Course File Checking Mechanism

1. Faculty need prepare the course file for all courses allotted to him/her. Course file must contain the following documents.

   i. Institute Academic calendar
   ii. Personal authenticated time table
   iii. Department Vision, Mission, PO, PEO and PSO's
   iv. Approved syllabus
   v. Approved students list for assigned course
   vi. Course plan (May use Ioncudos Format) –ISE plan, course articulation matrix, List of probable ICT tools and active learning tools to be used during course delivery and assessment.
   vii. UT1 and UT2 Question paper and sample answer sheets
   viii. Conduct and upload Course end survey on Moodle
   ix. ESE Question paper and Model Answer
   x. CO –PO Attainment Calculation (as per standard template circulated earlier)
   xi. Attainment Analysis & Action taken report
   xii. Upload study material on Moodle and provide the corresponding links
   xiii. Add recent journal paper relevant to your course contents.

2. Faculty will get it checked from Module Coordinator of the department.

3. If Module coordinator finds any lacunae in the course file, he/she will discuss this with concerned faculty and get it done from him. Finally, Module coordinator will give a remark on a form (Annexure-II) Guidelines regarding course file levels are given in Annexure-I

4. Module coordinator will submit the Annexure-II report to HoD.

5. HoD will verify this report with random file checking and submit the report (Annexure-III) to the Dean Academics.

5. Based on the report of Annexure-III, Academic Planning & Implementation team will call the files randomly from the departments for verification.

K. E. Society's

Rajarambapu Institute of Technology, Sakharale

(An Autonomous Institute affiliated to Shivaji University, Kolhapur)

Academic Calendar: 2023-2024 (Semester-I)

F. Y. B. Tech to Final Year B. Tech, F. Y. M. Tech, F. Y. MBA, F. Y. MBA (IEV)

Wk	August 2023							Particulars
	S	M	T	W	T	F	S	
1			1	2	3	4	5	August 7 to 18 : Deksharambh- Student Induction Program' for F. Y. B. Tech
2	6	7	8	9	10	11	12	August 17 to 18 : Induction program for F. Y. MBA & F. Y. MBA-IEV students
3	13	14	15	16	17	18	19	August 21 : Commencement of Instructional Activities for Semester I
4	20	21	22	23	24	25	26	August 28 to 31 : Declaration of ISE plan for all courses
5	27	28	29	30	31			
Academic Days: 09								*Probable Holidays: Independence Day: 15th August, Raksha Bandhan: 30th August.*

Wk	September 2023							Particulars
	S	M	T	W	T	F	S	September 21 to 23 : Unit Test - I
						1	2	September 29 to 30 : Display of attendance & defaulter list for month of August & September 2023 and counselling of students
6	3	4	5	6	7	8	9	
7	10	11	12	13	14	15	16	
8	17	18	19	20	21	22	23	
9	24	25	26	27	28	29	30	
Academic Days: 24								*Probable Holidays: Ganesh Chaturthi: 19th September, Eid-e-Milad: 28th September.*

Wk	October 2023							Particulars
	S	M	T	W	T	F	S	October 11 to 12 : Technical Events of all Departments. 1. Civil-Vastu 2. CSE-Technospere 3. Electrical -Enthuse 4. MBA-Vision
10	1	2	3	4	5	6	7	October 13 to 14 : Virangula - Cultural Event of RIT.
11	8	9	10	11	12	13	14	October 16 : Sharadanyas 2023
12	15	16	17	18	19	20	21	October 20 to 21 : Capstone project Review-I
13	22	23	24	25	26	27	28	October 30 to 31 : Display of attendance & defaulter list for month of October 2023 and counselling of students
14	29	30	31					October 30 to 31 And Nov. 1 : Unit Test -2
Academic Days: 20								*Probable Holidays: Birth Anniversary of Mahatma Gandhi : 2nd October, Dussehra: 24th October.*

Wk	November 2023							Particulars
	S	M	T	W	T	F	S	November 24 to 25 : Capstone project Review-II
				1	2	3	4	November 27 to 28 : Display of attendance & defaulter list for month of November 2023 and counselling of students
15	5	6	7	8	9	10	11	
16	12	13	14	15	16	17	18	
17	19	20	21	22	23	24	25	
18	26	27	28	29	30			
Academic Days: 21								*Probable Holidays: Diwali: 12th to 17th November*

Wk	December -2023							Particulars
	S	M	T	W	T	F	S	December 6 : End of Instructional Activities
						1	2	December 7 : Submission of ISE+UT 1+ UT 2 marks to exam center
19	3	4	5	6	7	8	9	December 8 : DPC/DPGC meeting to finalize 'XX' grades by department
20	10	11	12	13	14	15	16	December 9 : ADC meeting and display of final 'XX' grade and detention list
21	17	18	19	20	21	22	23	December 13 to 27 : End Semester Examination for Theory Course
22	24	25	26	27	28	29	30	December 28 to 29 : End Semester Examination for Practical Course & Capstone project
23	31							January 10 (2024) : Result Declaration
Academic Days: 19								*Probable Holidays: Christmas: 25th December.*
Total Academic Days: 90.								**15th January, 2024: Commencement of Instructional Activities for Semester II of F. Y. B. Tech**

Commencement and End of Instructional Activities	UT1, UT2, ESE
Cultural and Technical Events	Holiday
Sunday	

Coordinator Academic

Dean Academics

Director

Revision No./Date- 8/17-10-2023

K.E.Society's
Rajarambapu Institute of Technology,Rajaramnagar
Department of Mechanical Engineering
Personal Time Table
2023-24 / PART-I

Staff Name: Dr.S.D. Patil

PG	Lectures:	3	Practicals:	4	Tutorials:		Project:	IIP	ED	CAP	URE	MinPro	Sem	Total	19
UG	Lectures:	6	Practicals:	4	Tutorials:					2					

Sr.No	Time	Monday			Tuesday			Wedensday			Thursday			Friday			Saturday		
0	09:10 To 10:10																		
1	10:10 To 11:10	SY-A	ETH	M401	M Tech MT1	TE Lab	PG-ThCL												
2	11:10 To 12:10							SY-A	ETH	M401	B Tech Cap-Project								
3	12:10 To 12:55	LUNCH BREAK																	
4	12:55 To 01:55	B.TECH B	PE-IV-ICE	TRIB-Lab	TY B1	HT Lab	HTL	M Tech MT1	TE Lab	PG-ThCL	B.TECH B	PE-IV-ICE	CR206	M Tech MT1	AIC	CR205			
5	01:55 To 02:55	M Tech MT1	AIC	CR205							B Tech Cap-Project			M Tech MT1	AIC	CR205			
6	02:55 To 03:10	RECESS																	
7	03:10 To 04:10				SY-A	ETH	M401							B.TECH-B1	ICE Lab	CNCL1			
8	04:10 To 05:10							B.TECH B	PE-IV-ICE	CR206									
9	05:10 To 06:10																		

19

Time Table Incharge

HOD

Vision

To transform the department into center of excellence by synergizing teaching, learning and research to produce globally competent, innovative and entrepreneurial Mechanical Engineers.

Mission

- To develop state of the art facilities to stimulate faculty, staff and students to create, analyze, apply and disseminate knowledge.
- To build the competency to transform students into globally competent mechanical engineers by imparting quality education.
- To collaborate with research organizations, reputed educational institutions, industries and alumni for excellence in teaching, research and consultancy practices.

Programme Educational Objectives (PEOs):

- Graduates will contribute to social reformation through their devotion in science and technology leading to uplifted standard of living.
- Graduates will provide solutions to global technological challenges being entrepreneurs, consultants and researchers following ethical practices.
- Graduates will update themselves through lifelong learning such as higher studies, cutting edge research, skill enhancement and other professional activities.

Programme Outcomes (POs):

After successful completion of B. Tech. (Mechanical) program students will be able to:

- Apply the knowledge of mathematics, science, engineering fundamentals, and mechanical engineering to the solution of complex engineering problems.
- Identify, formulate, review research literature, and analyze complex mechanical engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- Design solutions for complex mechanical engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

- Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex mechanical engineering activities with an understanding of the limitations.
- Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- Communicate effectively on complex mechanical engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- Recognize the need for, and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

After successful completion of B. Tech. (Mechanical) program student will be able to:

- Use Company standards, national and international standards like IS BS, SAE, ISO, ASTM etc for designing and manufacturing of mechanical components and systems.
- Engage professionally in industries or as an entrepreneur by applying manufacturing, design, thermal and management practices.

Class:- **S Y B Tech Mech.**	Semester-III
Course Code :**ME2134**	Course Name : **Engineering Thermodynamics**

L	T	P	Credits
3	--	--	3

Course Description:
The aim of this course is to provide students the basic concepts of thermodynamic systems and their applications. It also covers the basic properties of gases, liquids and vapors (specific heat capacities), energy, entropy, enthalpy, exergy, anergy, laws of thermodynamics, vapor power cycles; ideal gas mixtures; and efficiencies of energy conversion systems, such as boilers, turbines, condensers, pump and the use of steam tables to gather energy properties of the steam at different conditions. The effective moving the heat energy generated in the various processes in the steam power plant is computed.

Course Learning Outcomes:
After successful completion of the course, students will be able to,
1. Apply thermodynamics principles to mechanical engineering applications
2. Describe entropy, change in entropy and increase of entropy principle.
3. Differentiate between available and unavailable energy with examples.
4. Recognize the properties of pure substances and use thermodynamic property tables charts.
5. Apply mathematical fundamental to study the properties of steam gas and gas mixtures
6. Explain the air and vapor power cycles and calculate cycle performance.

Prerequisite:
Students should know Concept of energy, work, heat and conversion between them.

Course Content

Unit No	Description	Hrs.
1.	**Basic Concepts:** Thermodynamics system, Microscopic & macroscopic point of view, thermodynamic system and control volume, thermodynamic properties, processes and cycles, Thermodynamic equilibrium, Quasi-Static process, Zeroth law of thermodynamics **First law of Thermodynamics**: First law for a closed system undergoing a cycle and change of state, energy, PMM1, first law of thermodynamics for steady flow process, steady flow energy equation applied to nozzle, diffuser, boiler, turbine, compressor, pump. (Numerical Treatment)	06
2.	**Second law of thermodynamics:** Limitations of first law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, PMM2, causes of irreversibility, Carnot	06

	theorem, corollary of Carnot theorem, thermodynamic temperature scale. **Entropy:** Clausius theorem, property of entropy, inequality of Clausius, entropy change in an irreversible process, principle of increase of entropy, entropy change for non-flow and flow processes, third law of thermodynamics (Numerical Treatment)	
3.	**Availability**: Energy of a heat input in a cycle, exergy destruction in heat transfer process, exergy of finite heat capacity body, exergy of closed and steady flow system, irreversibility second law efficiency (Numerical Treatment).	**06**
4.	**Properties of gases and gas mixtures:** Mole and Mass fraction, Dalton's and Amagat's Law. Properties of gas mixture – Molar mass, gas constant, density, change in internal energy, enthalpy, entropy and Gibbs function. Avogadro's law, equation of state, ideal gas equation, Vander Waal's equation, reduced properties, law of corresponding states, compressibility chart, Gibbs Dalton law, internal energy; enthalpy and specific heat of a gas mixtures, Simple Calculations (Numerical Treatment).	**06**
5.	**Properties of Pure Substances:** Formation of steam and its thermodynamic properties, p-v, p-T, T-v, T-s, h-s diagrams. p-v-T surface. Use of Steam Table and Mollier Chart. Determination of dryness fraction. Application of 1st and 2nd law for pure substances (Numerical Treatment).	**06**
6.	**Air and Vapor Power Cycles:** Air standard cycles, Carnot, Otto and Diesel, Carnot cycle using steam, limitations of Carnot cycle, Rankine cycle, representation on T-s and h-s planes, thermal efficiency, specific steam consumption. Work ratio, effect of steam supply pressure and temperature, condenser pressure on the performance. (Numerical Treatment).	**06**

References: -

Text Books:
- P.K. Nag, Engineering Thermodynamics, Tata McGraw Hill, New Delhi.
- Ballaney P.L., Thermal Engineering, Khanna Publishers, New Delhi.
- Kumar and Vasandani, Thermal Engineering, Metropolitan Book Co, Delhi.
- R. Yadav, Steam & Gas Turbines, CPH Allahabad.
- B. K. Sarkar, Thermal Engineering, Tata McGraw Hill.
- R. K. Rajput, Thermal Engineering, Laxmi Publications, New Delhi.
- Mahesh M Rathore, Thermal Engineering, McGraw Hill Education, New Delhi.

Reference Books:
- J P Holman, Thermodynamics, McGraw Hill, London.
- Wylen Van, G. J. & Sonntag R. E., Fundamentals of Classical Thermodynamics, John Wiley & Son, 6th edition, 2002.
- Yunus A. Cengel, Thermodynamics an Engineering Approach, Tata McGraw Hill.

Data Book:
- S. C. Jain, Steam Tables, Birla Publications Pvt. Ltd. Delhi, 16th edition, 2007.

25 Aug

Kasegaon Education Society (KES)

Rajarambapu Institute of Technology (RIT)

Mechanical Engineering

Curriculum: B.Tech. in ME 2023-2024 (2022-2026 cycle)	**Semester: 3**
Course: Engineering Thermodynamics (ME2032)	
Course faculty: Dr. Sharad D. Patil	

Course Outcomes (COs):

At the end of the course the student should be able to:

1. Apply thermodynamics principles to mechanical engineering applications
2. Describe entropy, change in entropy and increase of entropy principle
3. Differentiate between available and unavailable energy with examples
4. Recognize the properties of pure substances and use thermodynamic property tables, charts
5. Apply mathematical fundamental to study the properties of steam gas and gas mixtures
6. Explain the air and vapor power cycles and calculate cycle performance

Course Articulation Matrix: Mapping of (COs) with (POs)

Course Outcomes (COs) / Program Outcomes (POs)	PO_1	PO_2	PO_3	PO_4	PO_5	PO_6	PO_7	PO_8	PO_9	PO_10	PO_11	PO_12	PSO_1	PSO_2
1. Apply thermodynamics principles to mechanical engineering applications	3				1									
2. Describe entropy, change in entropy and increase of entropy principle	3													
3. Differentiate between available and unavailable energy with examples	3													
4. Recognize the properties of pure substances and use thermodynamic property tables, charts	3				1									
5. Apply mathematical fundamental to study the properties of steam gas and gas mixtures	3													
6. Explain the air and vapor power cycles and calculate cycle performance	3		3		1									

Course Content

Content	Hrs
Chapter No. 1 - Basic Concepts and First Law of Thermodynamics Basic Concepts: Thermodynamics system, Microscopic & macroscopic point of view, thermodynamic system and control volume, thermodynamic properties, processes and cycles, Thermodynamic equilibrium, Quasi-Static process, Zeroth law of thermodynamics. First law of Thermodynamics: First law for a closed system undergoing a cycle and change of state, energy, PMM1, first law of thermodynamics for steady flow process, steady flow energy equation applied to nozzle, diffuser, boiler, turbine, compressor, pump, (Numerical Treatment).	6
Chapter No. 2 - Second Law of Thermodynamics and Entropy Second law of thermodynamics: Limitations of first law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, PMM2, causes of irreversibility, Carnot theorem, corollary of Carnot theorem, thermodynamic temperature scale. Entropy: Clausius theorem, property of entropy, inequality of Clausius, entropy change in an irreversible process, principle of increase of entropy, entropy change for non-flow and flow processes, third law of thermodynamics (Numerical Treatment).	6
Chapter No. 3 - Availability Energy of a heat input in a cycle, exergy destruction in heat transfer process, exergy of finite heat capacity body, exergy of closed and steady flow system, irreversibility and Gouy-Stodola theorem and its applications, second law efficiency (Numerical Treatment).	6
Chapter No. 4 - Properties of Gas Mixture and Thermodynamic Relations Mole and Mass fraction, Dalton's and Amagat's Law. Properties of gas mixture – Molar mass, Gibbs Dalton law gas constant, (Numerical Treatment). Thermodynamic Relations: Change in internal energy, enthalpy, entropy and Gibbs function. Joule-Thomson Coefficient, Clausius Clapeyron equation.	6
Chapter No. 5 - Properties of Pure Substances Phase Change Process, Formation of steam and its thermodynamic properties, p-v, p-T, T-v, T-s, h-s diagrams. p-v-T surface. Use of Steam Table and Mollier Chart. Determination of dryness fraction. (Numerical Treatment). Equation of state, ideal gas equation, Vander Waal's Equation, Avagadro's law, reduced properties, law of corresponding states, compressibility chart.	6
Chapter No. 6 - Air and Vapor Power Cycles Air standard cycles, Carnot, Otto and Diesel, Carnot cycle using steam, limitations of Carnot cycle, Rankine cycle, representation on T-s and h-s planes, thermal efficiency, specific steam consumption. Work ratio, effect of steam supply pressure and temperature, condenser pressure on the performance. (Numerical Treatment).	6 hrs

Textbooks:

1. "Engineering Thermodynamics" by Onkar Singh (1st edition, 2010)

2. "Fundamentals of Engineering Thermodynamics" by Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, and Margaret B. Bailey (9th edition, 2017)
3. "Engineering Thermodynamics" by P.K. Nag (5th edition, 2013)
4. "Thermodynamics for Engineers" by Kenneth A. Kroos and Merle C. Potter (1st edition, 2020)

Reference Books:

1. "Thermodynamics: Principles and Applications" by John P. O'Connell and Giorgio V. Chau (1st edition, 2021)
2. "Thermodynamics: An Engineering Approach" by Yunus A. Çengel and Michael A. Boles (9th edition, 2020)
3. "Thermodynamics: Concepts and Applications" by Stephen R. Turns (1st edition, 2005)

Chapter wise Plan

Course Code and Title: **ME2032 / Engineering Thermodynamics**	
Chapter Number and Title: **1 - Basic Concepts and First Law of Thermodynamics**	Planned Hours: **6 hrs**

Lesson Schedule: -

Lecture No. - Portion covered per hour	**Planned Date**	**Delivery Date**	**Activities planned**
1. Thermodynamics system, Microscopic & macroscopic point of view, thermodynamic system and control volume	21/8/23		LT/GD
2. Thermodynamic properties, processes and cycles, Thermodynamic equilibrium	22/8/23		
3. Quasi-Static process, Zeroth law of thermodynamics	23/8/23		
4. First law for a closed system undergoing a cycle and change of state, energy, PMM1, first law of thermodynamics for steady flow process	28/8/23		
5. Steady flow energy equation applied to nozzle, diffuser, boiler, turbine, compressor, pump	29/8/23		

6. Numerical on First law of thermodynamics	30/9/23		

Course Code and Title: **ME2032 / Engineering Thermodynamics**	
Chapter Number and Title: **2 - Second Law of Thermodynamics and Entropy**	Planned Hours: **6 hrs**

Lesson Schedule:-

Lecture No. - Portion covered per hour	**Planned Date**	**Delivery Date**	**Activities planned**
7. Limitations of first law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, PMM2	4/9/23		LT/GD
8. Causes of irreversibility, Carnot theorem, corollary of Carnot theorem, thermodynamic temperature scale	5/9/23		
9. Clausius theorem, property of entropy, inequality of Clausius	69/23		
10. Entropy change in an irreversible process, principle of increase of entropy	11/9/23		
11. Entropy change for non-flow and flow processes, third law of thermodynamics	12/9/23		
12. Numerical on entropy	13/9/23		

Course Code and Title: **ME2032 / Engineering Thermodynamics**	
Chapter Number and Title: **3 - Availability**	Planned Hours: **6 hrs**

Lesson Schedule:-

Lecture No. - Portion covered per hour	**Planned Date**	**Delivery Date**	**Activities planned**

13. Energy of a heat input in a cycle, exergy destruction in heat transfer process	18/9/23		LT/GD/FC
14. Exergy of finite heat capacity body, exergy of closed and steady flow system	18/9/23		
15. irreversibility and Gouy-Stodola theorem and its applications	20/9/23		
16. second law efficiency	25/9/23		
17. Numerical on Availability-Part 1	26/9/23		
18. Numerical on Availability-Part 2	27/9/23		

Course Code and Title: **ME2032 / Engineering Thermodynamics**	
Chapter Number and Title: **4 - Properties of Gas Mixture and Thermodynamic Relations**	Planned Hours: **6 hrs**

Lesson Schedule: -

Lecture No. - Portion covered per hour	**Planned Date**	**Delivery Date**	**Activities planned**
19. Mole and Mass fraction, Dalton's and Amagat's Law. Properties of gas mixture – Molar mass, gas constant, density, change in internal energy, enthalpy, entropy	2/10/23		LT/GD
20. Gibbs function. Avogadro's law, equation of state	3/10/23		
21. Ideal gas equation, Vander Waal's equation,	4/10/23		
22. Reduced properties, law of corresponding states, compressibility chart, Gibbs Dalton law	9/10/23		
23. Joule-Thomson Coefficient, Clausius Clapeyron equation,	10/10/23		
24. Numerical	11/10/23		

Course Code and Title: **ME2032 / Engineering Thermodynamics**	
Chapter Number and Title: **5 - Properties of Pure Substances**	Planned Hours: **6 hrs**

Lesson Schedule:-

Lecture No. - Portion covered per hour	**Planned Date**	**Delivery Date**	**Activities planned**
25. Formation of steam and its thermodynamic properties	16/10/23		LT/GD
26. p-v, p-T, T-v, T-s, h-s diagrams. p-v-T surface	17/10/23		
27. Use of Steam Table and Mollier Chart. Determination of dryness fraction	18/10/23		
28. Application of 1st and 2nd law for pure substances	23/10/23		
29. Numerical-Part 1	24/10/23		
30. Numerical-Part 2	25/10/23		

Course Code and Title: **ME2032 / Engineering Thermodynamics**	
Chapter Number and Title: **6 - Air and Vapor Power Cycles**	Planned Hours: **6 hrs**

Lesson Schedule: -

Lecture No. - Portion covered per hour	**Planned Date**	**Delivery Date**	**Activities planned**
31. Carnot and Otto air standard cycle	30/10/23		LT/GD/CS
32. Diesel air standard cycle and comparison of air standard cycles	1/11/23		
33. Layout of steam power plant and its terminologies	2/11/23		
34. Carnot and Rankine cycle and its analysis	6/10/23		

35. Effect of steam supply pressure and temperature, condenser pressure on the performance	7/10/23		
36. Numerical	8/10/23		

Abbreviations:

Activities:	Lecture (LT), Think pair share (TPS), Flipped Classroom (FC), Jigsaw(JS), Project Based Learning(PBL), Presentations(PNS) , Demonstration (DM), Laboratory Visit (LV), Group Discussion (GD), Seminar(SM), Industrial Visits (IV), Case Studies (CS)

ISE & ESE Evaluation Scheme

Evaluation	Weightage	Particulars	Marks
ISE	20%	QUIZ	07
		Project base learning	08
		Industrial visit quiz	05
UT-01	23%	UT-01 (25 marks/1Hr)	25
UT-02	23%	UT-02 (25 marks/1Hr)	25
ESE	50%	ESE (100 marks /3Hrs)	50

Date:

Course in-charge **Module coordinator** **Academic Coordinator** **Head of Department**

S.Y. B.Tech - Div A - 2023-24

Sr.No.	EnrollNo	Student Name	Div	Batch	Batch Strength	Admitted Y/N
1	2006052	JADHAV ROHAN PARSHURAM	**A**	**A1**	**1**	
2	**2106006**	FAHIM ARIF MULLA	**A**	**A1**	**2**	
3	2106007	INGALE SHUBHAM SACHIN	A	A1	2	
4	2106016	VIPUL PRATAP SUTAR	A	A1	3	
5	2206001	JADHAV MANDAR SANJAY	A	A1	**4**	
6	2206002	SAVANT HARSHAD GORAKSHANATH	A	A1	5	
7	2206003	JADHAV RANVEER PRAVIN	A	A1	6	
8	2206004	KADAM HARSHAD CHANDRAKANT	A	A1	**7**	
9	2206005	MANE SIDDHESHVARI VASANT	A	A1	8	
10	2206006	MANE AKSHATA BALKISAN	A	A1	9	
11	2206007	GANBAVALE HARSHVARDHAN RAMESH	A	A1	**10**	
12	2206008	JADHAV ASHITOSH ISHWARA	A	A1	11	
13	2206009	OTARI UTKARSHA UMESH	A	A1	12	
14	2206010	SURYAWANSHI TANVI PRAKASH	A	A1	**13**	
15	2206011	PATIL SIDDHESH ARUN	A	A1	14	
16	2206012	JADHAV SNEHA SURYAKANT	A	A1	15	
17	2206013	PATIL TANAY SHARADCHANDRA	A	A1	**16**	
18	2206014	GURAV VARADRAJ RAMCHANDRA	A	A1	17	
19	2206015	PAWAR JAYANTRAO SAMPATRAO	A	A1	18	
20	2206016	PATIL SUJAL RAMCHANDRA	A	A1	**19**	
21	2206017	JADHAV SAMARTH RAJARAM	A	A1	20	
22	2206018	YEVALE OMKAR SANJAY	A	A1	21	
23	2106017	DHANARAJ SHIVAJI BACHAL	A	A2	1	
24	2206019	GHARGE RAJVARDHAN RANJEET	A	A2	2	
25	2206020	SAWANT JAYANT YUVRAJ	A	A2	3	
26	2206021	JANGAM PRANAV SUNIL	A	A2	4	
27	2206022	SHINDE KOMAL MANOJ	A	A2	5	
28	2206023	KUMBHAR TANUSHREE HANMANT	A	A2	6	
29	2206024	TAMBEWAGH PRATHMESH RAJENDRA	A	A2	7	
30	2206025	LANDAGE MANSI NITIN	A	A2	8	
31	2206026	DOIPHODE SUDHIR DNYANESHWAR	A	A2	9	
32	2206027	PATIL SAKSHI KIRAN	A	A2	10	
33	2206028	GODASE SOURABH SUNIL	A	A2	11	
34	2206029	PATIL VARAD SAMBHAJI	A	A2	12	
35	2206030	RASAL SHRIRAM SANTOSH	A	A2	13	
36	2206031	GADKAR TUSHAR YOGESH	A	A2	14	
37	2206032	SURYAWANSHI GOURI RUPESH	A	A2	15	
38	2206033	SHAIKH RIYAJ SALIM	A	A2	16	
39	2206034	PATIL SANDESH SOMNATH	A	A2	17	
40	2206035	MANE RAJVARDHAN MOHAN	A	A2	18	
41	2206036	NANNIKAR SAMARTH GANESH	A	A2	19	
42	2206037	SABANE HARSHAL SUDHAKAR	A	A2	20	
43	2106031	ABHIJIT SISALE	A	A3	1	

44	2206038	GHORPADE SATYAJEET SAMBHAJIRAO	A	A3	2	
45	2206039	MORE TANISHQ JAYWANT	A	A3	3	
46	2206040	DONAVADE OM AJITKUMAR	A	A3	4	
47	2206041	DAGADE ROHAN CHANDRAKANT	A	A3	5	
48	2206042	KADAM ADITYA VIJAY	A	A3	6	
49	2206043	GADGIL VIHANG SAMEER	A	A3	7	
50	2206044	KADAM AJIT RAJU	A	A3	8	
51	2206045	BHATMARE SANKET RAJENDRA	A	A3	9	
52	2206046	DUBAL YASHRAJ PRAMOD	A	A3	10	
53	2206047	GHADAGE SANIKA VIJAY	A	A3	11	
54	2206048	CHAVAN ANURAJ SACHIN	A	A3	12	
55	2206049	PATIL SANKET SUNIL	A	A3	13	
56	2206050	CHANKOTI AKSHAY MALLESHI	A	A3	14	
57	2206051	SUPANEKAR SOHAM NILESH	A	A3	15	
58	2206052	HUBALE ADITYA ASHOK	A	A3	16	
59	2206053	PATIL OMKAR LUXMAN	A	A3	17	
60	2206054	KUMBHAR SHARAYU SHASHIKANT	A	A3	18	
61	2206055	LOLE PRATIK VITTHAL	A	A3	19	
62	2206056	CHAVAN BHAVESH BHARAT	A	A3	20	
63	2106061	PRASAD HUBALE	A	A4	1	
64	2206057	BAVADE PRATIK RAHUL	A	A4	2	
65	2206058	MULLA SANIYA SHOUKAT	A	A4	3	
66	2206059	MORE GANESH VISHWAS	A	A4	4	
67	2206060	SOLASE YASH SUNIL	A	A4	5	
68	2206061	KAMBLE BHAGYASHRI HANMANT	A	A4	6	
69	2206062	VHANANVAR SANDIP RAMESH	A	A4	7	
70	2206063	DALVI PRANAV PRASAD	A	A4	8	
71	2206064	BUCHADE YASH PRASHANT	A	A4	9	
72	2206065	SALUNKHE VAISHNVI SACHIN	A	A4	10	
73	2206066	SARGAR JEEVAN MAHADEV	A	A4	11	
74	2206067	PATIL AVADHUT MAHESH	A	A4	12	
75	2206068	THORAWADE BHUMI PRABHAKAR	A	A4	13	
76	2206069	PATIL VIRAJ SHASHIKANT	A	A4	14	
77	2206070	GAIKWAD TEJAS ANIL	A	A4	15	
78	2206071	PATIL PRANAV PRAKASH	A	A4	16	
79	2206072	RELEKAR ASHUTOSH HANMANT	A	A4	17	
80	2206073	PATIL SOHAM RAMCHANDRA	A	A4	18	
81	2206074	SURYAWANSHI AMRUTA BHARAT	A	A4	19	
82	2206075	SHINDE SANKET DILIP	A	A4	20	
83	2206076	MULLA RISHAD KALANDAR	B	B1	1	
84	2206077	PATIL NISHANT MAHESH	B	B1	2	
85	2206078	TALAP NIKHIL RAJARAM	B	B1	3	
86	2206079	SHEWALE VIGHNESH JAYWANT	B	B1	4	
87	2206080	ANUSE RITESH RAVSAHEB	B	B1	5	
88	2206081	MANE RAHUL RAJESH	B	B1	6	

Activity Base Teaching plan

Course: Engineering Thermodynamics

Class: SY B.Tech Mechanical

Sr. No	Activity Name	Lecture No	Content
1.	Think-Pair- Share	3	Process, properties
2.	Activity-Jig Saw	10	PMM-I and II
3.	Poll	13	2nd Law of thermodynamics
4.	Reciprocal teaching	18	Exergy
5.	TPS	21	Mole , mass fraction
6.	Poll	22	Gas laws
7.	PBL	23	Steam properties, h,s, v,
8.	Poll	24	Critical P &T
9.	Think-Pair- Share	25	PVTsurfaces
10	Case Study	31	Steam power plant _Sugar factory
11	Reciprocal teaching	33	Air std cycles
12	Four Corner	36	Improvement in vapor power cycle

Dr Sharad D Patil

KE Society's

Rajarambapu Institute of Technology, Rajaramnagar

Department of Mechanical Engineering

Attainment of COs

Program: Mechanical Engineering		ME2033 Engineering Thermodynamics		Class: S Y B Tech.		Semester III	Academic Year: 2022-23	
Sr. No.	CO Statement	Direct Assessment					Indirect Assessment	Overall Attainment on Scale of 3	Overall Percentage Attainment
		ISE	UT I	UT II	ESE	Attainment Level Weighted Average	(Course End Survey)		
	Weigtage	0.2	0.15	0.15	0.5				
CO1	Apply thermodynamics principles to mechanical engineering applications	3	2	0	2	2.24	3	2.39	79.61
CO2	Describe entropy, change in entropy and increase of entropy principle	3	3	2	1	2.18	3	2.34	78.04
CO3	Differentiate between available and unavailable energy with examples	3	0	1	2	2.06	3	2.25	74.90
CO4	Recognize the properties of pure substances and use thermodynamic property tables, charts	3	0	2	2	2.24	3	2.39	79.61
CO5	Apply mathematical fundamental to study the properties of steam gas and gas mixtures	3	0	0	2	1.88	3	2.11	70.20
CO6	Explain the air and vapor power cycles and calculate cycle performance	3	0	0	2	1.88	3	2.11	70.20

Overall Attainment=0.8*Direct+0.2*Indirect

Course Coordinator: Prof. S. D. Patil	Academic/OBE Coordinator	HoD

KE Society's

Rajarambapu Institute of Technology, Rajaramnagar

Department of Mechanical Engineering

Attainment of POs

Program: Mechanical Engineering	ME2033 Engineering Thermodynamics	Class: S Y B Tech.	Semester III	Academic Year: 2022-23

CO-PO Mapping

CO No.	Overall CO Attainment	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2.39	3				1									
CO2	2.34	3													
CO3	2.25	3													
CO4	2.39	3				1									
CO5	2.11	3													
CO6	2.11	3													

CO-PO Attainment

CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2.39				0.80									
CO2	2.34													
CO3	2.25													
CO4	2.39				0.80									
CO5	2.11													
CO6	2.11													
PO Attainment From Course	2.26				0.80									

Course Coordinator: Prof. S. D. Patil	Academic/OBE Coordinator	HoD

CO Attainment Action Plan

Academic Year 2022-2023 (2021-2025 cycle)

Course Name: Engg Thermodynamics	Course Code:ME2033
Class: S Y B. Tech. in Mechanical	Semester:1 - Semester
Course Teacher: Dr. Sharad D. Patil	

1. CO attainment:

Sr.No.	CO Code	CO Statement	Overall Attainment %
1	CO1	Apply laws of thermodynamics to various flow devices	79.61
2	CO2	Describe entropy, change in entropy and increase of entropy principle	78.04
3	CO3	Compute available and unavailable energy of a substance	74.90
4	CO4	Recognize the properties of pure substances and use thermodynamic property tables, charts	79.61
5	CO5	Apply mathematical fundamental to study the properties of steam gas and gas mixtures	70.20
6	CO6	Compute performance of various thermodynamic air and vapor power cycles	70.20

Average marks -43.4 No of students-128

2. Observations from CO attainment:

Attainment for the all CO is satisfactory,

3. Action Plan for improvement of CO attainment:

- Focus will be given on CO5 & CO6 by solving more problems with group assignments

4. Sign of Course In-charge

5. Remark by Head of Department with sign

Stick to your CO attainment action plan.

Enroll No

K.E.Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated to SUK)

Unit Test-I

S. Y. B. Tech. Mechanical Engineering Semester- III

Course Name: Engineering Thermodynamics

Course Code: ME2033

Q.P.Code
UT22

Day &Date:...Thur., 10/11/2022

Time: ...11:45...to...12:45 pm.

Max. Marks- 25

Instructions: 1) *Figures to the right indicate full marks.*

2) *Assume suitable data if necessary and mention it clearly.*

3) *Use of steam table is allowed.*

Q.1 Solve the following **Marks**

(a) i) In a throttling device, what do we get as SFEE when changes in PE and KE are taken zero? **CO1** **05**

1) $\frac{\delta Q}{dm} \neq 0$ 2) $\frac{\delta W}{dm} \neq 0$ 3) $h_1 = h_2$ 4) none of these

ii) Heat and work are

1) Point functions 2) System properties

3) Path functions 4) Intensive properties

iii) In adiabatic process, Heat Transfer is __________

1) variable 2) zero 3) constant 4) can't be determined

iv) A system in which energy can crosses the boundary of the system but the mass cannot is known as

1) Open System 2) Isolated System

3) Closed System 4) None of the mentioned

v) The sum of all the microscopic forms of energy is called the ____________ of a system.

1) Kinetic Energy 2) Latent Energy

3) Internal Energy 4) Potential Energy

(b) Explain the difference between extensive and intensive properties of the systems with examples **CO1** **05**

(c)	Write the statements of the second law of thermodynamics.	**CO2**	**05**
	OR		
(c)	What are the limitations of the first law of thermodynamics?	**CO2**	**05**
(d)	During a process, the temperature of the system rises from 100°C to 200°C. Heat transfer per degree rise in temperature, at each temperature reached during the process is given by $$dQ/dT = 1.005\ kJ/K$$ The work done on the system per degree rise in temperature at each temperature reached, is given by $$dW/dT = (4 - 0.12T)\ kJ/K$$ Calculate the change in internal energy of the system during the process.	**CO1**	**05**
	OR		
(d)	In a pump, water of 2000 kg/min is compressed from 100 kPa to 1 MPa. The density of water is 1000 kg/m^3 and its temperature does not change. The inlet diameter of the pump is 100 mm and outlet diameter is 150 mm, and the inlet is 50 m below the outlet. Determine the work done by the pump.	**CO1**	**05**
(e)	Derive general steady flow energy equation as per the first law of thermodynamics.	**CO1**	**05**

KE Society's

Rajarambapu Institute of Technology, Rajaramnagar

Department of Mechanical Engineering

Result Analysis: Attainment of COs

Examination: UT I/2022-23	Class: S Y B Tech. MECH	Semester III
Program: Mechanical Engineering	Engineering Thermodynamics	

	Question	Q1(a)	Q1(b)	Q1(c)	Q1(d)	Q1(e)	Total (25)
	CO	CO1	CO1	CO2	CO1	CO1	
	Marks	5	5	5	5	5	
	PRN Number						
1	2106001	0	0	1	0	0	1
2	2106002	4	3	1	0	0	8
3	2106003	2	3	2	0	4	11
4	2106005	3	4	0	0	0	7
5	2106008	3	1	4	0	0	8
6	2106009	5	3	1	0	1	10
7	2106010	5	3	3	5	3	19
8	2106011	4	3	2	1	3	13
9	2106013	1	1	1	0	0	3
10	2106014	4	1	0	0	1	6
11	2106018	2	1	4	5	2	14
12	2106019	5	0	1	0	4	10
13	2106021	3	4	3	0	0	10
14	2106022	5	3	2	0	0	10
15	2106023	5	3	3.5	5	3.5	20
16	2106026	5	3	2	5	1	16
17	2106027	5	2	0.5	0.5	0.5	8.5
18	2106029	4	2	0	0	0	6
19	2106030	3	3.5	4.5	2	4	17
20	2106032	4	2	2	0	0	8
21	2106034	4	0.5	0	1	0	5.5
22	2106035	4	2	0	2	0	8
23	2106037	4	1	0	1	1	7
24	2106039	4	3	3	1	0	11
25	2106041	3	0.5	1	0	0.5	5
26	2106042	4	0	1	0	5	10
27	2106044	4	1	3	0.5	3.5	12

28	2106045	4	2	3	4	4	17
29	2106047	1	1	1	0	0	3
30	2106048	4	3	3	5	5	20
31	2106049	5	1	1	5	1	13

32	2106051	4	2	0	0	0	6
33	2106052	4	4.5	3.5	2	4.5	18.5
34	2106055	5	3	4	3	5	20
35	2106056	5	1	0	0	0	6
36	2106057	5	5	3	0	2	15
37	2106058	4	2	1	0	0	7
38	2106059	5	3	4	1	5	18
39	2106060	5	0.5	0	0	0	5.5
40	2106065	5	2	2	5	4	18
41	2106068	4	0	3	3	0	10
42	2106071	5	4	4	5	4	22
43	2106072	5	3	1	3	2	14
44	2106074	4	4	4	5	5	22
45	2106077	4	1	4	3	0	12
46	2106079	4	5	4	0	4	17
47	2106081	4	3	3	1	3	14
48	2106083	5	3	3	3	0	14
49	2106084	5	4	4	3	2	18
50	2106086	4	3	4	5	4	20
51	2106087	4	0.5	1	1	4	10.5
52	2106089	5	5	3	4	4	21
53	2106090	4	4	4	2	4.5	18.5
54	2106092	5	2	2	4	4	17
55	2106093	5	3	1	1	1	11
56	2106094	5	3	4	3	5	20
57	2106096	5	4	3.5	2	3	17.5
58	2106097	5	4	0	4	0	13
59	2106099	5	0	3	0.5	0.5	9
60	2106100	5	4	4	3	3	19
61	2106101	5	3.5	0.5	3.5	2	14.5
62	2106102	5	3	2	0	0	10
63	2106103	5	2	3	5	4.5	19.5
64	2106104	5	2	3	3	4	17
65	2106105	3	2	3	5	4.5	17.5
66	2106108	3	2	0	0	0	5
67	2106109	3	2	0	1	1.5	7.5
68	2106110	3	2	2	0	1	8
69	2106112	4	4	3	5	3.5	19.5
70	2106113	4	4	3	5	5	21
71	2106116	4	4	3.5	3.5	4	19
72	2106118	4	4	4	3	5	20
73	2106119	4	1	2.5	1	0.5	9
74	2106120	4	5	4	4	4	21
75	2106122	4	3	0	1	0	8

76	2106123	4	2	0	5	0	11
77	2106124	4	1	3	0.5	1	9.5
78	2106125	3	2	2	3	4	14
79	2106127	3	1	4	0	0	8
80	2106128	3	3	2	2	0	10
81	2106129	2	4	3.5	5	4	18.5
82	2106025	2.5	1.5	3.5	3.5	5	16
83	2106040	1	2	2	0	0	5
84	2106107	3	3.5	5	0	3	14.5
85	2108007	0	1	5	1	4	11
86	2256001	0	0.5	4	1	0	5.5
87	2256002	2.5	2.5	5	1	5	16
88	2256003	1	1	3	2	2	9
89	2256004	0.5	0.5	2.5	2	0	5.5
90	2256005	2	1.5	4	4	2.5	14
91	2256006	1	2	4	1	2.5	10.5
92	2256007	0	0	5	4	5	14
93	2256008	2	1	5	3.5	2	13.5
94	2256009	4	0	5	4	5	18
95	2256010	2.5	1	4	3.5	4	15
96	2256011	5	0	5	3	5	18
97	2256012	2	1	4	4	4	15
98	2256013	4	2.5	5	4	4.5	20
99	2256014	2	2	5	3.5	5	17.5
100	2256015	2.5	1.5	4	2.5	0	10.5
101	2256016	2.5	2	4	4	0	12.5
102	2256017	3	4	5	4	3	19
103	2256018	3	0	5	2	0	10
104	2256019	3	1	5	4.5	4	17.5
105	2256020	4	2.5	5	5	5	21.5
106	2256021	4	2	5	3	2	16
107	2256022	3	4	4	4	3	18
108	2256023	4	3.5	5	1.5	5	19
109	2256024	2.5	0	4	2	3	11.5
110	2256025	3	3.5	5	4.5	0	16
111	2256026	2	0.5	4	2	4	12.5
112	2256027	2	1	3	2	4	12
113	2256028	4.5	3.5	4	3	3	18
114	2256029	3	0	5	4	5	17
115	2256030	4	4	4	3.5	2.5	18
116	2256031	4	1	4	3	4	16
117	2256032	2	0	5	3	2	12
118	2256033	3	0	5	4	4	16
119	2256034	4	3	5	4	5	21

