credit.
- If you use MATLAB to solve for a system of equations, please email your script to mmb49@pitt.edu with the subject "MEMS 0031 Midterm 2 Script".
- All work must be substantiated by the work preceding it. A result with no methodology and no mathematics will be marked incorrect.
- Do not write in the table to the right.

Problem	Points	Score
1	15	
2	20	
3	25	
4	40	
Total:	100	

Academic Integrity Statement:

I hereby attest that I have received no assistance (from a friend, from an on-line resource, etc.), and that I have provided no assistance, during this exam. All the work presented within is solely my own work.

Signature: ____

Date: ___________________________

Problem #1

1. (15 points) An inventor published the following data from an experiment of a power cycle, where the hot-side temperature reservoir was 527 °C, and the cold-side temperature reservoir was 27 °C. For each of the following scenarios, determine if there is a violation of the 2$^{\text{nd}}$ Law, and if so, identify which statement:

   (a) (5 pts.) Q_H=700[kJ], Q_L=300 [kJ], W=400 [kJ]

2. (5 pts.) Q_H=640[kJ], Q_L=240 [kJ], W=400 [kJ]

3. (5 pts.) Q_H=640[kJ], Q_L=200 [kJ], W=400 [kJ]

Problem #2

2. (20 points) A refrigerator with β=4.5 receives 0.8 [kW] of electrical power. The heat rejected from the refrigerated space occurs within the condenser; the condensation process occurs at 28 °C. The temperature of the surroundings is of 20 °C. Determine the following:

   (a) (7.5 pts.) The rate at which energy is rejected to the surroundings;

(b) (7.5 pts.) The lowest theoretical temperature of the cold-side temperature reservoir (i.e. the refrigerated space);

(c) (5 pts.) The maximum theoretical power (in [kW]) that a waste-heat recovery device could produce when operating between the condenser and surroundings.

Problem #3

3. (25 points) A Carnot refrigeration cycle, using 0.1 [kg] of air as the working fluid, removes heat from the low-temperature reservoir at a temperature of -23 °C. The quantity of heat removed during this process is 3.4 [kJ]. Heat is then rejected to the high-temperature reservoir, which exists at a temperature of 27 °C. The volume at the end of the heat rejection process is 0.01 [m^3]. Determine/complete the following:

   (a) (10 pts.) Draw the $P-\nu$ and $T-s$ diagram of this cycle, labeling each state (with proper P, ν, T and s values) and process between states;

(b) (15 pts.) The work associated with each of the four processes. Units to be reported in [kJ].

Problem #4

4. (40 points) Consider 1 [kg] of air, which is initially treated as an Ideal gas. The air undergoes a reversible process from an initial state, where the pressure is 100 [kPa] and the temperature is 298.15 [K], to a final state where the pressure is 1,200 [kPa]. If the work put into the system is 200 [kJ], determine the following:

   (a) (20 pts.) The final temperature at State 2;

(b) (10 pts.) The change of entropy between the final and initial state, using Table A.6; using the following formulation:

$$ds = \int_{T_1}^{T_2} \frac{C_{P0}}{T}\, dT - R\ln\left(\frac{P_2}{P_1}\right)$$

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(b) (10 pts.) The change of entropy between the final and initial state, using Table A.7.1: