

ROY G. PERRY COLLEGE OF ENGINEERING
MECHANICAL ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY

ASSESSMENT REPORT COVER PAGE

MCEG 2013/2301 THERMODYNAMICS I

FALL 2021 SEMESTER

NAME OF INSTRUCTOR: Dr. Paul O. Biney

TABLE OF CONTENTS

1. **Report Cover Page**
2. **Detailed Course Syllabus**
3. **End of Semester Outcomes Assessment Report**
4. **Grade Sheet Showing Student and Class Performance in Outcomes**
5. **Supporting Outcomes Specific Assignments**

5.1	Assignments assessing students' ability to to design a system, component, or process to meet desired needs (outcome "c")
-----	--

5.2	Assignments assessing students' ability to identify, formulate, and solve engineering problems (Outcome "e")
-----	---

5.3 Assignments assessing students' ability to to communicate effectively, both written and orally (outcome g).

Detailed Course Syllabus
(Distributed to Students at the beginning of the Semester)
ABET Outcomes measured using course should be
explicitly listed in the syllabus

Course Description in ABET Format

1.	Course number and name:	MCEG 2301 [2013] Thermodynamics I
2.	Credits and contact hours:	3 credit hours; 3 contact hours
3.	Instructor's or course coordinator's name:	Dr. Paul O. Biney
4.	Text book: Title:	Thermodynamics: An Engineering Approach, 9 th edition, 2018, McGraw Hill: ISBN 978-1-259-82267-2.
	Author:	Yunus Cengel, Michael A. Boles & Mehmet Kanoglu,
	Publisher, Year & Edition:	McGraw Hill, 2018
	a. Other Supplemental material	Fundamentals of Engineering Thermodynamics, 7th edition M. J. Moran, H. N. Shapiro, D. D. Boettner and M.B. Bailey ISBN-10: 0470495901 ISBN-13: 978- 0470495902
5.	Specific course information	
	a. Brief description of the content of the course (catalog description)	First Law, transformation of energy, theoretical limitations, Second Law, absolute temperature, entropy, and available energy, properties of gases, liquids, and vapors, and irreversibility.
	b. Prerequisites or	MATH 2414 [2024]* and PHYS 2325 [2513].
	Co-requisites	None
	c. **Indicate whether a required, elective, or selected elective (as per definition provided) course in the program	Required
6.	a. Specific goals for the course specific outcomes of instruction (e.g. The student will be able to explain the significance of current research about a particular topic.)	b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.
	Given a complex engineering problem, students will be able to :	The specific goals for the course specific outcomes listed on the left column will address the following student learning outcomes:
	1. Identify and Formulate engineering/technical/computing problems using principles of engineering/mathematics/science	
	Given an engineering problem, the students are able to:	
	i. Understand the given problem and identify the subject area and concepts involved.	
	ii. Convert the problem into a well labeled sketch (such as free body diagram, flow chart, functional block diagram, schematic diagram).	
	iii. Formulate the engineering problem into a mathematical model [using basic, intermediate and advanced mathematics ranging from algebra & trigonometry, calculus, probability & statics, complex analysis to Fourier transform & LaPlace transforms] or experimental framework stating all relevant assumptions.	
	iv. Formulate the engineering problem into an engineering model [using relevant laws and equations from engineering and science areas) stating all relevant assumptions.	
	2. Solve the problems	
	Given an engineering problem that has been formulated, students are able to:	

Non ABET Outcome (8)
An ability to identify, formulate, and solve **engineering problems** by applying principles of engineering, science, and mathematics.

- i. Solve the resulting engineering/mathematical/science formulations analytically, numerically, experimentally or through the use of appropriate software or computer program.
- ii. Evaluate and interpret the result.

7 **Brief list of topics to be covered**

Introduction and Basic Concepts	5 hrs
Energy, Energy Trans-fer, and General Energy Analysis	4 hrs
Properties of Pure Substances	5 hrs
Energy Analysis of Closed Systems	4 hrs
Mass and Energy Analysis of Control Volumes	7 hrs
The Second Law of Thermodynamics	5 hrs
ENTROPY & Principle of Increase of Entropy	5 hrs
Fuels, combustion, first and second law analysis of reacting systems	4 hrs
Detailed Design – Analysis and Refinement and application to project	5 hrs

***Course numbers in bracket are the old course numbers**

****Required** courses are required of all students in the program, **elective** courses (often referred to as open or free electives) are optional for students, and **selected elective** courses are those for which students must take one or more courses from a specified group. **Please hide all of the row and column lines when done.**



**MECHANICAL ENGINEERING DEPARTMENT
MCEG 2301 Thermodynamics I
Fall 2021 Semester**

Instructor:	Dr. Paul O. Biney
Section # and CRN:	Lecture Section P01: CRN 16910; Recitation Section P81: CRN 16914
Office Location:	C.L. Wilson Engineering Building, Room 102B
Office Phone:	936-361-9842
Email Address:	pobiney@pvamu.edu
Office Hours:	Mondays: 2:00 – 5:00 PM; Wednesdays: 2:00 PM – 5:00 PM; Other times by appointment
Mode of Instruction:	Face to Face
Course Location:	New Electrical Engr Bldg Room 115 for Section P01 S.R. Collins Engr Tech Bldg Room 224 for Recitation Section P81
Class Days & Times:	P01: TR 8:00 – 9:20 AM; P81: T 5:00 – 5:50 PM
Catalog Description:	MCEG 2301 Thermodynamics I: 3 semester hours. First Law, transformation of energy, theoretical limitations, Second Law, absolute temperature, entropy, and available energy, properties of gases, liquids, and vapors, and irreversibility.
Prerequisites:	MATH 2414 OR MATH 2024 and PHYS 2325 OR PHYS 2513
Co-requisites:	None
Required Text(s):	Thermodynamics: An Engineering Approach, 9 th edition, Yunus Cengel, Michael A. Boles & Mehmet Kanoglu, 2018, McGraw Hill: ISBN 978-1-259-82267-2.
Recommended Text(s):	

Student Learning Outcomes:

	Upon successful completion of this course, students will be able to:	Student Learning Outcome # Alignment	Core Curriculum Outcome Alignment
1	Define thermodynamics, closed and open systems, control volume, steady and unsteady processes	8	Empirical and Quantitative Skills
2	Apply both the SI and English system of units	8	
3	Define and describe properties of a system such as temperature, pressure, density specific volume, internal energy, enthalpy and entropy	8	
4	Define and discuss the concepts of heat, work, and other forms of energy	8	
3	Determine the properties of a pure substance from thermodynamic tables	8	
4	Discuss the physics of phase change processes and illustrate P-v, T-v, P-T, property diagrams and P-v-T surfaces of pure substances	8	
5	Describe the ideal gas law and apply it to solve thermodynamics problems and use the compressibility chart for non ideal gases.	8	
6	Apply the First Law of Thermodynamics to closed and open systems undergoing both steady and unsteady processes	8	
7	Apply the first law to real systems such as nozzles & diffusers, compressors and pumps, boilers and condensers, heat exchangers, the steam power plant, the refrigeration and other engineering systems.	8	
8	Explain the 2 nd Law of Thermodynamics	8	
9	Identify valid processes as those that satisfy both the first and second laws of thermodynamics.	8	
10	Define and discuss thermal energy reservoirs, reversible and irreversible processes, heat engines, refrigerators, and heat pumps	8	
11	Analyze and solve problems involving Carnot and real heat engines, refrigerators and heat pumps.	8	
12	Describe the Kelvin–Planck and Clausius statements of the second law of thermodynamics	8	
13	Define and explain what entropy is	8	
14	Find the entropy change of real substances from available tables and compute the entropy change for ideal gases.	8	
15	Define isentropic process and efficiency and analyze non isentropic devices .	8	
16	Perform entropy balance and determine the irreversibility of different processes.	8	
17	Analyze a process to determine if the process is possible, impossible, or reversible as described.	8	

Add other objectives or specialized accrediting agency requirements as needed.

How Mechanical Engineering Courses meet Department Objectives & ABET Criterion 3

Specific objectives of the Mechanical Engineering Program are to produce graduates who will:

1. have the necessary knowledge and skills to enable them have successful careers in mechanical engineering and related fields;
2. have leadership skills to advance their careers through increasing levels of responsibilities and leadership;
3. have the necessary educational background to successfully pursue graduate or advanced professional degrees and continuing professional development, and
4. actively participate in professional and community services.

ABET Criterion 3: Program Outcomes and Assessment

Engineering Programs must demonstrate that their graduates have:

Outcome	New Student Learning Outcome
1	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (including use of the techniques, skills, and modern engineering tools necessary for engineering practice)
2	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factor (including use of the techniques, skills, and modern engineering tools necessary for engineering practice). Partly covered in the course but not assessed in this course
3	An ability to communicate effectively with a range of audiences

4	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6	An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions (including use of the techniques, skills, and modern engineering tools necessary for engineering practice)
7	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies
8	An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics

Assessment Matrix

	MCEG Courses	ABET EAC Student Outcomes 1-7							
		Fall 2018	Spring 19	Fall 2019	Spring 2020	Fall 2020	Spring 2021	Fall 2021	Spring 2022
	1021 Mech. Drawing & Desg.	2	2	2	2	2SACS		2SACS	
	2013 Thermodynamics I	8SACS	8SACS	8SACS	8SACS	8SACS		8SACS	
	2023 Materials Sci/Engr.	8SACS	8SACS	8SACS	8SACS		8SACS		8SACS
	2053 Engineering Mechanics II	8SACS	8SACS	8SACS	8SACS	8SACS		8SACS	
	3011 Measurement Lab	7	6	7	6	7	6	7	6
	3013 Heat Transfer	1		1		2	1	2	1
	3021 Thermal Sci. Lab	6	6	6	6		6		6
	3023 Thermodynamics II	1	1	1	1		2		2
	3031 Manufacturing Lab		2		4		2		4
	3033 Manufacturing Proc		2		4		2		4
	3043 Machine Design I	2		2		2		2	
	3053 Kinematic Design	1		1		1		1	
	3063 Fluid Mechanics	1	6	1	6	1	6	1	6
	4043 Machine Design II	2		2		2		2	
	4063 Dynamic Systems		1		1		1		1
	4093 Finite Element	1		1		1		1	
	4472 Senior Project I	4, 5		4, 5		4, 5		4, 5	
	4482 Senior Project II		2,3,7		2,3,7		2,3,7		2,3,7

Major Course Requirements

Method of Determining Final Course Grade

Course Grade Requirement	Total (%)
1) Homework Assignments (By Group)	10
2) Pre & Post Quiz on class pre-reading assignments and lecture for the class period (PPQ)	30
3) Test 1	15
4) Test 2	15
5) Group Retake of Tests 1 & 2 (Group needs to meet to discuss and solve test problems)	10
6) Test 3	15
Attendance (4%) , TaskStream Assignment Submission (1%)	5
Total:	100

Grading Criteria and Conversion:

A = 90 - 100
 B = 80 - 89
 C = 70 - 79
 D = 60 - 69
 F = 0 - 59

Note: The instructor reserves the right to alter it during the semester

DISABILITY REQUIREMENTS:

Do you have any special needs in this class related to a disability? Any student who has or believes they may have a disability that requires accommodations is advised to contact the Office for Students with Disabilities at 936-857-2610.

IMPORTANT DATES:

Instruction Begins	August 23, 2021
12th Class Day (Census Date)	September 07, 2021
Labor Day	September 06, 2021
Last day to drop course(s) without academic record	September 07, 2021
Automatic grade of "W" begins	September 08, 2021
Mid-Semester Exam Period	October 14-16, 2021
Mid-Semester Grades Due	October 20, 2021
Last day to apply for Fall graduation (ceremony participation)	October 28, 2021
Automatic "W" grade ends	November 01, 2021
Priority registration for continuing students for Spring 2021	November 08-12, 2021
Thanksgiving Holiday	November 25-27, 2021
Last day to apply for Fall graduation (degree conferral only)	December 01, 2021
Last Day for Class	December 01, 2021
Last day to Withdraw from the University for Fall 2021	December 01, 2021
Final Exam Period	December 02 -08, 2021
Final Grades for graduating students due	December 08, 2021
Commencement	December 11, 2021
Final Grades for all students due	December 13, 2021
Winter Break (University Closed)	Dec, 24, 2021 – Dec 31, 2021

Course Procedures or Additional Instructor Policies

Taskstream

Taskstream is a tool that Prairie View A&M University uses for assessment purposes. One of your assignments may be required to be submitted as an "artifact," an item of coursework that serves as evidence that course objectives are met. If applicable, more information will be provided during the semester, but for general information, you can visit Taskstream via the link in eCourses.

Academic Integrity

Academic dishonesty of any sort (plagiarism, cheating, fabrication or facilitation) is prohibited under any circumstance. Any detected actions of dishonesty will cause the failure of the class directly.

Course Policy

Assignments & Due Dates

Homework will be submitted on e-course by the due date and time. Late homework will be charged a 10% penalty for each day late – weekend days do count. Circumstances beyond your control (i.e. illness, computer failure, weather, etc.) will be considered as required.

Examinations & Quizzes

No makeup tests or quizzes will be given. However, there will be one optional make-up test for students who missed T2sta 1 or 2. Other students can take the make-up test to replace Test 1 or Test 2 if they so desire.

Course Attendance

Faculty will record attendance and report absences per the Attendance Reporting schedule as determined by the Office of the Registrar. Students who are sick or who are self-quarantining due to COVID-19 related illnesses or exposure, must not attend in-person class sessions. Students who are feeling sick

should follow PVAMU's COVID guidelines posted at
<https://www.pvamu.edu/coronavirus/>.

Class Seating Charts

Seating charts are encouraged during the pandemic because they assist with contact tracing. Faculty should be prepared to share who attended and where students sat should they be contacted by the COVID-19 campus personnel or by the Operations Center (Ops Center) due to potential positive cases revealed through testing and contact tracing.

THERMODYNAMICS I
TENTATIVE COMBINED COURSE MAP AND CALENDAR
Thermodynamics I is used to assess ABET Student Learning Outcome 8

At the end of this course, students will:

- 8 *Have the ability to identify, formulate, and solve engineering **thermodynamics** problems by applying principles of engineering **thermodynamics**, science, and mathematics*

Week	Date	MODULE # & DESCRIPTION OF MODULE TOPICS	ABET Student Learning Outcomes	LEARNING OBJECTIVES By the end of this module, students will be able to:	Content Delivery Method and Class Type	Learning Assignment & Practice Activities	Due Dates
1	08/24/21	MODULE 1: Introduction and Basic Concepts Discussion of Syllabus and course 1-1 Thermodynamics and Energy 1-2 Importance of Dimensions and Units 1-3 System and Control Volumes	8	1. Identify the unique vocabulary associated with thermodynamics through the precise definition of basic concepts to form a sound foundation for the development of the principles of thermodynamics. 2. Utilize the metric SI and the English unit systems 3. Define and explain the basic concepts of thermodynamics such as system, state, state postulate, equilibrium, process, and cycle. 4. Explain properties of a system and define density, specific gravity, and specific weight. 5. Explain the concepts of temperature, temperature scales, pressure, and absolute and gauge pressure. 6. Apply an intuitive systematic problem-solving technique to thermodynamics problems.	Face to Face PPT, (PPQ) Engr Equation Solver (EES) TPRS	Review posted notes Complete Pre-quiz on class notes Embedded notes Quiz Homework 1	09/09/21
	08/26/21	1-4 Properties of A System 1-5 Density and Specific Gravity 1-6 State and Equilibrium 1-7 Processes and Cycles	8		Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	
2	08/31/21	1-8 Temperature and The Zeroth Law of Thermodynamics 1-9 Pressure 1-10 Pressure Measurement Devices 1-11 Problem-Solving Technique	8		Face to Face PPT, (PPQ) (EES) TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	
	09/02/21	MODULE 2: Energy, Energy Transfer, and General Energy Analysis 2-1 Introduction 2-2 Forms of energy 2-3 Energy Transfer by Heat	8	1. Introduce the concept of energy and define its various forms. 2. Discuss the nature of internal energy. 3. Define the concept of heat and the terminology associated with energy transfer by heat. 4. Define the concept of work, including electrical work and several forms of mechanical work. 5. Introduce the first law of thermodynamics, energy balances, and mechanisms of energy transfer to or from a system. 6. Determine that a fluid flowing across a control surface of a control volume carries energy across the control surface in addition to any	Face to Face PPT, (PPQ) (EES) TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz Homework 2	09/21/21
3	09/07/21	2-4 Energy transfer by work 2-5 Mechanical forms of work	8		Face to Face PPT, (PPQ) (EES) TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	
	09/09/21	2-6 The first law of thermodynamics 2-7 Energy Conversion Efficiencies	8		Zoon PPT	Review posted notes Pre-quiz on class notes	Hwk 1 Due

Week	Date	MODULE # & DESCRIPTION OF MODULE TOPICS	ABET Student Learning Outcomes	LEARNING OBJECTIVES By the end of this module, students will be able to:	Content Delivery Method and Class Type	Learning Assignment & Practice Activities	Due Dates
				energy transfer across the control surface that may be in the form of heat and/or work. 7. Define energy conversion efficiencies. Discuss the implications of energy conversion on the environment.	PPQ EES	Embedded notes Quiz	
4	09/14/21	MODULE 3: Properties of Pure Substances 3-1 Pure Substance 3-2 Phases of a Pure Substance 3-3 Phase-Change Processes of Pure Substances 3-4 Property Diagrams for Phase-Change Processes	8	1. Introduce the concept of a pure substance. 2. Discuss the physics of phase-change processes. 3. Illustrate the P-v, T-v, and P-T property diagrams and P-v-T surfaces of pure substances. 4. Demonstrate the procedures for determining thermodynamic properties of pure substances from tables of property data.	Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	Homework 3 09/30/21
	09/16/21	3-5 Property Tables	8	5. Describe the hypothetical substance "ideal gas" and the ideal-gas equation of state. 6. Apply the ideal-gas equation of state in the solution of typical problems.	Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	
5	09/21/21	3-6 The Ideal-Gas Equation of State 3-7 Compressibility Factor—a Measure of Deviation from Ideal-Gas Behaviour 3-8 Other Equations of State	8	7. Introduce the compressibility factor, which accounts for the deviation of real gases from ideal-gas behavior. 8. Present some of the best-known equations of state.	Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	HWK 2 Due
	09/23/21	MODULE 4: Energy Analysis of Closed Systems 4-1 Moving Boundary Work 4-2 Energy Balance for Closed Systems	8	1. Examine the moving boundary work or $P dV$ work commonly encountered in reciprocating devices such as automotive engines and compressors. 2. Identify the first law of thermodynamics as simply a statement of the conservation of energy principle for closed (fixed-mass) systems.	Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	Homework 4 10/12/21
6	09/28/21	4-3 Specific Heats 4-4 Internal Energy, Enthalpy, and Specific Heats of Ideal Gases 4-5 Internal Energy, Enthalpy, and Specific Heats of Solids and Liquids	8	3. Develop the general energy balance applied to closed systems. 4. Define the specific heat at constant volume and the specific heat at constant pressure. 5. Relate the specific heats to the calculation of the changes in internal energy and enthalpy of ideal gases. 6. Describe incompressible substances and determine the changes in their internal energy and enthalpy. 7. Solve energy balance problems for closed	Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	

Week	Date	MODULE # & DESCRIPTION OF MODULE TOPICS	ABET Student Learning Outcomes	LEARNING OBJECTIVES By the end of this module, students will be able to:	Content Delivery Method and Class Type	Learning Assignment & Practice Activities	Due Dates
	09/30/21	TEST 1	8	(fixed-mass) systems that involve heat and work interactions for general pure substances, ideal gases, and incompressible substances.	Zoon PPT PPQ EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	HWK 3 DUE
7	10/05/21	MODULE 5: Mass and Energy Analysis of Control Volumes 5–1 Conservation of Mass	8	1. Develop the conservation of mass principle. 2. Apply the conservation of mass principle to various systems including steady- and unsteady- flow control volumes. 3. Apply the first law of thermodynamics as the statement of the conservation of energy principle to control volumes. 4. Identify the energy carried by a fluid stream crossing a control surface as the sum of internal energy, flow work, kinetic energy, and potential energy of the fluid and to relate the combination of the internal energy and the flow work to the property enthalpy. 5. Solve energy balance problems for common steady-flow devices such as nozzles, compressors, turbines, throttling valves, mixing chambers, and heat exchangers. 6. Apply the energy balance to general unsteady-flow processes with particular emphasis on the uniform-flow process as the model for commonly encountered charging and discharging processes.	Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz Homework 5	10/19/21
	10/07/21	5–2 Flow Work and the Energy of a Flowing Fluid 5–3 Energy Analysis of Steady-Flow Systems	8		Face to Face PPT, Turning Point (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	
8	10/12/21	5.4 -5.4.3 Some Steady-Flow Engineering Devices (Nozzles & Diffusers, Turbines & compressors, Throttling valves)	8		Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	HWK 4 DUE
	10/14/21	5.4.4-5.4.5 Steady-Flow Engineering Devices (Mixing chambers, Heat exchangers, Pipe & duct flow)	8		Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz Hwk 6	10/26/21
9	10/19/21	5.5 Energy Analysis of Unsteady-Flow Processes	8		Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	HWK 5 DUE
	10/21/21	MODULE 6: The Second Law of Thermodynamics 6–1 Introduction to the Second Law 6–2 Thermal Energy Reservoirs 6–3 Heat Engines	8		Zoon PPT PPQ EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz Homework 7	11/04/21

Week	Date	MODULE # & DESCRIPTION OF MODULE TOPICS	ABET Student Learning Outcomes	LEARNING OBJECTIVES By the end of this module, students will be able to:	Content Delivery Method and Class Type	Learning Assignment & Practice Activities	Due Dates
10	10/26/21	6-4 Refrigerators and Heat Pumps 6-5 Perpetual-motion Machines 6-6 Reversible And Irreversible Processes	8	refrigerators, and heat pumps. 4. Describe the Kelvin–Planck and Clausius statements of the second law of thermodynamics. 5. Discuss the concepts of perpetual-motion machines.	Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	HWK 6 DUE
	10/28/21	6-7 The Carnot Cycle 6-8 The Thermodynamic Temperature Scale 6-9 The Carnot Heat Engine 6-10 The Carnot Refrigerator And Heat Pump	8	6. Apply the second law of thermodynamics to cycles and cyclic devices. 7. Apply the second law to develop the absolute thermodynamic temperature scale. 8. Describe the Carnot cycle. 9. Examine the Carnot principles, idealized Carnot heat engines, refrigerators, and heat pumps. 10. Determine the expressions for the thermal efficiencies and coefficients of performance for reversible heat engines, heat pumps, and refrigerators.	Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	
11	11/02/21	MODULE 7: ENTROPY 7-1 Entropy 7-2 The Increase of Entropy Principle 7-3 Entropy Change of Pure Substances	8	1. Apply the second law of thermodynamics to processes. 2. Define a new property called entropy to quantify the second-law effects. 3. Establish and apply the increase of entropy principle. 4. Calculate the entropy changes that take place during processes for pure substances, incompressible substances, and ideal gases. 5. Differentiate a special class of idealized processes, called isentropic processes, and develop the property relations for these processes. 6. Derive the reversible steady-flow work relations. 7. Develop the isentropic efficiencies for various steady-flow devices. 8. Summarize and apply the entropy balance to various systems	Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz Homework 8	11/30/21
	11/04/21	TEST 2	8		Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	HWK 7 DUE
12	11/09/21	7-4 Isentropic Processes 7-5 Property Diagrams Involving Entropy 7-6 What is Entropy?	8		Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	
	11/11/21	7-7 The $T ds$ Relations 7-8 Entropy Change of Liquids and Solids	8		Zoon PPT PPQ EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes	

Week	Date	MODULE # & DESCRIPTION OF MODULE TOPICS	ABET Student Learning Outcomes	LEARNING OBJECTIVES By the end of this module, students will be able to:	Content Delivery Method and Class Type	Learning Assignment & Practice Activities	Due Dates
13	11/16/21	7–9 The Entropy Change of Ideal Gases 7–10 Reversible Steady-flow Work	8		Face to Face PPT, (PPQ) EES TPRS	Quiz Review posted notes Pre-quiz on class notes Embedded notes Quiz	
	11/18/21	7–11 Minimizing the Compressor Work 7–12 Isentropic Efficiencies of Steady-flow Devices Make-Up Test (After Class)	8		Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	
14	11/23/21	7-12 isentropic Efficiency 7–13 Entropy Balance	8		Face to Face PPT, (PPQ) EES TPRS	Review posted notes Pre-quiz on class notes Embedded notes Quiz	
	11/25/21	THANKSGIVING HOLIDAY					
15	11/30/21	COURSE REVIEW FOR FINAL EXAM					HWK 8 Due
		Test 3: FINAL EXAM (Date Not Published)					

Acronym	Interpretation
Face to Face PPT	Face to Face PowerPoint Presentation
EES	Engr Equation Solver (Software for solving problems)
TPSRS	Turning Point Student Response System (Web based)
Pre & Post Quiz on class pre-reading assignments and lecture for the class period (PPQ)	Each class section will begin or end with a quiz on the reading assignment and questions on what was discussed in the current and previous classes.
Quiz Embedded in Lecture Presentation	Short quiz questions will be embedded in the class PowerPoint Presentations

Student Support and Success

John B. Coleman Library

The John B. Coleman Library's mission is to enhance the scholarly pursuit of knowledge, to foster intellectual curiosity, and to promote life-long learning and research through our innovative services, resources, and cultural programs, which support the Prairie View A&M University's global mission of teaching, service, and research. It maintains library collections and access both on campus, online, and through local agreements to further the educational goals of students and faculty. Website: <https://www.pvamu.edu/library/>; Phone: 936-261-1500

Academic Advising Services

Academic Advising Services offers students a variety of services that contributes to student success and leads towards graduation. We assist students with understanding university policies and procedures that affect academic progress. We support the early alert program to help students get connected to success early in the semester. We help refer students to the appropriate academic support services when they are unsure of the best resource for their needs. Faculty advisors support some students in their respective colleges. Your faculty advisor can be identified in PantherTracks. Advisors with Academic Advising Services are available to all students. We are located across campus. Find your advisor's location by academic major at www.pvamu.edu/advising. Phone: 936-261-5911

The University Tutoring Center

The University Tutoring Center (UTC) offers free tutoring and academic support to all registered PVAMU students. The mission of the UTC is to help provide a solid academic foundation that enables students to become confident, capable, independent learners. Competent and caring staff and peer tutors guide students in identifying, acquiring, and enhancing the knowledge, skills, and attitudes needed to reach their desired goals. Tutoring and academic support are offered face-to-face in the UTC, in virtual face-to-face sessions (<https://www.pvamu.edu/student-success/sass/university-tutoring-center/>), and through online sessions (<https://www.pvamu.edu/pvplace/>). Other support services available for students include Supplemental Instruction, Study Break, Academic Success Workshops, and Algebra Study Jam. Location: J. B. Coleman Library, Rm. 307; Phone: 936-261-1561; Email: pvtutoring@pvamu.edu; Website: <https://www.pvamu.edu/student-success/sass/university-tutoring-center/>

Writing Center

The Writing Center provides well-trained peer tutors to assist students with writing assignments at any stage of the writing process. Tutors help students with various writing tasks from understanding assignments, brainstorming, drafting, revising, editing, researching, and integrating sources. Students have free access to Grammarly online writing assistance. Grammarly is an automated proofreading and plagiarism detection tool. Students must register for Grammarly by using their student email address. In addition, students have access to face-to-face and virtual tutoring services either asynchronously via email or synchronously via Face to Face. Location: J. B. Coleman Library, Rm. 209; Phone: 936-261-3724; Website: <https://www.pvamu.edu/student-success/writing-center/>; Grammarly Registration: <https://www.grammarly.com/enterprise/signup>

Academic Early Alert

Academic Early Alert is a proactive system of communication and collaboration between faculty, academic advisors, and PVAMU students that is designed to support student success by promptly identifying issues and allowing for intervention. Academic Early Alerts help students by providing a central location to schedule advising appointments, view advisor contact information, and request assistance. Students who recognize that they have a problem that is negatively affecting their academic performance or ability to continue school may self-refer an Academic Early Alert. To do so, students will log in to PV Place and click on Academic Early Alert on the left sidebar. Phone: 936-261-5902; Website: <https://www.pvamu.edu/student-success/early-alert/>

Student Counseling Services

The Student Counseling Services unit offers a range of services and programs to assist students in maximizing their potential for success: short-term individual, couples, and group counseling, as well as crisis intervention, outreach, consultation, and referral services. The staff is licensed by the State of Texas and assists students who are dealing with academic skills concerns, situational crises, adjustment

problems, and emotional difficulties. Information shared with the staff is treated confidentially and in accordance with Texas State Law. Location: Hobart Taylor, 2nd floor; Phone: 936-261-3564; Website: <https://www.pvamu.edu/healthservices/student-counseling-services/>

Office of Testing Services

Testing Services serves to create opportunities by offering a suite of exams that aid in the students' academic and professional success. Currently, we administer entrance (HESI A2), college readiness (TSI assessment), Prior Learning (CLEP, DSST), and proctored exams. Location: Wilhelmina Delco, 3rd Floor, Rm. 305; Phone: 936-261-3627; Email: aetesting@pvamu.edu; Website: www.pvamu.edu/testing

Office of Diagnostic Testing and Disability Services

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, contact the Office of Disability Services. As a federally-mandated educational support unit, the Office of Disability Services serves as the repository for confidential disability files for faculty, staff, and students. For persons with a disability, the Office develops individualized ADA letters of request for accommodations. Other services include learning style inventories, awareness workshops, accessibility pathways, webinars, computer laboratory with adapted hard and software, adapted furniture, proctoring non-standardized test administrations, ASL interpreters, ALDs, digital recorders, Livescribe, and a comprehensive referral network across campus and the broader community. Location: Hobart Taylor, Rm. 1D128; Phone: 936-261-3583; Website: <https://www.pvamu.edu/disabilityservices/>

Center for Instructional Innovation and Technology Services (CIITS)

Distance Learning, also referred to as Distance Education, is the employment of alternative instructional delivery methods to extend programs and services to persons unable to attend college in the traditional manner. The Center for Instructional Innovation and Technology Services (CIITS) supports student learning through online, hybrid, web-assist, and 2-way video course delivery. For more details and contact information, visit:

<https://www.pvamu.edu/dlearning/distance-learning-2-2/students-2/>; Phone: 936-261-3283

Veteran Affairs

Veterans Services works with student veterans, current military and military dependents to support their transition to the college environment and continued persistence to graduation. The Office coordinates and certifies benefits for both the G.I. Bill and the Texas Hazlewood Act. Location: Evans Hall, Rm. 102; Phone: 936-261-3563; Website: <https://www.pvamu.edu/sa/departments/veteranaffairs/>

Office for Student Engagement

The Office for Student Engagement delivers comprehensive programs and services designed to meet the co-curricular needs of students. The Office implements inclusive and accessible programs and services that enhance student development through exposure to and participation in diverse and relevant social, cultural, intellectual, recreational, community service, leadership development, and campus governance. Location: Memorial Student Center, Rm. 221; Phone: 936-261-1340; Website: <https://www.pvamu.edu/studentengagement/>

Career Services

Career Services supports students through professional development, career readiness, and placement and employment assistance. The Office provides one-on-one career coaching, interview preparation, resume and letter writing, and career exploration workshops and seminars. Services are provided for students at the Northwest Houston Center and College of Nursing in the Medical Center twice a month or on a requested basis. Distance Learning students are encouraged to visit the Career Services website for information regarding services provided. Location: Anderson Hall, 2nd floor; Phone: 936-261-3570; Website: <https://www.pvamu.edu/careerservices/>

University Rules and Procedures

Academic Misconduct

Academic dishonesty is defined as any form of cheating or dishonesty that has the effect or intent of interfering with any academic exercise or fair evaluation of a student's performance. The college faculty can provide additional information, particularly related to a specific course, laboratory, or assignment.

You are expected to practice academic honesty in every aspect of this course and all other courses. Make sure you are familiar with the *University Administrative Guidelines on Academic Integrity*, which can be found on the Academic Integrity webpage. Students who engage in academic misconduct are subject to university disciplinary procedures. As listed in the *University Administrative Guidelines on Academic Integrity*, the University Online Catalog, and the Student Code of Conduct, the following are examples of prohibited conduct. This list is not designed to be all-inclusive or exhaustive. In addition to academic sanctions, any student found to have committed academic misconduct that is also a violation of criminal law may also be subject to disciplinary review and action by the Office of Student Conduct (as outlined in the Student Code of Conduct).

Forms of Academic Dishonesty:

1. Cheating: Deception in which a student misrepresents that he/she has mastered information on an academic exercise that he/she has not learned, giving or receiving aid unauthorized by the instructor on assignments or examinations. Examples: unauthorized use of notes for a test; using a "cheat sheet" on a quiz or exam; any alteration made on a graded test or exam which is then resubmitted to the teacher;
2. Plagiarism: Careless or deliberate use of the work or the ideas of another; representation of another's work, words, ideas, or data as your own without permission or appropriate acknowledgment. Examples: copying another's paper or answers, failure to identify information or essays from the internet and submitting or representing it as your own; submitting an assignment which has been partially or wholly done by another and claiming it as yours; not properly acknowledging a source which has been summarized or paraphrased in your work; failure to acknowledge the use of another's words with quotation marks;
3. Collusion: When more than one student or person contributes to a piece of work that is submitted as the work of an individual;
4. Conspiracy: Agreeing with one or more persons to commit an act of academic/scholastic dishonesty; and
5. Multiple Submission: Submission of work from one course to satisfy a requirement in another course without explicit permission. Example: using a paper prepared and graded for credit in one course to fulfill a requirement and receive credit in a different course.

Nonacademic Misconduct

The university respects the rights of instructors to teach and students to learn. Maintenance of these rights requires campus conditions that do not impede their exercise. Campus behavior that interferes with either (1) the instructor's ability to conduct the class, (2) the inability of other students to profit from the instructional program, or (3) campus behavior that interferes with the rights of others will not be tolerated. An individual engaging in such disruptive behavior may be subject to disciplinary action. The Office of Student Conduct will adjudicate such incidents under nonacademic procedures.

Sexual Misconduct

Sexual harassment of students and employees at Prairie View A&M University is unacceptable and will not be tolerated. Any member of the university community violating the university's sexual harassment policy will be subject to disciplinary action. In accordance with the Texas A&M University System guidelines, your instructor is obligated to report to the Office of Title IX Compliance (titleixteam@pvamu.edu) any instance of sexual misconduct involving a student, which includes sexual assault, stalking, dating violence, domestic violence, and sexual harassment, about which the instructor becomes aware during this course through writing, discussion, or personal disclosure. The faculty and staff of PVAMU actively strive to provide a learning, working, and living environment that promotes

respect that is free from sexual misconduct, discrimination, and all forms of violence. If students, faculty, or staff would like assistance or have questions, they may contact the Title IX Coordinator at 936-261-2144 or titleixteam@pvamu.edu. More information can be found at www.pvamu.edu/titleix, including confidential resources available on campus.

Pregnancy, Pregnancy-related, and Parenting Accommodations

Title IX of the Education Amendments of 1972 prohibits sex discrimination, which includes discrimination based on pregnancy, marital status, or parental status. Students seeking accommodations related to pregnancy, pregnancy-related conditions, or parenting (reasonably immediate postpartum period) are encouraged to contact Student Disability Services or the Dean of Students' Office for additional information and to request accommodations.

Non-Discrimination Statement

Prairie View A&M University does not discriminate on the basis of race, color, sex, religion, national origin, age, disability, genetic information, veteran status, sexual orientation, or gender identity in its programs and activities. The University is committed to supporting students and complying with The Texas A&M University System non-discrimination policy. It seeks to establish an environment that is free of bias, discrimination, and harassment. If you experience an incident of discrimination or harassment, we encourage you to report it. If you would like to speak with someone who may be able to afford you privacy or confidentiality, there are individuals who can meet with you. The Director of Equal Opportunity & Diversity has been designated to handle inquiries regarding the non-discrimination policies and can be reached at Harrington Science Building, Suite 109 or by phone at 936-261-1744 or 1792.

Class Attendance Policy (See the University Online Catalog for Full Attendance Policy)

Prairie View A&M University requires regular class attendance. Attending all classes supports the full academic development of each learner, whether classes are taught with the instructor physically present or via distance learning technologies such as interactive video and/or the internet. Excessive absenteeism, whether excused or unexcused, may result in a student's course grade being reduced or in the assignment of a grade of "F." Absences are accumulated beginning with the first day of class during regular semesters and summer terms. Each faculty member will include the University's attendance policy in each course syllabus.

Student Academic Appeals Process

Authority and responsibility for assigning grades to students rest with the faculty. However, in those instances where students believe that miscommunication, errors, or unfairness of any kind may have adversely affected the instructor's assessment of their academic performance, the student has a right to appeal by the procedure listed in the University Online Catalog and by doing so within thirty days of receiving the grade or experiencing any other problematic academic event that prompted the complaint.

Technical Considerations

Minimum Recommended Hardware and Software:

- Intel PC or Laptop with Windows 10 or later version; Mac with OS High Sierra*
- Smartphone or iPad/Tablet with Wi-Fi*
- High-speed Internet access
- 8 GB Memory
- Hard drive with 320 GB storage space
- 15" monitor, 800x600, color or 16 bit
- Sound card w/speakers
- Microphone and recording software
- Keyboard & mouse
- Most current version of Google Chrome, Safari, or Firefox

Note: Be sure to enable Java & pop-ups in the Web browser preferences

* Smartphones, Google Chrome books, and Android tablets may not be supported. iPads are the only tablets supported.

Participants should have a basic proficiency of the following computer skills:

- Sending and receiving email
- A working knowledge of the Internet
- Microsoft Word (or a program convertible to Word)
- Acrobat PDF Reader
- Windows or Mac OS
- Video conferencing software

Netiquette (online etiquette)

Students are expected to participate in all discussions and virtual classroom chats as directed. Students are to be respectful and courteous to others on discussion boards. Foul or abusive language will not be tolerated. Do not use ALL CAPS for communicating to others AS IT CAN BE INTERPRETED AS YELLING. Avoid slang terms such as "wassup?" and texting abbreviations such as "u" instead of "you." Limit and possibly avoid the use of emoticons. Be cautious when using humor or sarcasm as tone is sometimes lost in an email or discussion post, and the message might be taken seriously or sound offensive.

Video Conferencing Etiquette

When using Face to Face, WebEx, or other video conferencing tools, confirm the visible area is tidy, clear of background clutter, inappropriate or offensive posters, and other distractions. Ensure you dress appropriately and avoid using high traffic or noisy areas. Stay muted when you are not speaking and avoid eating/drinking during the session. Before the class session begins, test audio, video, and lighting to alleviate technology issues.

Technical Support

Students should go to <https://mypassword.pvamu.edu/> if they have password issues. The page will provide instructions for resetting passwords and contact information if login issues persist. For other technical questions regarding eCourses, call the Center for Instructional Innovation and Technology Services at 936-261-3283 or email ciits@pvamu.edu.

Communication Expectations and Standards

Emails or discussion postings will receive a response from the instructor, usually in less than 48 hours. Urgent emails should be marked as such. Check regularly for responses.

Discussion Requirement

Online courses often require minimal to no face-to-face meetings. However, conversations about the readings, lectures, materials, and other aspects of the course can occur in a seminar fashion. The use of the discussion board will accomplish this. The instructor will determine the exact use of discussion boards.

It is strongly suggested that students type their discussion postings in a word processing application such as Word and save it to their PC or a removable drive before posting to the discussion board. This is important for two reasons: 1) If for some reason your discussion responses are lost in your online course, you will have another copy; 2) Grammatical errors can be greatly minimized by the use of the spell-and-grammar check functions in word processing applications. Once the post(s) have been typed and corrected in the word processing application, copy and paste to the discussion board.

COVID-19 Campus Safety Measures [NOTE: Delete this section when the COVID-19 pandemic is over]

To promote public safety and protect students, faculty, and staff during the coronavirus pandemic, PVAMU has adopted policies and practices to limit virus transmission.

- **Self-monitoring** - Students should follow CDC recommendations for self-monitoring. Students who have a fever or exhibit symptoms of COVID-19 should participate in class remotely and should not participate in face-to-face instruction.

- **Face Coverings** - Face coverings (cloth face covering, surgical mask, etc.) are recommended in classrooms, teaching laboratories, common spaces such as lobbies and hallways, public study spaces, libraries, academic resource, and support offices, and outdoor spaces where 6 feet of physical distancing is challenging to maintain reliably.
- **Physical Distancing** - Physical distancing should be maintained between students, instructors, and others in course and course-related activities where possible.
- **Personal Illness and Quarantine** - Students required to quarantine are to participate in courses and course-related activities remotely and must not attend face-to-face course activities. Students should notify their instructors of the quarantine requirement. Students under quarantine are expected to participate in courses and complete graded work unless they have symptoms that are too severe to participate in course activities. Students experiencing personal injury or illness that is too severe for the student to attend class qualify for an excused absence. To receive an excused absence, students must provide appropriate documentation to the Office for Student Conduct, studentconduct@pvamu.edu.

End of Semester

Course Assessment Report

This summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance (**stated as %**) in each course outcome assessed in this class and the **two previous times course was assessed**.
- The acceptable class average for the class in each outcome area as set by your Department. **You cannot use any number of your choice**
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's **critical evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

5. Overall Trend over last three assessment periods

- Instructors summary of overall performance trend for each outcome measured over the last three periods.

5. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer NO.

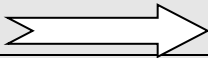
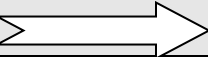
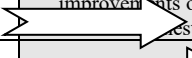
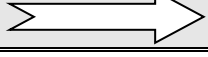
END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT

MCEG 2301 [2013] P01 THERMODYNAMICS I

FALL 2021 SEMESTER

Report Prepared by: Dr. Paul O. Biney

Report Date: May 23, 2021

Semester	Analysis Type	Number of Students	Outcome 8 An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics			
			Expected Class Average/	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
FALL 2021	Direct	23	70	70	53.6	23.8
SPRING 2021	Direct	26	70	70	58.6	26.9
FALL 2020	Direct	13	70	70	42.5	11.8
Implementation Summary	Items implemented from previous report or after meeting previous instructor	Detailed Class notes were prepared from the Text book and made available through e-course. Review questions were provided to students to answer as they read the notes to gain fundamental understanding. Frequent quizzes were given.				
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them 	The major problems were: 1. Students found it difficult to understand the fundamentals even though the course was taught at the fundamental level. It appears that the students did not understand the fundamentals. 2. Students did not appear to learn from day to day because they were unable to answer the same fundamental questions on several successive Formative QUIZZES.				
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas 	The following is recommended for implementation: All of the Pre-Class reading assignments will be transformed to pre-class reading quiz that is a multiple choice or numeric answer question that would automatically be graded on Canvas as a pre-concepts evaluation and then discussed in the beginning of class to reinforce understanding. Only about 40 % of the pre-class reading questions were converted into pre-class reading quiz, but recommendation is to convert all the questions to pre-class reading quiz in the Spring 2022 semester. Then at last 10 minutes of the class will be used to test students' post understanding of the same concepts in a formative quiz to be conducted on Canvas each class day or at least once a week				
Overall Trend over Periods	Ascertained if there were improvements over previous semesters 	Performance is the lowest in the past 3 semesters.				
Were Expectations Met?		NO				

**Grade Sheet Showing
Student and Class Performance in Outcomes
The computed semester average in each outcome
as stated in the Assessment report are
highlighted in boldface**

Grade Sheet Showing Student and Class Performance in Course Outcomes
MCEG 2013 Thermodynamics I FALL 2021 Semester

OUTCOMES ----->		OUTCOME 8					
PC----->		TESTS					
Assignment Description -->		T1	T2	T3	FQ	TOT	PCENT
MAX POINTS----->		100	100	100	100	400	100
Name							
		37.0	22.5	28.0	52.6	140.1	43.4
		56.5	28.5	37.0	66.9	188.9	58.6
		83.0	55.5	56.0	71.0	265.5	82.3
		38.0	38.0	32.5	47.7	156.2	48.4
		41.0	63.0	13.0	59.3	176.3	54.7
		28.0	31.0	21.0	35.0	115.0	35.6
		55.0	77.5	60.0	71.5	264.0	81.9
		31.0	20.5	20.0	27.4	98.9	30.7
		32.0	24.0	14.0	36.9	106.9	33.1
		55.0	35.5	34.5	87.8	212.8	66.0
		50.0	28.0	52.0	49.6	179.6	55.7
		69.0	64.5	53.0	50.7	237.2	73.5
		26.5	29.5	49.0	50.9	155.9	48.3
		17.5	27.0	10.0	21.7	76.2	23.6
		38.0	80.0	42.0	53.7	213.7	66.2
		28.5	36	29.5	51.8	145.8	45.2
		30.5	27.5	13.0	45.8	116.8	36.2
		76.0	27.5	18.0	43.1	164.6	51.0
		26.0	34.5	35.0	51.2	146.7	45.5
		80.0	56.0	44.5	56.6	237.1	73.5
		55.0	55.0	74.0	49.3	233.3	72.3
AVERAGE		46.0	41.8	37.9	51.0	176.6	53.6
STDEV		21.2	17.7	18.6	14.6	51.6	17.1
Total Number of Students	21						
Acceptable Average	70						21.0
% Student at/above acceptable A	70						23.8
Outcme/PC met? Yes or No							NO

**OUTCOME SPECIFIC ASSIGNMENTS
USED TO ASSESS OUTCOMES**

ASSIGNMENTS FOR OUTCOME “8”

The ability to apply knowledge of mathematics, science, and engineering

**MECHANICAL ENGINEERING DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
MCEG 2013 THERMODYNAMICS I
FALL 2021
Instructor: Dr. Paul O. Biney**

Title of Assignment

Test 1

Outcome Measured Using this Assignment

Outcome 8

An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematic.

Check the outcome characteristics related to this assignment

Requires students to	
x	identify engineering problems
x	formulate engineering problems
x	solve engineering problems
Involves the application of the principles of	
x	engineering
	science
	mathematics

Brief justification of why this assignment is suitable for this outcome

i.
9

Questions tests students ability to identify, formulate and solve thermodynamics problems

FALL 2021 TEST 1 PART A
Master Solution & Grading Scheme

Test 1 Part A

Answer all Questions directly on the question sheets

Show all calculations directly on the question sheets

UPLOAD YOUR WORK ON E-COURSE BY 8:00 AM on 10/19/2021

Q1) If a system changed its state from state 1 to state 2, can we calculate the work and the heat transfer if states 1 and 2 are completely known?

- ☐ No, because both states are known
- ☐ Yes, because we know at least one state
- ☐ Yes, because we know the two states
- ☒ No, because we need to know the path
- ☐ None of the options provided is right

Q2) The initial temperature and pressure of a gas in a closed system are $T_1=100\text{ }^{\circ}\text{C}$, $P_1=250\text{ kPa}$. The gas is compressed isothermally until its final pressure $P_2=500\text{ kPa}$

Which of the statement below is true about the final temperature, T_2 .

- ☐ $T_2 = 200\text{ }^{\circ}\text{C}$ (double T_1) because the pressure doubled during the process.
- ☐ $T_2=50\text{ }^{\circ}\text{C}$ (half of T_1) because of the pressure increase.
- ☐ T_2 cannot be determined because there is not enough information to determine it.
- ☒ $T_2=100\text{ }^{\circ}\text{C}$ for this process
- ☐ We need to know the volume before we can calculate the final temperature

Q3) The temperatures at locations A and B inside a system are $50\text{ }^{\circ}\text{C}$ and 50°C respectively one hour ago. The temperatures at locations A and B now are $80\text{ }^{\circ}\text{C}$ and $80\text{ }^{\circ}\text{C}$ respectively. Which of the following statements is true about this system.

- ☐ The system is uniform and steady
- ☐ The system is not uniform and it is not steady
- ☒ The system is uniform but not steady
- ☐ The system is steady but not uniform
- ☐ None of the options provided is true

Q4) A gas in a piston cylinder arrangement undergoes a polytropic process from $P_1=770$ kPa, $V_1=0.25$ m³ to a final pressure $P_2=150$ kPa. if the polytropic index, $n=1.22$, what will be the final volume in m³?

$$P_1 V_1^{1.22} = P_2 V_2^{1.22}$$

$$V_2 = V_1 \left(\frac{P_1}{P_2} \right)^{\frac{1}{1.22}} = (0.25 \text{ m}^3) \left(\frac{770 \text{ kPa}}{150 \text{ kPa}} \right)^{\frac{1}{1.22}}$$

$$V_2 = 0.9555 \text{ m}^3$$

Q5) 5 kg of gas in a **closed rigid vessel** of volume 0.25 m³ is heated from $P_1=200$ kPa, $T_1=25$ °C to a temperature of $T_2=500$ °C. Determine the final specific volume, v_2 , in m³/kg.

Since we have a rigid closed system

$$V_2 = V_1$$

$$\text{But } v_1 = \frac{V}{m} = \frac{0.25 \text{ m}^3}{5 \text{ kg}} = 0.05 \text{ m}^3/\text{kg}$$

$$\text{Thus } v_2 = v_1 = 0.05 \text{ m}^3/\text{kg}$$

Q6) 550 kJ of work goes into a closed system while the system loses 100 kJ of heat from one surface and loses 150 kJ of heat from a second surface. If the initial internal energy of the system was 700 kJ, what is the final internal energy of the system?

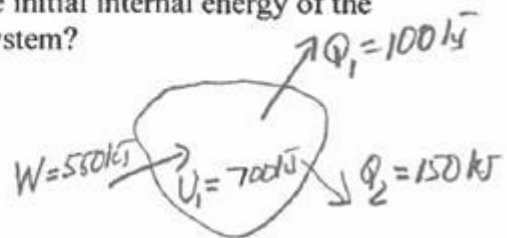
$$E_{in} - E_{out} = U_2 - U_1 \quad \Delta KE = \Delta PE = 0$$

$$W - (Q_1 + Q_2) = U_2 - U_1$$

$$U_2 = W - (Q_1 + Q_2) + U_1$$

$$U_2 = 550 \text{ kJ} - (100 + 150) \text{ kJ} + 700 \text{ kJ}$$

$$U_2 = 1000 \text{ kJ}$$



Q7) A motor drives a pulley that hoists a mass of 1000 kg through a height of 80 m. if $g=9.8$ m/s² and the efficiency of the pulley system is 77 %, what energy must be supplied to the motor.

$$m = 1000 \text{ kg} \quad H = 80 \text{ m}$$

$$E_{\text{out}} = mgh = (1000 \text{ kg})(9.8 \text{ m/s}^2)(80 \text{ m}) = 784,000 \text{ J}$$

$$\eta = \frac{E_{\text{out}}}{E_{\text{in}}} \Rightarrow E_{\text{in}} = \frac{E_{\text{out}}}{\eta}$$

$$E_{\text{in}} = \frac{784,000 \text{ J}}{0.77} = 1,018,181 \text{ J}$$

$$\therefore E_{\text{in}} = 1,018.18 \text{ kJ}$$

Q8) Refrigerant 134a is at a temperature of 20 °C and a specific volume of 0.23373 m³/kg. Determine the specific internal energy u , of the refrigerant in kJ/kg

$$\text{At } 20^\circ\text{C} \quad v_f = 0.0008160 \text{ m}^3/\text{kg}, \quad v_g = 0.036012 \text{ m}^3/\text{kg}$$

$v > v_g$, thus we have Superheated vapor

$$\text{From the Superheated table for R134a, at } 20^\circ\text{C} \text{ ; } v = 0.23373$$

$$u = 248.81 \text{ kJ/kg}$$

Q9) For the steam at a Pressure of 10 MPa and specific volume of 0.0011200 m³/kg, find the specific internal energy, u , in kJ/kg.

$$\text{At } P = 10 \text{ MPa} \approx 10,000 \text{ kPa} \quad v_f = 0.001452 \frac{\text{m}^3}{\text{kg}}, \quad v_g = 0.018028 \frac{\text{m}^3}{\text{kg}}$$

$v < v_f$ thus, compressed liquid

From compressed liquid Tables

$$\text{at } P = 10 \text{ MPa}, \quad v = 0.0011200$$

$$u = 756.48 \text{ kJ/kg}$$

Q10) Water is at a temperature of 200°C and specific internal energy, $u=1750 \text{ kJ/kg}$. What is the value of its specific enthalpy, h in kJ/kg ?

At $T=200^\circ\text{C}$ $u_f = 850.46 \frac{\text{kJ}}{\text{kg}}$, $u_g = 2594.2 \frac{\text{kJ}}{\text{kg}}$

u is between u_f & u_g , thus saturated mixture

$$x = \frac{u - u_f}{u_{fg}} = \frac{(1750 - 850.46) \text{ kJ/kg}}{(1743.7) \text{ kJ/kg}} = 0.5159$$

$$h = h_f + x h_{fg} = 852.26 \frac{\text{kJ}}{\text{kg}} + (0.5159)(1439.8) \frac{\text{kJ}}{\text{kg}}$$

$$h = 1852.9 \text{ kJ/kg}$$

Q11) A gas in a closed system is heated from $T_1=150^\circ\text{C}$ to a final state where $T_2=750^\circ\text{C}$

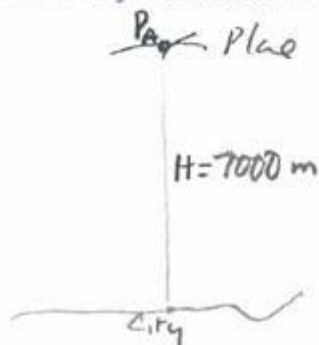
What is the temperature change of this gas in $^\circ\text{R}$?

$$\Delta T ^\circ\text{C} = (750 - 150)^\circ\text{C} = 600^\circ\text{C}$$

$$\Delta T ^\circ\text{F} = 1.8 (\Delta T ^\circ\text{C}) = (1.8)(600) = 1080 ^\circ\text{F}$$

$$\Delta T ^\circ\text{R} = \Delta T ^\circ\text{F} = 1080 ^\circ\text{R}$$

Q12) The pilot of an airplane reads an absolute pressure of 50 kPa at an altitude of 7000 m above a city. if the average density of air is 0.95 kg/m^3 , what will be the local atmospheric pressure on the ground in the city in kPa . Assume $g=9.8 \text{ m/s}^2$



$$P_A + \rho g H = P_{\text{city}}$$

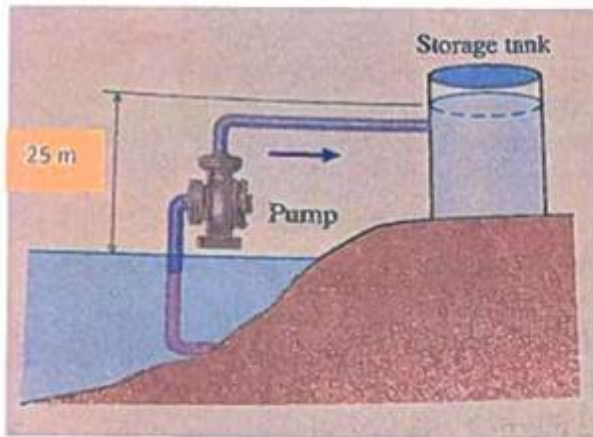
$$P_{\text{city}} = P_A + \rho g H$$

$$P_{\text{city}} = 50 \text{ kPa} + \left(0.95 \frac{\text{kg}}{\text{m}^3}\right) \left(\frac{9.8 \text{ m/s}^2}{1000}\right) (7000) \text{ k}$$

$$= 115.2 \text{ kPa}$$

PART B QUESTION 3

Water is pumped from a lake to a storage tank located 25 meters above the lake as shown in the Figure. The flow rate of the water pumped is $0.1 \text{ m}^3/\text{s}$. Assume the density of water, $\rho = 1000 \text{ kg/m}^3$ and that $g = 9.81 \text{ m/s}^2$.



a) Calculate the mass flow rate of the water in kg/s .

$$\text{Volume Flow rate } Q = 0.1 \text{ m}^3/\text{s}, \quad \rho = 1000 \text{ kg/m}^3$$
$$\dot{m} = \rho Q = (1000 \text{ kg/m}^3)(0.1 \text{ m}^3/\text{s}) = 100 \text{ kg/s}$$

7 1/2

b) Calculate the specific energy, e , delivered to the water by the pump in kJ/kg .

$$e = gH$$
$$= (9.81 \text{ m/s}^2)(25 \text{ m})$$
$$= 245.25 \frac{\text{J}}{\text{kg}}$$

7 1/2

c) Calculate the power output from the pump to the water in kW

$$P = \dot{E} = \dot{m}e$$
$$= (100 \text{ kg/s}) \left(245.25 \frac{\text{J}}{\text{kg}} \right) \frac{1 \text{ kW}}{1000 \text{ J}}$$
$$P = 24.53 \text{ kW}$$

7 1/2

d) Calculate the power input to the motor pump system in kW if the efficiency of the pump-motor system is 75%

$$\eta = \frac{P_{\text{out}}}{P_{\text{in}}} \Rightarrow P_{\text{in}} = \frac{P_{\text{out}}}{\eta}$$
$$P_{\text{in}} = \frac{24.53 \text{ kW}}{0.75}$$
$$= 32.7 \text{ kW}$$

7 1/2

$$67\frac{1}{2} / 10$$

$$67\frac{1}{2} + 28 = (95\frac{1}{2} W)$$

Group 4: Tyson Morris, Tyler Rhodes
Josh Jones, Yafet Tekie,
Zack Taylor

Test 1 Part A

Answer all Questions directly on the question sheets

Show all calculations directly on the question sheets

UPLOAD YOUR WORK ON E-COURSE BY 8:00 AM on 10/19/2021

Q1) If a system changed its state from state 1 to state 2, can we calculate the work and the heat transfer if states 1 and 2 are completely known?

- ☐ No, because both states are known
- ☐ Yes, because we know at least one state
- ☐ Yes, because we know the two states
- ☒ No, because we need to know the path ✓ 5
- ☐ None of the options provided is right

Q2) The initial temperature and pressure of a gas in a closed system are $T_1 = 100^\circ\text{C}$, $P_1 = 250$ kPa. The gas is compressed isothermally until its final pressure $P_2 = 500$ kPa

Which of the statement below is true about the final temperature, T_2 .

- ☐ $T_2 = 200^\circ\text{C}$ (double T_1) because the pressure doubled during the process.
- ☐ $T_2 = 50^\circ\text{C}$ (half of T_1) because of the pressure increase.
- ☐ T_2 cannot be determined because there is not enough information to determine it.
- ☒ $T_2 = 100^\circ\text{C}$ for this process ✓ 5
- ☐ We need to know the volume before we can calculate the final temperature

Q3) The temperatures at locations A and B inside a system are 50°C and 50°C respectively one hour ago. The temperatures at locations A and B now are 80°C and 80°C respectively. Which of the following statements is true about this system.

- ☐ The system is uniform and steady
- ☐ The system is not uniform and it is not steady
- ☒ The system is uniform but not steady ✓ 5
- ☐ The system is steady but not uniform
- ☐ None of the options provided is true

Sample Student Solution

Q4) A gas in a piston cylinder arrangement undergoes a polytropic process from $P_1=770$ kPa, $V_1=0.25$ m³ to a final pressure $P_2=150$ kPa. if the polytropic index, $n=1.22$, what will be the final volume in m³?

$$\begin{aligned} P_1 V_1^n &= P_2 V_2^n \\ (770)(0.25)^{1.22} &= 150 V_2^{1.22} \\ 0.946 &= V_2^{1.22} \\ 0.956 &= V_2 \end{aligned}$$

$$\boxed{0.956 \text{ m}^3}$$

Q5) 5 kg of gas in a closed rigid vessel of volume 0.25 m³ is heated from $P_1=200$ kPa, $T_1=25$ °C to a temperature of $T_2=500$ °C. Determine the final specific volume, v_2 , in m³/kg.

$$v_1 = \frac{V}{m} = \frac{0.25}{5} = \boxed{0.05 \text{ m}^3/\text{kg}}$$

Q6) 550 kJ of work goes into a closed system while the system loses 100kJ of heat from one surface and loses 150 kJ of heat from a second surface. If the initial internal energy of the system was 700 kJ, what is the final internal energy of the system?

$$700 + 550 - 100 - 150 = \boxed{1000 \text{ kJ}}$$

Show Equation

Q7) A motor drives a pulley that hoists a mass of 1000 kg through a height of 80 m. if $g=9.8$ m/s² and the efficiency of the pulley system is 77 %, what energy must be supplied to the motor.

$$E = mgh$$

$$= (1000)(9.8)(80)$$

$$= 784000$$

Efficiency

$$= \frac{784000}{x}$$

$$0.77 = \frac{784000}{x}$$

$$x = \boxed{1018181.82}$$

Show equations!

Q8) Refrigerant 134a is at a temperature of 20 °C and a specific volume of 0.23373 m³/kg. Determine the specific internal energy u , of the refrigerant in kJ/kg

$$v_g = 0.03502$$

$v > v_g$, so superheated

u @ 20°C in superheated table:

$$u = \boxed{248.81 \text{ kJ/kg}}$$

Q9) For the steam at a Pressure of 10 MPa and specific volume of 0.0011200 m³/kg, find the specific internal energy, u , in kJ/kg.

$v < v_g$, so compressed

$$v @ 10 \text{ MPa} = 0.0011200$$

$$u = \boxed{756.48 \text{ kJ/kg}}$$

Q10) Water is at a temperature of 200 °C and specific internal energy, $u=1750$ kJ/kg. What is the value of its specific enthalpy, h in kJ/kg?

$$u = u_f + x u_{fg}$$

$$1750 = 850 + x(1743.7)$$

$$900 = 1743.7x$$

$$0.516 = x$$

10

$$h = h_f + x h_{fg}$$

$$h = 852.26 + (0.516)(1939.8)$$

$$h = 1853.48 \text{ kJ/kg}$$

Q11) A gas in a closed system is heated from $T_1=150$ °C to a final state where $T_2=750$ °C. What is the temperature change of this gas in °R?

$$\Delta R = 1.8 \Delta C$$

$$\Delta R = 1.8(600)$$

$$\Delta R = 1080$$

Units

$$\Delta C = T_2 - T_1 = 750 - 150 = 600$$

Q12) The pilot of an airplane reads an absolute pressure of 50 kPa at an altitude of 7000 m above a city. If the average density of air is 0.95 kg/m³, what will be the local atmospheric pressure on the ground in the city in kPa. Assume $g=9.8$ m/s².

$$P = P_{atm} + \rho g h$$

$$P = 50 + (0.95)(9.8)(7000/1000)$$

$$P = 115.237 \text{ kPa}$$

$$\rho = 0.95 \text{ kg/m}^3$$

$$g = 9.81 \text{ m/s}^2$$

84/90 W 28/30 FALL 2021 TEST 1 PART B
ANSWER ALL QUESTIONS

PART B QUESTION 1

A piston cylinder device contains 0.005 m³ of liquid water and 0.8 m³ of water vapor in equilibrium at 1000 kPa. Heat is transferred at constant pressure until the final temperature, T₂=300 °C. Determine:

- a) The initial temperature, T₁ in °C

$T_{@1000kPa} = 179.88^\circ\text{C}$

- b) The initial mass of liquid, m_f, the initial mass of vapor, m_g, and the initial total mass of the mixture, m_T

$v = \frac{V}{m}$

$m_f = \frac{V_f}{v_f} = \frac{0.005}{0.001127} = 4.437 \text{ kg} = \text{initial mass of liquid}$

$m_g = \frac{V_g}{v_g} = \frac{0.8}{0.19436} = 4.116 \text{ kg} = \text{initial mass of vapor}$

$m_{total} = m_f + m_g = 4.116 + 4.437 = 8.553 \text{ kg}$

- c) The quality, x, of the mixture at state 1

$v = \frac{V}{m} = \frac{0.805}{8.553} = 0.094 \text{ m}^3/\text{kg}$

$v = v_f + x v_{fg}$

$0.094 = 0.001127 + x(0.193233)$

$0.481 = x$

$v_{fg} = v_g - v_f$

$v_{fg} = 0.19436 - 0.001127$

$v_{fg} = 0.193233$

- d) The specific volume, v, of the mixture at state 1

$v = \frac{V}{m} = \frac{0.805}{8.553} = 0.094 \text{ m}^3/\text{kg}$

- e) The final pressure, P₂ in kPa, and the final specific volume, v₂ in m³/kg

isobaric, so $P_2 = P_1 = 1000 \text{ kPa}$

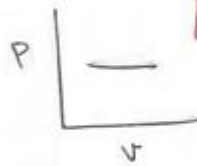
at 1 MPa and 300°C on superheated table, $v_2 = 0.25799 \text{ m}^3/\text{kg}$

f) The final total volume, V_2 in m^3

$$v = \frac{V}{m}$$
$$0.25799 = \frac{V}{8.653}$$
$$\boxed{2.207 \text{ m}^3 = V_2}$$

4

g) Show the process on a P-v diagram



Incomplete!!!
1

PART B QUESTION 2

Steam is at a pressure, $P=20$ MPa and temperature $T=500$ °C. The specific gas constant for steam is $R=0.4615$ kJ/kg-K. For water, the critical pressure, $P_c=22.06$ MPa and the critical temperature $T_c=647.1$ K

1. Determine the specific volume of the steam using the steam table.

$$v = 0.012721 \text{ m}^3/\text{kg}$$

explain

26/30

2. Determine the specific volume of the steam assuming the steam behaves as an ideal gas

$$Pv = RT$$

$$(20,000)v = (0.4615)(773)$$

$$v = 0.178 \text{ m}^3/\text{kg}$$

$$500 + 273 = 773$$

3. Compute the reduce pressure, P_r and the reduced temperature, T_r .

$$P_r = \frac{P}{P_c} = \frac{20}{22.06} = 0.907 \text{ MPa}$$

$$T_r = \frac{T}{T_c} = \frac{773}{647.1} = 1.195 \text{ K}$$

4. Using the values of P_r and T_r computed, use the compressibility chart to estimate the value of the compressibility factor, Z

$$Z = 0.815$$

5. Compute the specific volume of the steam based on the Z value obtained from the compressibility chart.

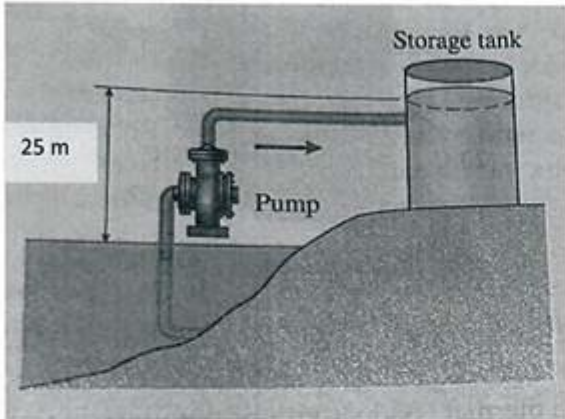
$$Z = \frac{Pv}{RT}$$

$$v = \frac{ZRT}{P}$$

$$v = \frac{(0.815)(0.4615)(773)}{20,000} = 0.0145 \text{ m}^3/\text{kg}$$

PART B QUESTION 3

Water is pumped from a lake to a storage tank located 25 meters above the lake as shown in the Figure. The flow rate of the water pumped is $0.1 \text{ m}^3/\text{s}$. Assume the density of water, $\rho = 1000 \text{ kg/m}^3$ and that $g = 9.81 \text{ m/s}^2$.



$$\frac{29\frac{1}{2}}{30}$$

- a) Calculate the mass flow rate of the water in kg/s .

$$\begin{aligned} \dot{m} &= \rho \dot{V} \\ &= (1000)(0.1) \\ \dot{m} &= 100 \text{ kg/s} \end{aligned}$$

- b) Calculate the specific energy, e , delivered to the water by the pump in kJ/kg .

$$\begin{aligned} \text{only PE, so:} \\ e = PE = gh = (9.81)(25) \left(\frac{1 \text{ kJ/kg}}{1000 \text{ m}^2/\text{s}^2} \right) \\ e = 0.24525 \text{ kJ/kg} \end{aligned}$$

- c) Calculate the power output from the pump to the water in kW

$$P = \dot{m} e = (100)(0.24525) = 24.525 \text{ kW}$$

- d) Calculate the power input to the motor pump system in kW if the efficiency of the pump-motor system is 75%

$$\text{efficiency \%} = 100 \times \frac{\text{output}}{\text{input}}$$

$$75 = 100 \times \frac{24.525}{x}$$

$$x = 32.7$$

$$\text{input} = 32.7 \text{ kW}$$

MECHANICAL ENGINEERING DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
MCEG 2013 THERMODYNAMICS I

FALL 2021

Instructor: Dr. Paul O. Biney

Title of Assignment

Test 2

Outcome Measured Using this Assignment

Outcome 8

An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematic.

Check the outcome characteristics related to this assignment

Requires students to	
x	identify engineering problems
x	formulate engineering problems
x	solve engineering problems
Involves the application of the principles of	
x	engineering
	science
	mathematics

Brief justification of why this assignment is suitable for this outcome

Sample Graded Student Solution

FALL 2021 TEST 1 PART A
Master Solution & Grading Scheme

Fall 2021 Thermodynamics I Test 2 Part A
Answer All Questions

1. Air in a rigid closed vessel is initially at pressure $P_1=100$ kPa, $V_1=100$ oC. The air is heated to a final temperature $T_2=500$ oC. What the work done in kJ? Air in a rigid closed vessel is initially at pressure $P_1=100$ kPa, $V_1=100$ oC. The air is heated to a final temperature $T_2=500$ oC. What the work done in kJ?

Rigid Vessel, Volume is constant

$$W = \int P dV = 0 \text{ since } dV = 0 \text{ for rigid vessel}$$

2. Refrigerant R-134a at a temperature of 50°C has a specific volume, $v=0.12766$ m³/kg. The pressure in MPa is

$$v_f = \frac{1}{2}(0.0008997 + 0.0009151) = 0.0009074$$

$$v_g = \frac{1}{2}(0.015951 + 0.014276) = 0.01511$$

$h > h_g$ thus superheated vapor

$$P_2 = 0.20 \text{ MPa}$$

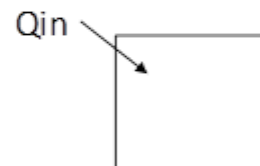
3. Air in a rigid closed vessel is initially at $P_1=100$ kPa, $T_1=390$ K, $V_1=12.5$ m³. The air is heated to a final temperature $T_2=770$ K. Assume the air is an ideal gas and that $R=0.287$ kJ/kg-K and $c_v=0.718$ kJ/kg-K. The total heat transferred in kJ is

Energy Balance

$$E_{in} - E_{out} = E_2 - E_1$$

$$Q_{in} = m(u_2 - u_1)$$

$$Q = mc_v(T_2 - T_1)$$



Find m from ideal gas equation

$$P_1 V_1 = m R T_1 \text{ Thus } m = P_1 V_1 / (R T_1) = (100 \text{ kPa})(12.5 \text{ m}^3) / [(0.287 \text{ kJ/kg-K})(390 \text{ K})] = 11.17 \text{ kg}$$

Energy Balance

$$E_{in} - E_{out} = E_2 - E_1 \quad \text{Thus } Q_{in} = m(u_2 - u_1)$$

$$Q_{in} = mc_v(T_2 - T_1) = (11.17 \text{ kg})(0.718 \text{ kJ/kg-K})(770 - 390) \text{ K} = 3047.0 \text{ kJ}$$

$$Q_{in} = 3,047.0 \text{ kJ} \text{ or By air Tables } 278.93 \text{ kJ/kg, } u_2 = 0.5*(560.01 + 576.12) = 568.07$$

$$Q_{in} = m(u_2 - u_1) = 11.17(568.07 - 278.93) = 3229.0 \text{ kJ}$$

4. 250 kJ of work goes into a closed system while the system loses 80 kJ of heat. If the initial internal energy of the system was 300 kJ, what is the final internal energy of the system?

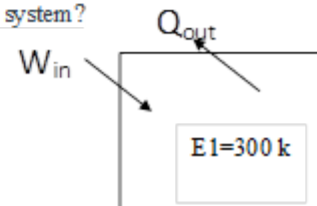
Energy Balance

$$E_{in} - E_{out} = E_2 - E_1$$

$$W_{in} - Q_{out} = E_2 - E_1$$

$$E_2 = W_{in} - Q_{out} + E_1$$

$$= 250 - 80 + 300 = 470 \text{ kJ}$$



1. A crane lifts a bucket of cement with a mass of 450 kg vertically up with a constant velocity of 2 m/s. Assuming $g=9.81 \text{ m/s}^2$, the rate of power in kW used by the crane is

a) 0.9
b) 4.42
c) 8.83
d) 8.52
e) 1.8

$$P = mgH/t = mgV$$

$$P = (450 \text{ kg})(9.81 \text{ m/s}^2)(2 \text{ m/s})/1000 = 8.83 \text{ kW}$$

2. As a result of heat transferred to a gas in a system, the temperature changed by 700 K. What is this temperature change in °R?

$$\Delta T \text{ } ^\circ\text{F} = \Delta T \text{ } ^\circ\text{R} = 1.8 \Delta T \text{ K} = (1.8)(700) = 1260 \text{ } ^\circ\text{R}$$

3. If m is the mass and h is the specific enthalpy, then the total enthalpy of a system H is given by

a) $H=h/m$
b) $H=m/h$
c) $H=mh$
d) $H=h$
e) None of the above is correct

4. A cylinder/piston contains 2 kg of air at 100 kPa, 20°C. The air is compressed polytropically to a pressure of 900 kPa. Calculate the absolute value of the work required if the polytropic exponent $n = 1.25$. Assume $R=0.287 \text{ kJ/kg}\cdot\text{K}$. (Hint: First calculate V_1 , and then V_2)

$$T_1 = 20 + 273.15 = 293.15 \text{ K},$$

$$P_1 V_1 = mRT_1, \text{ thus } V_1 = mRT_1/P_1 = (2 \text{ kg})(0.287 \text{ kJ/kg}\cdot\text{K})(293.15 \text{ K})/(100 \text{ kPa})$$

$$V_1 = 1.683 \text{ m}^3$$

$$P_1 V_1^n = P_2 V_2^n, \text{ thus } V_2 = V_1 [P_1/P_2]^{1/n}$$

$$V_2 = (1.683 \text{ m}^3)[100/900]^{1/1.25}$$

$$V_2 = 0.2901 \text{ m}^3$$

$$W = (P_2 V_2 - P_1 V_1)/(1-n) = [(900 \text{ kPa})(0.2901 \text{ m}^3) - (100 \text{ kPa})(1.683 \text{ m}^3)]/(1-1.25) = -371.4 \text{ kJ}$$

$$W = 371.4 \text{ kJ into system or on system}$$

5. kg of refrigerant R-134a passes through the throttle valve shown. The properties at the inlet are provided on the figure. The refrigerant loses an amount of heat, $Q=15 \text{ kJ}$ as it flows through the valve. By making an energy balance on the system, the computed value of the enthalpy at the exit state 2, h_2 in kJ

Energy balance gives

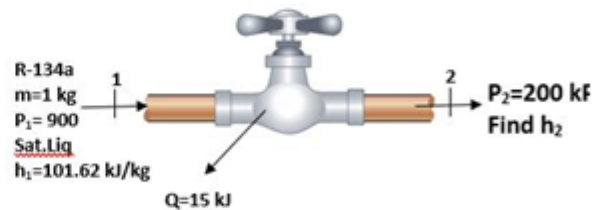
$$E_{in} = E_{out}$$

$$mh_1 = mh_2 + Q$$

$$h_2 = h_1 - Q/m$$

$$h_2 = 101.62 \text{ kJ/kg} - 15 \text{ kJ}/1 \text{ kg}$$

$$h_2 = 86.62 \text{ kJ/kg}$$



6. By making an energy balance on the turbine shown in the figure, calculate the power output of the turbine in kW

Energy balance gives

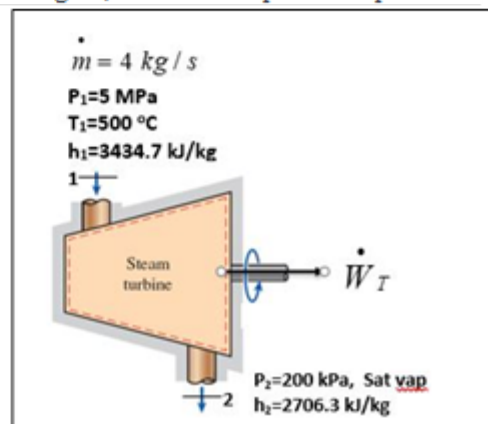
$$E_{in} = E_{out}$$

$$mh_1 = mh_2 + W$$

$$W = m(h_1 - h_2)$$

$$W = (4 \text{ kg/s})(3434.7 - 2706.3)$$

$$W = 2,913.6 \text{ kW}$$



THERMODYNAMICS I FALL 2021 SEMESTER TEST 2 Part B

ANSWER QUESTION 1 AND ANY 1 OTHER QUESTION

SHOW YOUR CALCULATIONS

11/11/2021

Name of Student (PRINT) Master Solution

I UNDERSTAND THAT CHEATING OR SEEKING HELP DURING THIS QUIZ WILL RESULT IN "F" GRADE

Student's Signature

QUESTION 1 [25]

The 1.5 m³ rigid tank shown below initially contains air at . The valve connected to the tank is opened allowing air at $P_i=500$ kPa, $T_i=500$ K to enter the tank until the final condition in the tank is $T_2=400$ K, $P_2=350$ kPa at which time the valve is completely closed. For air, assume the gas constant $R=0.287$ kJ/kg-K. Read all properties from the air tables.

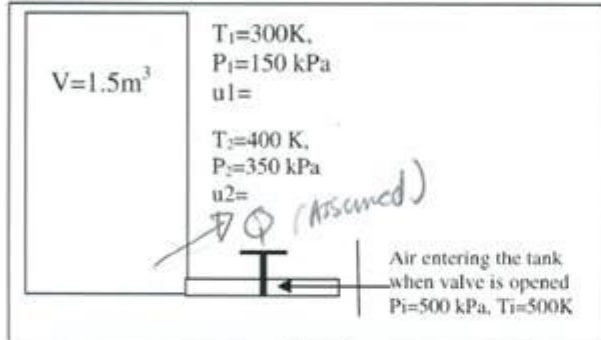


Figure 1

- i. Applying the ideal gas law, calculate the mass of air, m_1 , initially in the tank.

$$\begin{aligned}
 P_1 &= 150 \text{ kPa}, \quad T_1 = 300 \text{ K}, \quad V = 1.5 \text{ m}^3 \\
 P_1 V_1 &= m_1 R T_1 \\
 m_1 &= \frac{P_1 V_1}{R T_1} = \frac{(150 \text{ kPa})(1.5 \text{ m}^3)}{(0.287 \frac{\text{kJ}}{\text{kg-K}})(300 \text{ K})} \\
 m_1 &= 2.613 \text{ kg}
 \end{aligned}
 \quad \left. \vphantom{\begin{aligned} P_1 &= 150 \text{ kPa}, \quad T_1 = 300 \text{ K}, \quad V = 1.5 \text{ m}^3 \\ P_1 V_1 &= m_1 R T_1 \\ m_1 &= \frac{P_1 V_1}{R T_1} = \frac{(150 \text{ kPa})(1.5 \text{ m}^3)}{(0.287 \frac{\text{kJ}}{\text{kg-K}})(300 \text{ K})} \right\} 4$$

- ii. Calculate the final mass of air, m_2 , in the tank.

$$\begin{aligned}
 P_2 &= 350 \text{ kPa}, \quad T_2 = 400 \text{ K}, \quad V_2 = V_1 = 1.5 \text{ m}^3 \quad (\text{rigid tank}) \\
 m_2 &= \frac{P_2 V_2}{R T_2} = \frac{(350 \text{ kPa})(1.5 \text{ m}^3)}{(0.287 \frac{\text{kJ}}{\text{kg-K}})(400 \text{ K})} \\
 m_2 &= 4.573 \text{ kg}
 \end{aligned}
 \quad \left. \vphantom{\begin{aligned} P_2 &= 350 \text{ kPa}, \quad T_2 = 400 \text{ K}, \quad V_2 = V_1 = 1.5 \text{ m}^3 \quad (\text{rigid tank}) \\ m_2 &= \frac{P_2 V_2}{R T_2} = \frac{(350 \text{ kPa})(1.5 \text{ m}^3)}{(0.287 \frac{\text{kJ}}{\text{kg-K}})(400 \text{ K})} \right\} 4$$

- iii. Applying the law of conservation of mass, calculate the total mass of air, m_i , that entered the tank during the process.

$$\left. \begin{aligned} m_i - m_e &= m_2 - m_1 & m_e &= 0 \\ m_i &= m_2 - m_1 \\ &= (4.573 - 2.613) \text{ kg} \\ &= 1.96 \text{ kg} \end{aligned} \right\} 4$$

- iv. Determine the initial and final specific internal energy, u_1 and u_2 of the air in the tank, and the enthalpy h_i at the inlet to the tank / from the air Tables

For air at $T_1 = 300\text{K}$, $u_1 = 214.07 \text{ kJ/kg}$ — 2

For air at $T_i = 500\text{K}$, $h_i = 503.02 \text{ kJ/kg}$ — 2

For air at $T_2 = 400\text{K}$, $u_2 = 286.16 \text{ kJ/kg}$ — 2

- v. Determine the specific enthalpy, h_i , of the air entering the tank from the air Tables —

- vi. Making an energy Balance on the system, Calculate the total heat transfer during the process.

$$\left. \begin{aligned} E_{in} - E_{out} &= E_2 - E_1 \\ m_i h_i - Q &= m_2 u_2 - m_1 u_1 \\ Q &= m_i h_i - (m_2 u_2 - m_1 u_1) \end{aligned} \right\} 3$$

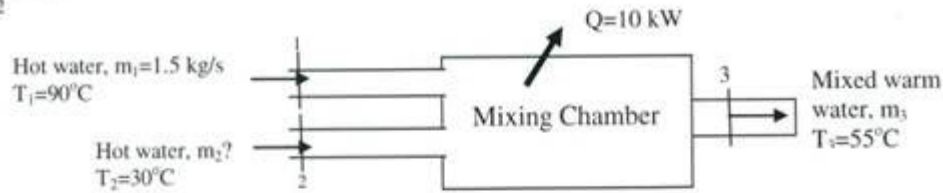
$$\begin{aligned} &= (2.613 \text{ kg})(503.02 \frac{\text{kJ}}{\text{kg}}) - [(4.573)(286.16) - (2.613)(214.07)] \text{ kJ} \\ &= -288.4 \text{ kJ} \end{aligned}$$

$$Q = 288.4 \text{ kJ (into system)} \quad \left. \right\} 4$$

QUESTION 2 [15]

A hot water stream at 90 °C enters a mixing chamber with a mass flow rate of 1.5 kg/s where it is mixed with a stream of cold water at 30 °C. After mixing, the mixed stream leaves the mixing chamber at 55 °C. Assume kinetic energy and potential energy changes are negligible. The system loses 10 kW of heat. To the surroundings.

Figure 2



- i. Write the conservation of mass equation for the control volume and express the mass flow rate m_3 in terms of the mass flow rates m_1 and m_2

$$\left. \begin{aligned} m_i &= m_e \\ m_1 + m_2 &= m_3 \end{aligned} \right\} 2 \frac{1}{2}$$

Thus $m_3 = m_1 + m_2$

- ii. Determine the specific enthalpies h_1 , h_2 , and h_3 at states 1, 2, and 3 respectively

For water at $T_1 = 90^\circ\text{C}$, $h_1 \approx h_{f \text{ at } 90^\circ\text{C}} = 377.04 \text{ kJ/kg}$

At $T_2 = 30^\circ\text{C}$, $h_2 \approx h_{f \text{ at } 30^\circ\text{C}} = 125.74 \text{ kJ/kg}$

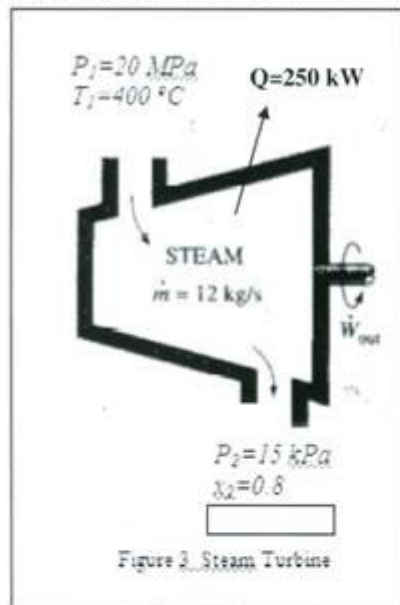
At $T_3 = 55^\circ\text{C}$, $h_3 \approx h_{f \text{ at } 55^\circ\text{C}} = 230.26 \text{ kJ/kg}$

- iii. Applying energy balance on the control volume, determine the mass flow rate of the cold water, m_2 in kg/s

$$\begin{aligned} E_i &= E_e \Rightarrow m_1 h_1 + m_2 h_2 = m_3 h_3 + Q \\ m_1 h_1 + m_2 h_2 &= (m_1 + m_2) h_3 + Q \\ m_2 (h_2 - h_3) &= m_1 (h_3 - h_1) + Q \\ \text{Thus } m_2 &= \frac{m_1 (h_3 - h_1)}{(h_2 - h_3)} + \frac{Q}{(h_2 - h_3)} = 1.5 \left(\frac{230.26 - 377.04}{125.74 - 230.26} \right) + \frac{10 \text{ kW}}{(125.74 - 230.26) \text{ kJ/kg}} \\ m_2 &= 2.011 \text{ kg/s} \end{aligned}$$

QUESTION 3 [15]

Steam flows steadily through the turbine shown in Figure 3. The inlet conditions at state 1 and the outlet conditions at state 2 are shown in the Figure 1. Assume the kinetic and potential energy changes are zero. The turbine loses 250 kW of heat to the surroundings.



Determine

- (i) the specific enthalpy at the inlet, h_1

At $P_1 = 20 \text{ MPa}$
 $T_1 = 400^\circ\text{C}$ we are superheated
 $h_1 = 2816.9 \text{ kJ/kg}$ — 2

- ii) the specific enthalpy at the exit h_2

$$h_2 = h_{f2} + x_2 h_{fg2}$$

$h_{f2} = 225.94 \text{ kJ/kg}$, $h_{fg2} = 2372.3 \text{ kJ/kg}$

$$h_2 = 225.94 + (0.8)(2372.3) = 2123.8 \text{ kJ/kg}$$
 — 3

- (i) By making an energy balance on the turbine, calculate the power output of the turbine in kW.

$$E_{in} = E_{out}$$

$$m h_1 = m h_2 + Q + W$$

$$W = m(h_1 - h_2) - Q$$

$$= (12 \text{ kg/s})(2816.9 - 2123.8) - 250$$

$$\dot{W} = 8,067.4 \text{ kW}$$

85/115 = 74%
Group 5

Fall 2021 Thermodynamics I Test 2 Part A

Answer All Questions

Hunter Evans
Darrian Scull
Jordan Joubert
Manuel Reyes
Safiatou Zampallige

1. Air in a rigid closed vessel is initially at pressure $P_1=100$ kPa, $V_1=100$ oC. The air is heated to a final temperature $T_2=500$ oC. What the work done in kJ? Air in a rigid closed vessel is initially at pressure $P_1=100$ kPa, $V_1=100$ oC. The air is heated to a final temperature $T_2=500$ oC. What the work done in kJ?

$P_1=100$ kPa
 $T_1=100$ °C
 $T_2=500$ °C

$Q=W \cdot \Delta V$
work is 0 kJ because change in volume is 0

2. Refrigerant R-134a at a temperature of 50 °C has a specific volume, $v=0.12766$ m³/kg. The pressure in MPa is

41/60

3

0.20 MPa

How??

3. Air in a rigid closed vessel is initially at $P_1=100$ kPa, $T_1=390$ K, $V_1=12.5$ m³. The air is heated to a final temperature $T_2=770$ K. Assume the air is an ideal gas and that $R=0.287$ kJ/kg and $c_v=0.718$ kJ/kg-K. The total heat transferred in kJ is

$n = \frac{PV}{RAT} = \frac{100 \cdot 12.5}{0.287 \cdot (770-390)} = 11.46$ kg

$T_1=390$
 $T_2=770$ K

$Q = m \cdot c_v \cdot \Delta T$
 $= 11.46 \cdot 0.718 \cdot (770-390)$
 $Q = 3126.74$ kJ

Use energy balance

4. 250 kJ of work goes into a closed system while the system loses 80 kJ of heat. If the initial internal energy of the system was 300 kJ, what is the final internal energy of the system?

300
+250
550
-80
470 kJ

$E_1 - E_{out} + E_{in} = E_2 - E_1$
 $E_2 = 250 - 80 + 300$
 $E_2 = 470$ kJ

Show & sketch with energy input & output

5. A crane lifts a bucket of cement with a mass of 450 kg vertically up with a constant velocity of 2 m/s. Assuming $g=9.81$ m/s², the rate of power in kW used by the crane is

- a) 0.9
- b) 4.42
- c) 8.83

$\dot{W} = (mg) \cdot V = 450 \cdot 9.81 \cdot 2 = 8829$ W

Sample Student Solution

7. If m is the mass and h is the specific enthalpy, then the total enthalpy of a system H is given by

- a) $H=h/m$
- b) $H=m/h$
- c) $H=mh$ ✓
- d) $H=h$
- e) None of the above is correct

8. A cylinder/piston contains 2 kg of air at 100 kPa, 20°C. The air is compressed polytropically to a pressure of 900 kPa. Calculate the absolute value of the work required if the polytropic exponent $n = 1.25$. Assume $R=0.287$ kJ/kg·K. (Hint: First calculate V_1 , and then V_2)

$m=2 \text{ kg}$ $P_1=100 \text{ kPa}$ $T_1=20^\circ\text{C}$
 $n=1.25$ $P_2=900 \text{ kPa}$ $R=0.287$

~~Still wrong!~~
~~Ideal Gas Law~~
 ~~$PV=mRT$~~
 ~~$W = Q = nRT \ln\left(\frac{V_2}{V_1}\right)$~~
 ~~$= 1.25 \cdot 0.287 \cdot 20 \cdot \ln\left(\frac{0.179}{1.05}\right)$~~
 ~~$W = -12.69 \text{ kJ}$~~

$P_1 V_1^n = P_2 V_2^n$
 $V_2 = \sqrt[n]{\frac{P_1 V_1}{P_2}}$
 $V_2 = \sqrt[1.25]{\frac{100 \cdot 1.05}{900}}$
 $V_2 = 0.179$

9. kg of refrigerant R-134a passes through the throttle valve shown. The properties at the inlet are provided on the figure. The refrigerant loses an amount of heat, $Q=15$ kJ as it flows through the valve. By making an energy balance on the system, the computed value of the enthalpy at the exit state 2, h_2 in kJ is

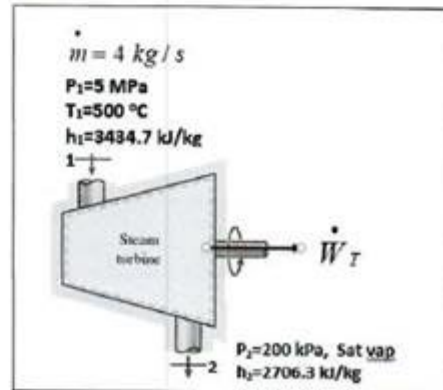
~~Do energy balance~~
 ~~$-W = m(h_2 - h_1)$~~
 ~~$h_2 = \frac{Q}{m} - h_1$~~
 ~~$= \frac{-15}{1} - 101.62$~~
 ~~$h_2 = -116.62 \text{ kJ}$~~

$W=0$



10. By making an energy balance on the turbine shown in the figure, calculate the power output of the turbine in kW

$E_{in} = E_{out}$
 $\dot{m}h_1 = \dot{m}h_2 + \dot{W}_T$
 $\dot{W}_T = \dot{m}(h_1 - h_2)$
 $\dot{W}_T = 4 \cdot (3434.7 - 2706.3)$
 $\dot{W}_T = 2913.6 \text{ kJ/s}$



QUESTION 1 [25]

The 1.5 m^3 rigid tank shown below initially contains air at . The valve connected to the tank is opened allowing air at $P_i=500 \text{ kPa}$, $T_i=500\text{K}$ to enter the tank until the final condition in the tank is $T_2=400 \text{ K}$, $P_2=350 \text{ kPa}$ at which time the valve is completely closed. For air, assume the gas constant $R=0.287 \text{ kJ/kg}\cdot\text{K}$, Read all properties from the air tables.

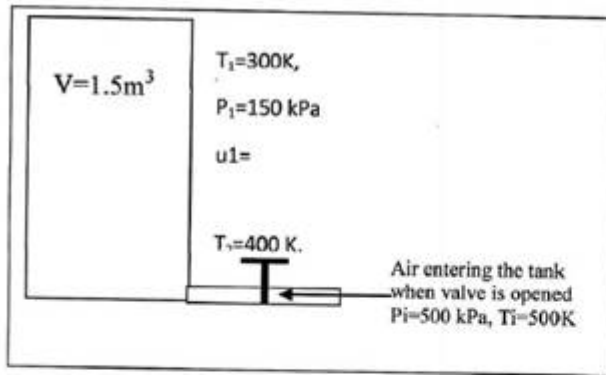


Figure 1

- i. Applying the ideal gas law, calculate the mass of air, m_1 , initially in the tank.

$$PV = mRT$$

$$m_1 = \frac{PV}{RT}$$

$$m_1 = \frac{150 \cdot 1.5}{0.287 \cdot 300} = 2.613 \text{ kg}$$

4

- ii. Calculate the final mass of air, m_2 , in the tank.

$$m_2 = \frac{PV}{RT} = \frac{350 \cdot 1.5}{0.287 \cdot 400} = 4.513 \text{ kg}$$

4

- iii. Applying the law of conservation of mass, calculate the total mass of air, m_i , that entered the tank during the process.

$$m_i = m_2 - m_1$$

$$= 4.577 - 2.613 = 1.964 \text{ kg}$$

$$m_i = 1.96 \text{ kg}$$

4

- iv. Determine the initial and final specific internal energy, u_1 and u_2 of the air in the tank, and the enthalpy h_i at the inlet to the tank/ from the air Tables

$$u_1 = 214.07 \text{ kJ/kg}$$

$$u_2 = 286.16 \text{ kJ/kg}$$

$$h_i = 503.02 \text{ kJ/kg}$$

- v. Determine the specific enthalpy, h_i , of the air entering the tank from the air Tables

$$h_i = 503.02 \text{ kJ/kg}$$

OK

- vi. Making an energy Balance on the system, Calculate the total heat transfer during the process.

$$Q = m_i h_i - (m_2 u_2 - m_1 u_1) \quad \frac{1}{2} \text{ Make Energy Balance}$$

$$Q = 1.96 \cdot 503.02 - (4.577 \cdot 286.16 - 2.613 \cdot 214.07)$$

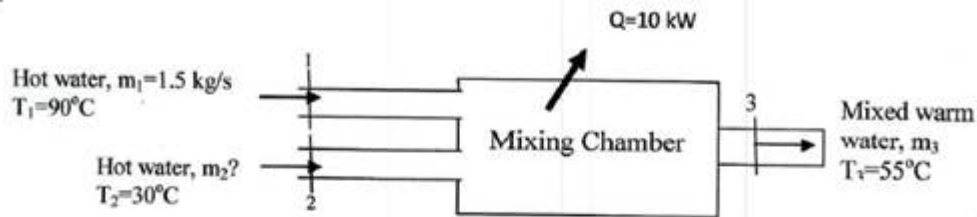
$$Q = 236.67 \text{ kJ}$$

3

QUESTION 2 [15]

A hot water stream at 90 °C enters a mixing chamber with a mass flow rate of 1.5 kg/s where it is mixed with a stream of cold water at 30 °C. After mixing, the mixed stream leaves the mixing chamber at 55 °C. Assume kinetic energy and potential energy changes are negligible. The system loses 10 kW of heat to the surroundings.

Figure 2



12.2
15

- i. Write the conservation of mass equation for the control volume and express the mass flow rate m_3 in terms of the mass flow rates m_1 and m_2

$$\dot{m}_{in} = \dot{m}_{out}$$

$$\dot{m}_1 + \dot{m}_2 = \dot{m}_3$$

✓ 2.2

- ii. Determine the specific enthalpies h_1 , h_2 , and h_3 at states 1, 2, and 3 respectively

$$h_1 = h_f(90^\circ\text{C}) = 376.82 \text{ kJ/kg}$$

$$h_2 = h_f(30^\circ\text{C}) = 125.79 \text{ kJ/kg}$$

$$h_3 = h_f(55^\circ\text{C}) = 230.23 \text{ kJ/kg}$$

iii. Applying energy balance on the control volume, determine the mass flow rate of the cold water, $\dot{m}_2$, in kg/s

$$\begin{aligned} E_{in} &= E_{out} \\ \dot{m}_1 h_1 + \dot{m}_2 h_2 &= \dot{m}_3 h_3 + Q_{out} \quad \checkmark \\ (1.5 \cdot 376.92) + (\dot{m}_2 \cdot 125.79) &= (1.5 + \dot{m}_2) \cdot 230.23 + 10 \\ \dot{m}_2 &= 2.01 \text{ kg/s} \quad \checkmark \end{aligned}$$

iv. How much heat is transferred across the mixing chamber boundary?

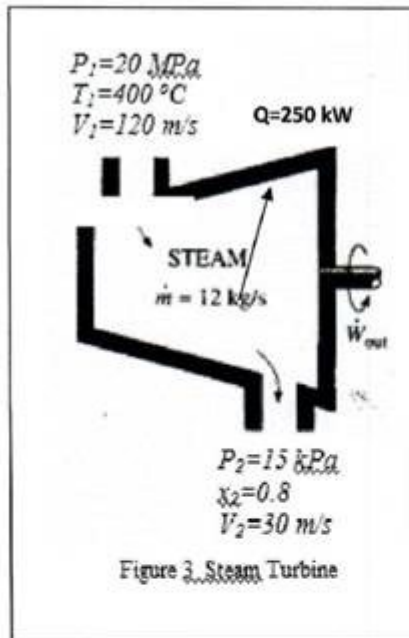
$$\begin{aligned} &h_1 + h_2 + h_3 + Q \\ &\dot{m}_1 h_1 + \dot{m}_2 h_2 + \dot{m}_3 h_3 + Q \\ &(1.5 \cdot 376.92) + (2.01 \cdot 125.79) + (3.5 \cdot 230.23) + 10 \\ &= 1634.0229 \text{ kW} \end{aligned}$$

Q is given!!
-1

QUESTION 3 [15]

Steam flows steadily through the turbine shown in Figure 3. The inlet conditions at state 1 and the outlet conditions at state 2 are shown in the Figure 1. Assume the kinetic and potential energy changes are zero.

The turbine loses 250 kW of heat to the surroundings.



Determine

- (i) the specific enthalpy at the inlet, h_1

$T_1 = 400^\circ\text{C}$
 $P_1 = 20 \text{ MPa}$
 $h_1 = 2916.9 \text{ kJ/kg}$

8/15

Figure 3

Figure 3

- ii) the specific enthalpy at the exit h_2

$P_2 = 15 \text{ kPa}$
 $x_2 = 0.8$

$h_2 = h_f + x h_{fg}$
 $h_2 = 225.41 + 0.8(2254.1 - 225.41)$
 $h_2 = 2026.13 \text{ kJ/kg}$

**MECHANICAL ENGINEERING DEPARTMENT
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET
MCEG 2013 THERMODYNAMICS I
FALL 2021
Instructor: Dr. Paul O. Biney**

Title of Assignment

Test 3

Outcome Measured Using this Assignment

Outcome 8

An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematic.

Check the outcome characteristics related to this assignment

Requires students to	
x	identify engineering problems
x	formulate engineering problems
x	solve engineering problems
Involves the application of the principles of	
x	engineering
	science
	mathematics

Brief justification of why this assignment is suitable for this outcome

- ii. Questions tests students ability to identify, formulate and solve thermodynamics problems

Test 3 Questions, Solution & Grading Scheme

THERMODYNAMICS I FALL 2021 FINAL EXAM PART B ANSWER QUESTION 1 and any other 1 QUESTION

Show your work clearly and answer the sub-questions in the order asked.

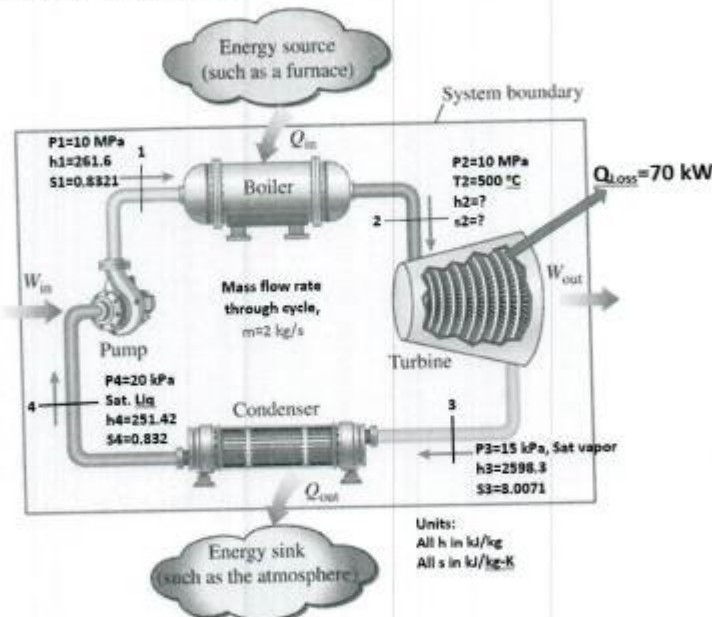
Name Muster Solution

12/07/2021

By writing my name above, I understand and agree that any dishonesty on this exam will result in an "F" grade in the course.

QUESTION 1 [25 Points]

For the steam power cycle shown in the Figure, the mass flow rate of water through the cycle is 2 kg/s. All of the properties at the various state points are indicated in the Figure.



- Find the specific enthalpy h_2 and the specific entropy, s_2 at state 2 from your steam Tables. **Double check your answers to ensure you have read the table correctly.**
- By making an energy balance on the boiler, calculate the rate of heat input to the boiler, Q_{in} in kW
- By making an energy balance on the turbine, calculate the power output of the turbine W_{out} , in kW
- By making an energy balance on the condenser, calculate the rate of heat rejected from the condenser, Q_{out} in kW
- By making an energy balance on the pump, calculate the power input to the pump, W_{in} , in kW
- calculate the net power output, W_{net} , in kW
- Calculate the thermal efficiency of the cycle
- Determine S_{gen} for the Turbine in kW/K and indicate if the turbine process is possible or impossible, reversible or irreversible. Assume the turbine is losing heat to the surroundings at $T_o = 300$ K
- Determine S_{gen} for the condenser in kW/K if the heat is lost to the surroundings at $T_o = 300$ K and indicate if the condenser process is possible or impossible, reversible or irreversible.

a) At $P_2 = 10 \text{ MPa}$, $T_2 = 500^\circ\text{C}$ we have superheated vapor

$$h_2 = 3375.1 \text{ kJ/kg}, \quad s_2 = 6.5995 \text{ kJ/kg-K}$$

(b) $E_{in} = E_{out}$
 $m h_1 + Q_{in} = m h_2$

$$Q_{in} = m(h_2 - h_1)$$

$$Q_{in} = (2 \text{ kg/s})(3375.1 - 261.6) \frac{\text{kJ}}{\text{kg}} = 6227.0 \text{ kW}$$

(c) $E_{in} = E_{out}$

$$m h_2 = Q_{loss} + W_{out} + m h_3$$

$$W_{out} = m(h_2 - h_3) - Q_{loss}$$

$$= (2 \text{ kg/s})(3375.1 - 2598.3) \frac{\text{kJ}}{\text{kg}} = 1483.6 \text{ kW}$$

(d) $E_{in} = E_{out}$

$$m h_3 = m h_4 + Q_{out}$$

$$Q_{out} = m(h_3 - h_4) = (2 \text{ kg/s})(2598.3 - 251.42) \frac{\text{kJ}}{\text{kg}} = 4693.8 \text{ kW}$$

(e) $E_{in} = E_{out}$

$$m h_4 + W_{in} = m h_1$$

$$W_{in} = m(h_1 - h_4) = (2 \text{ kg/s})(261.6 - 251.42) \frac{\text{kJ}}{\text{kg}} = 20.63 \text{ kW}$$

(f) $W_{net} = W_{out} - W_{in}$

$$= (1483.6 - 20.63) \text{ kW} = 1463.2 \text{ kW}$$

(g) $\eta_{th} = \frac{W_{net}}{Q_{in}}$

$$= \frac{1463.2 \text{ kW}}{6227.0 \text{ kW}} = 0.235 \quad (23.5\%)$$

(h) For Turbine $S_{gen} = \Delta S_{sys} + \Delta S_{surr}$

$$= 0 + m s_3 - m s_2 + \frac{Q_{loss}}{T_0}$$

$$= (2 \text{ kg/s})(8.0071 - 6.5995) \frac{\text{kJ}}{\text{kg-K}} + \frac{70 \text{ kW}}{300 \text{ K}}$$

$$S_{gen} = 3.049 \text{ kW/K}$$

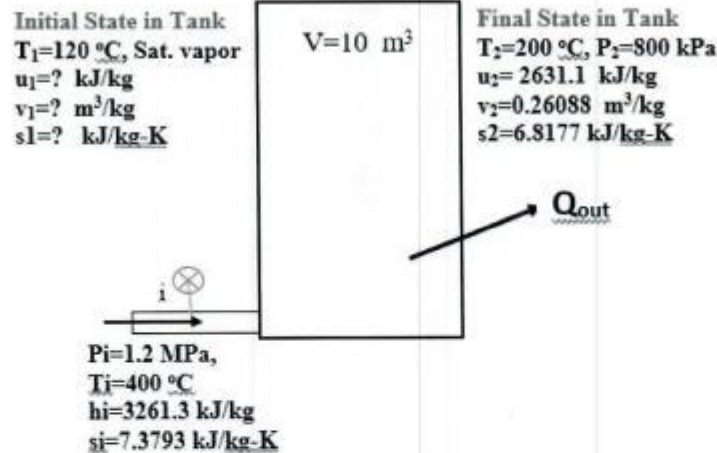
$S_{gen} > 0 \Rightarrow$ process is possible but irreversible

(i) For Condenser, $S_{gen} = \Delta S_{sys} + \Delta S_{surr} = m s_4 - m s_3 + \frac{Q_{out}}{T_0} = (2 \text{ kg/s})(0.832 - 8.007) + \frac{4693.8}{300}$

Bonus
Questions

QUESTION 2 [25 Points]

A rigid tank of volume 10 m^3 initially contains saturated water vapor at a temperature of 120°C . Steam at a pressure 1.2 MPa and a temperature of 400°C enters the tank through a valve in steam line that is connected to the tank until the final pressure in the tank is 800 kPa , at which time the temperature is 200°C . All kinetic and potential energy effects can be neglected. A schematic of the problem and properties at all state points except state 1 are shown in the figure below.



- Given that the initial state of the steam is a saturated vapor at $T_1=120^\circ\text{C}$, read the values of the specific volume, v_1 , specific internal energy, u_1 , and the specific entropy, s_1 at state 1
- Calculate the initial mass, m_1 , of steam in the tank in kg
- Calculate the final mass, m_2 , of steam in the tank in kg
- By making a mass balance on the control volume, calculate the mass of steam that entered the tank, m_i , in kg
- By making an energy balance on the system and assuming the system lost heat as shown on the diagram, compute the heat lost Q_{out} during the process in kJ
- Calculate the entropy change of the system, ΔS_{system} in kJ/K
- Calculate the entropy change of the surrounding, ΔS_{sur} in kJ/K, if the heat is lost to the surrounding at $T_b=300 \text{ K}$
- Calculate the entropy generated, S_{gen} in kJ/K
- From your answer for S_{gen} , explain whether the process as described is possible or impossible, reversible or irreversible,

(a) At $T_1 = 120^\circ\text{C}$, Saturated Vapour
 $S_1 = S_g = 7.1292 \text{ kJ/kg-K}$ $V_1 = 0.89133 \text{ m}^3/\text{kg}$
 $u_1 = u_g = 2528.9 \text{ kJ/kg-K}$ } 3

(b) $m_1 = \frac{V}{V_1} = \frac{10 \text{ m}^3}{0.89133 \text{ m}^3/\text{kg}} = 11.22 \text{ kg}$ } 3

(c) $m_2 = \frac{V}{V_2} = \frac{10 \text{ m}^3}{0.26088 \text{ m}^3/\text{kg}} = 38.33 \text{ kg}$ } 3

(d) $m_i - m_e = m_2 - m_1$ $m_e = 0$
 $m_i = m_2 - m_1 = (38.33 - 11.22) \text{ kg} = 27.11 \text{ kg}$ } 3

(e) $E_{in} - E_{out} = E_2 - E_1$
 $m_i h_i - Q_{out} = m_2 u_2 - m_1 u_1$
 $Q_{out} = m_i h_i - (m_2 u_2 - m_1 u_1)$
 $= (27.11 \text{ kg})(3261.3 \text{ kJ/kg}) - [(38.33)(2631.1) - (11.22)(2528.9)] \text{ kJ}$
 $= 15,939.8 \text{ kJ}$ } 3

(f) $\Delta S_{\text{system}} = m_2 s_2 - m_1 s_1$
 $= (38.33 \text{ kg})(6.8177 \frac{\text{kJ}}{\text{kg-K}}) - (11.22 \text{ kg})(7.1292 \frac{\text{kJ}}{\text{kg-K}})$
 $= 181.4 \frac{\text{kJ}}{\text{K}}$ } 1/2

(g) $\Delta S_{\text{surr}} = -m_i s_i + \frac{Q_{out}}{T_0}$
 $= -(27.11 \text{ kg})(7.3793 \frac{\text{kJ}}{\text{kg-K}}) + \frac{15,939.8}{300}$
 $= -146.9 \frac{\text{kJ}}{\text{K}}$ } 1/2

(h) $S_{\text{gen}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}}$
 $= (181.4 - 146.9) \frac{\text{kJ}}{\text{K}}$
 $= 34.5 \frac{\text{kJ}}{\text{K}}$ } 1/2

(i) $S_{\text{gen}} > 0$ This process as described is possible but irreversible } 1/2

QUESTION 3 [25 Points]

Air contained in a piston cylinder arrangement is expanded in a polytropic process from $P_1=900\text{ kPa}$, $V_1=0.05\text{ m}^3$, $T_1=400\text{ }^\circ\text{C}$ to $P_2=170\text{ kPa}$. The polytropic index, $n=1.2$. Assume that the air is an ideal gas with constant specific heats and that $R=0.287\text{ kJ/kg}\cdot\text{K}$, $c_p=1.005\text{ kJ/kg}\cdot\text{K}$ and $c_v=0.718\text{ kJ/kg}\cdot\text{K}$.

- Show the process on a $P=V$ diagram
- Calculate the final total volume V_2 , in m^3 .
- Calculate the work done, W in kJ and indicate the direction of the work as input or output. Make a sketch of the system and indicate the direction of the work
- Calculate the mass of air in the system in kg .
- Calculate the final temperature, T_2 , in K
- Applying energy balance to the system, calculate the heat transfer, Q in kJ and indicate whether it is heat input or output. Show the direction of the heat input or output on a sketch of the system.
- Calculate the entropy change of the system in kJ/K
- Calculate the entropy change of the surroundings if the surrounding is at $T_o=300\text{ K}$
- Calculate S_{gen} and from the value of S_{gen} , indicate whether the process is possible or impossible, reversible or irreversible.

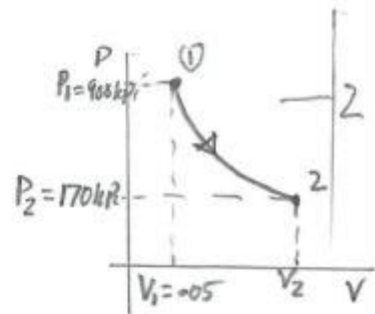
(a) Polytropic expansion process

$$(b) \quad P_2 V_2^{1.2} = P_1 V_1^{1.2}$$

$$V_2^{1.2} = V_1^{1.2} \left(\frac{P_1}{P_2} \right)$$

$$V_2 = V_1 \left(\frac{P_1}{P_2} \right)^{\frac{1}{1.2}} = 0.05 \text{ m}^3 \left(\frac{900}{170} \right)^{\frac{1}{1.2}}$$

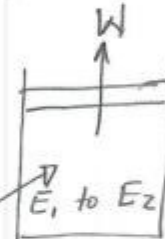
$$V_2 = 0.2005 \text{ m}^3$$



$$(c) \quad W = \frac{P_2 V_2 - P_1 V_1}{1-n}$$

$$= \frac{(170 \text{ kPa})(0.2005 \text{ m}^3) - (900 \text{ kPa})(0.05 \text{ m}^3)}{1-1.2}$$

$$W = 54.57 \text{ kJ}$$



$$(d) \quad P_1 V_1 = m R \bar{T}_1 \quad \bar{T}_1 = \frac{400 + 273.15}{2} = 673.15 \text{ K}$$

$$m = \frac{P_1 V_1}{R \bar{T}_1} = \frac{(900 \text{ kPa})(0.05 \text{ m}^3)}{(0.287 \frac{\text{kJ}}{\text{kg} \cdot \text{K}})(673.15 \text{ K})}$$

$$m = 0.2329 \text{ kg}$$

$$(e) \quad P_2 V_2 = m R \bar{T}_2 \Rightarrow \bar{T}_2 = \frac{P_2 V_2}{m R}$$

$$\bar{T}_2 = \frac{(170 \text{ kPa})(0.2005 \text{ m}^3)}{(0.287 \frac{\text{kJ}}{\text{kg} \cdot \text{K}})(0.2329)} = 509.9 \text{ K}$$

$$(f) \quad E_{in} - E_{out} = E_2 - E_1$$

$$Q - W = m(u_2 - u_1)$$

$$Q = W + m(u_2 - u_1)$$

$$= 54.57 \text{ kJ} + (0.2329 \text{ kg})(0.718 \frac{\text{kJ}}{\text{kg} \cdot \text{K}})(509.9 - 673.15) \text{ K}$$

$$= 27.27 \text{ kJ}$$

$$(g) \quad \Delta S_{\text{system}} = m(s_2 - s_1) = m \left[c_p \ln \left(\frac{T_2}{T_1} \right) - R \ln \left(\frac{P_2}{P_1} \right) \right]$$

$$= (0.2329) \left[1.005 \ln \left(\frac{509.9}{673.15} \right) - 0.287 \ln \left(\frac{170}{900} \right) \right] = 0.0464 \frac{\text{kJ}}{\text{K}}$$

$$(h) \quad \Delta S_{\text{sur}} = -\frac{Q}{T} = -\frac{27.27}{300} = -0.09088 \frac{\text{kJ}}{\text{K}}$$

Sample Student Solution

Make-Up Test Part A Worksheet

Name Tyson Morris

Write the question number followed by your solution

By writing my name above, I understand and agree that any dishonesty on this exam will result in an "F" grade in the course.

$$1) \Delta e_{\text{mech}} = \frac{V_2^2 - V_1^2}{2} = \frac{15^2 - 0^2}{2} = \frac{225}{2} = 112.5 \text{ J/kg}$$

$$\text{Power} = \dot{m} \Delta e \quad \dot{m} = \rho \dot{V} \\ (0)(112.5) \quad \dot{m} = (0.2)(5) \\ \boxed{= 675 \text{ W}} \quad \dot{m} = 0$$

$$2) v = \frac{V}{m} \quad V_{\text{air}} = 10 \text{ m/s} = 45 \text{ ft/s} = 0.024436 \text{ m/s} \\ m = \frac{V}{v} = \frac{7.5}{0.024436} \\ \boxed{m = 285.7 \text{ kg}}$$

$$3) 1.8 \Delta C = \Delta F \\ 1.8(250) = \Delta F = 450^\circ \text{F}$$

$$4) P_R = \frac{P}{P_i} = \frac{66.4}{33.2} = 2 \\ T_c = \frac{T}{T_i} = \frac{12.35}{9.5} = 1.3 \\ \boxed{Z = 0.7}$$

$$5) PV = mRT \quad 12.35 \text{ K} \times \frac{5}{9} = \text{K} \\ (66.4)(5.5) = m(0.4461)(0.7801) \\ 332 = m(3.404) \\ \boxed{59.2 \text{ mol} = m}$$

$$7) \eta = \frac{W_{\text{out}}}{W_{\text{in}}} = \frac{3000}{7500} = 0.4 = \boxed{40\%}$$

$$8) \eta_{\text{th, cv}} = 1 - \frac{T_L}{T_H} \quad \frac{400 + 273 + 673}{27 + 273 + 300} \\ 1 - \frac{300}{673} = 0.55 = \boxed{55\%}$$

$$10) W_{\text{in}} = 27 \text{ kW} \quad \dot{m} = \rho \dot{V} \\ (1000)(0.1) \\ \dot{m} = 100 \text{ kg/s} \\ P_{\text{out}} = \dot{m} \Delta e \quad \Delta e_{\text{mech}} = \Delta PE \\ (100)(218.25) \quad g(Z_2 - Z_1) \\ P_{\text{out}} = 21825 \text{ W} \quad (9.81)(25) \\ P_{\text{out}} = 21.825 \text{ kW} \quad 245.25 \text{ J/kg} \\ \Delta e = 245.25 - 27 = 218.25 \text{ J/kg} \\ \eta = \frac{P_{\text{out}}}{P_{\text{in}}} = \frac{21.825}{27} \\ = 0.81 = \boxed{81\%}$$

$$11) W = \frac{V_2^2 - V_1^2}{2} \quad V_1 = \frac{3.5}{2.5} = 1.4 \text{ m/s} \\ V_2 = \frac{1}{2.5} = 0.4 \text{ m/s}$$

$$13) W = \frac{V_2^2 - V_1^2}{2} = \frac{1.5^2 - 0.5^2}{2} = 1 \text{ J} \\ E = \frac{1}{2} m V^2$$

THERMODYNAMICS I
FALL 2021 FINAL EXAM PART B
ANSWER QUESTION 1 and any other 1 QUESTION

Show your work clearly and answer the sub-questions in the order asked.

37
50

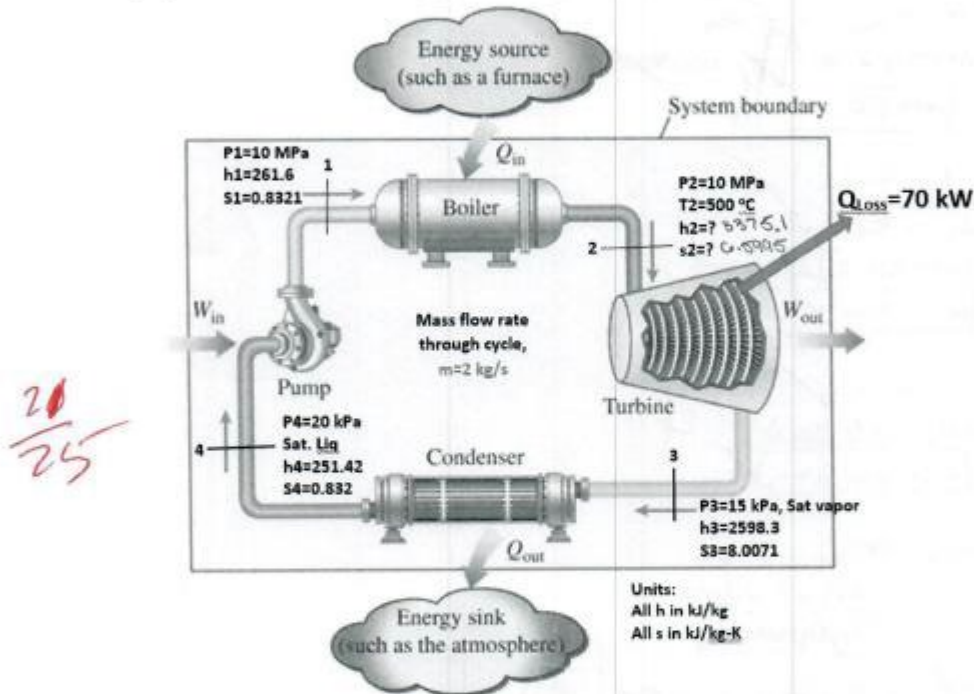
Name Tyson Morris

12/07/2021

By writing my name above, I understand and agree that any dishonesty on this exam will result in an "F" grade in the course.

QUESTION 1 [25 Points]

For the steam power cycle shown in the Figure, the mass flow rate of water through the cycle is 2 kg/s. All of the properties at the various state points are indicated in the Figure.



- Find the specific enthalpy h_2 and the specific entropy, s_2 at state 2 from your steam Tables. *Double check your answers to ensure you have read the table correctly.*
- By making an energy balance on the boiler, calculate the rate of heat input to the boiler, Q_{in} in kW
- By making an energy balance on the turbine, calculate the power output of the turbine W_{out} , in kW
- By making an energy balance on the condenser, calculate the rate of heat rejected from the condenser, Q_{out} in kW
- By making an energy balance on the pump, calculate the power input to the pump, W_{in} , in kW
- calculate the net power output, W_{net} , in kW
- Calculate the thermal efficiency of the cycle
- Determine S_{gen} for the Turbine in kW/K and indicate if the turbine process is possible or impossible, reversible or irreversible. Assume the turbine is losing heat to the surroundings at $T_o=300$ K
- Determine S_{gen} for the condenser in kW/K if the heat is lost to the surroundings at $T_o=300$ K and indicate if the condenser process is possible or impossible, reversible or irreversible.

a) $h_2 = 3375.1 \text{ kJ/kg}$
 $z_2 = 6.5995 \text{ kJ/kg} \cdot \text{K}$

b) $E_{in} = E_{out}$
 $m h_1 + Q_2 = m h_2$
 $2(2514.2) + Q_{in} = 2(3375.1)$
 $5028.2 + Q_{in} = 6750.2$
 $Q_{in} = 1722 \text{ kW}$

c) $E_{in} = E_{out}$
 $m h_2 = Q_{in} + W_{in} + m h_3$
 $2(3375.1) = 70 + W_{in} + 2(2514.2)$
 $1489.6 \text{ kW} = W_{in}$

d) $E_{in} = E_{out}$
 $m h_3 = Q_{in} + m h_4$
 $2(2514.2) = Q_{in} + 2(2514.2)$
 $4093.76 \text{ kW} = Q_{in}$

e) $m h_4 + W_{in} = m h_3$
 $2(2514.2) + W_{in} = 2(2514.2)$
 $W_{in} = 0 \text{ kW}$

f) $W_{net} = E_{out}$
 $= 1489.6 + 4093.76$
 5583.36 kW

g) $\eta_{net} = \frac{W_{net}}{Q_{in}} = \frac{5583.36}{6273.96} = 0.891$

h) $S_{gen} = \Delta S_{sys} + \Delta S_{surr}$
 $(m_2 s_2 - m_1 s_1) + (m_3 s_3 - m_4 s_4) - \frac{Q_1}{T_1}$
 $(2(6.5995) - 2(6.5995)) + (2(6.5995) - 2(6.5995)) - \frac{-70}{-300}$
 $2.2152 + 2.2152 - 0.233$
 $5.397 \text{ kJ/kg} \cdot \text{K}$

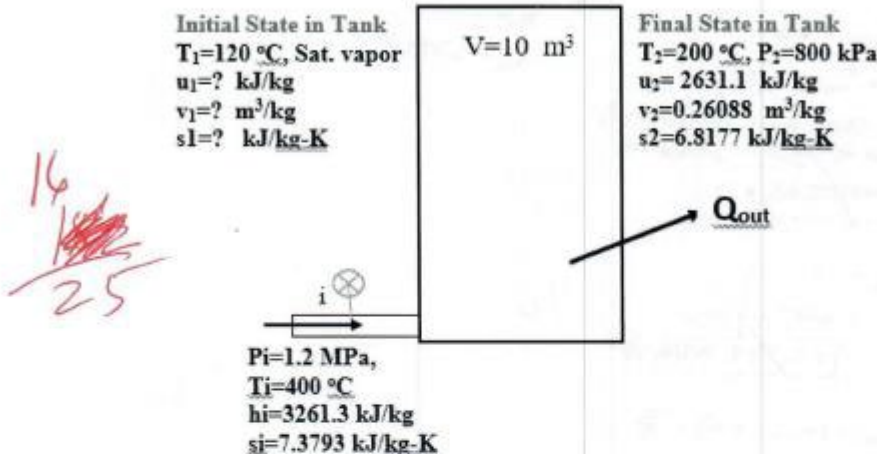
possible, irreversible

i) $S_{gen} = (m_3 s_3 - m_2 s_2) + (m_4 s_4 - m_1 s_1) - \frac{Q_1}{T_1}$
 $(2(6.5995) - 2(6.5995)) + (2(6.5995) - 2(6.5995)) - \frac{-4093.76}{-300}$
 $-14.3602 + -14.3602 - 13.65$
 $-42.3704 \text{ kJ/kg} \cdot \text{K}$

impossible, irreversible

QUESTION 2 [25 Points]

A rigid tank of volume 10 m^3 initially contains saturated water vapor at a temperature of 120°C . Steam at a pressure 1.2 MPa and a temperature of 400°C enters the tank through a valve in steam line that is connected to the tank until the final pressure in the tank is 800 kPa , at which time the temperature is 200°C . All kinetic and potential energy effects can be neglected. A schematic of the problem and properties at all state points except state 1 are shown in the figure below.



- Given that the initial state of the steam is a saturated vapor at $T_1 = 120^\circ\text{C}$, read the values of the specific volume, v_1 , specific internal energy, u_1 , and the specific entropy, s_1 at state 1
- Calculate the initial mass, m_1 , of steam in the tank in kg
- Calculate the final mass, m_2 , of steam in the tank in kg
- By making a mass balance on the control volume, calculate the mass of steam that entered the tank, m_i , in kg
- By making an energy balance on the system and assuming the system lost heat as shown on the diagram, compute the heat lost Q_{out} during the process in kJ
- Calculate the entropy change of the system, ΔS_{system} in kJ/K
- Calculate the entropy change of the surrounding, ΔS_{sur} in kJ/K, if the heat is lost to the surrounding at $T_b = 300 \text{ K}$
- Calculate the entropy generated, S_{gen} in kJ/K
- From your answer for S_{gen} , explain whether the process as described is possible or impossible, reversible or irreversible.

a) $v_1 = 0.89133 \text{ m}^3/\text{kg}$
 $u_1 = 2528.9 \text{ kJ/kg}$
 $s_1 = 7.1292 \text{ kJ/kg-K}$

b) $v_1 = \frac{V}{m_1}$
 $0.89133 = \frac{10}{m_1}$
 $m_1 = 11.22 \text{ kg}$

c) $v_2 = \frac{V}{m_2}$
 $0.26088 = \frac{10}{m_2}$
 $m_2 = 38.3 \text{ kg}$

d) $m_2 - m_1 = \Delta m = m_i$
 $38.3 - 11.22 = \Delta m = m_i$
 $\boxed{27.08 \text{ kg} = \Delta m = m_i}$

e) $E_{in} = E_{out}$
 $m h_1 = Q_{out} + m h_2$
 $(11.22)(1700) = Q_{out} + (38.3)(2899.8)$
 $30301.82 = Q_{out} + 108064.24$
 $\boxed{-78903.02 \text{ kJ} = Q_{out}}$

$h_1 = 2706.0$
 $h_2 = 2899.8$

f) $\Delta S_{sys} = S - S_i$
 $= 0.3177 - 1.1292$
 $\boxed{-0.8115 \text{ kJ/kg} \cdot \text{K}}$

g) $\Delta S_{sur} = (m e_2 - m e_1) - \frac{Q_i}{T_i}$
 $-0.8115 + (10)(0) - \frac{(11.22)(1700)}{300}$
 $\boxed{3411.02 \text{ kJ/kg} \cdot \text{K}}$

h) $S_{gen} = \Delta S_{sys} + \Delta S_{sur}$
 $-0.8115 + 3411.02$
 $\boxed{34071 \text{ kJ/kg} \cdot \text{K}}$

i) possible, irreversible why? $\frac{1}{2}$