120	2256035	3	0	4	3	0	10
121	2256036	2	3.5	4	4	4	17.5
122	2256037	0	0	4	4.5	4.5	13
123	2256038	3	0	4	3	3.5	13.5
124	2256039	0	2	4	4	4	14
125	2256040	4	1.5	4	2	3.5	15
126	2256041	0	1.5	4	2	4	11.5
127	2006052	2	1	0	0	0	3
128	2006096	0	2	0	0	0	2

Questions	Q1(a)	Q1(b)	Q1(c)	Q1(d)	Q1(e)
CO	CO1	CO1	CO2	CO1	CO1
Marks	5	5	5	5	5
Threshold %	50				
Threshold Marks	2.5	2.5	2.5	2.5	2.5
No. of Students Above Threshold Marks	102	54	85	64	69
Total No. of Students in Class	128				
Percentage Attainment	79.69	42.19	66.41	50.00	53.91
CO Wise Average Percentage Attainment*	56.45			66.41	
Attainment Level**	2			3	

CO	Average Attainment Level**
CO1	2
CO2	3
CO3	
CO4	
CO5	
CO6	

*Calulate CO wise Percentage Attainment Level Manually

**Enter the level of Attainment as per Below Range

0%- 33 % = 1

34%-66% =2

67%-100%=3

K.E.Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated to SUK)

Unit Test-II

S. Y. B. Tech. Mechanical Engineering Semester- III

Course Name: Engineering Thermodynamics

Course Code: ME2033

Enroll No

Q.P.Code
UT19

Day &Date: Wednesday, 21/12/2022

Time: 11.45 am to 12.45 pm Max. Marks- 25

Instructions: 1) *Figures to the right indicate full marks.*

2) *Assume suitable data if necessary and mention it clearly.*

3) *Use of steam table is allowed.*

				Marks
Q.1	Solve the following.			
	(a)	State and prove the Clausius theorem. -OR- Establish the inequality of Clausius.	CO2	05
	(b)	An inventor claims to have develop a heat engine that receives 750 kJ of heat from a source at 550 K and rejecting the waste heat 260kJ to a sink at 290 K. Is this a reasonable claim? Why? -OR- A heat source at 800 K loses 2000 kJ of heat to a sink at (a) 500 K and (b) 750 K. Determine which heat transfer process is more irreversible.	CO2	05
	(c)	What did you understand by mole fraction, mass fraction, Avagadro's principle and Dalton's law of partial pressure?	CO4	05
	(d)	A 500 kg iron block is initially at 200°C and is allowed to cool to 27°C by transferring heat to the surrounding air at 27°C. Determine the reversible work and the irreversibility for this process. (Take Cp = 0.4 kJ/kgK)	CO3	05
	(g)	Derive an equation for the exergy of a finite heat capacity body.	CO3	05

R.I.T. Rajaramnagar Exam. Centre

Rajarambapu Institute of Technology, Rajaramnagar

Department of Mechanical Engineering

Result Analysis: Attainment of COs

Examination: UT I/2021-22

Examination: UT II/2022-23	Class: S Y B Tech.	Semester III
Program: Mechanical Engineering	Engineering Thermodynamics	

	Question	Q1(a)	Q1(b)	Q1(c)	Q1(d)	Q1€	Total (25)
	CO	CO2	CO2	CO4	CO3	CO3	
	Marks	5	5	5	5	5	
	PRN Number						
1	2006052	NA	NA	NA	NA	NA	0
2	2006096	0	0	0	0	0	0
3	2106001	0.5	1	0	0.5	0	2
4	2106002	2	4	2	0	0	8
5	2106003	5	4	2	0	1	12
6	2106005	4	4	2	0	0	10
7	2106008	1	0.5	4	0.5	4	10
8	2106009	5	5	0	4	0	14
9	2106010	5	5	3.5	1	0	14.5
10	2106011	5	4	3	0	0	12
11	2106013	0	0.5	2	0.5	0	3
12	2106014	5	5	0	0	0	10
13	2106018	0.5	3	0.5	4	0	8
14	2106019	5	4	1	0	0	10
15	2106021	2	0	1	0	0	3
16	2106022	5	0	2	0	0	7
17	2106023	5	3	3	2	4	17
18	2106025	5	4	1	4	2	16
19	2106026	2	2	1	4	0	9
20	2106027	4	4	1	3	0	12
21	2106029	1	3	0.5	4	0	8.5
22	2106030	3	4	1	4	4	16
23	2106032	1	0	0	1	0	2
24	2106034	0	0	0	0	2	2
25	2106035	1	0.5	0	2	4	7.5
26	2106037	1	0	0	3	0	4

27	2106039	4	0.5	0	0	0	4.5
28	2106040	4	0	0	4	0	8
29	2106041	0.5	0.5	1	3	0.5	5.5
30	2106042	3	4	0	0	5	12
31	2106044	4.5	5	4	0	1	14.5
32	2106045	4	3	1	2	2	12
33	2106047	1	4	0	0	1	6
34	2106048	1	1	2	2	4	10

35	2106049	0.5	0	0	0.5	0	1
36	2106051	0	2	0	3	0	5
37	2106052	4	5	3	4	0	16
38	2106055	5	4	3	4	4	20
39	2106056	0	0	0	1	0	1
40	2106057	0	4	0	0	0	4
41	2106058	0	0	0	4	0.5	4.5
42	2106059	2	4	0	4	0	10
43	2106060	2	4	0	0.5	0	6.5
44	2106065	4	2	0	0	0	6
45	2106068	4	2	0	0	4	10
46	2106072	4	4	0	3	0	11
47	2106074	5	1	0	1	0	7
48	2106077	5	0	2	0	0	7
49	2106079	1	4	0.5	0	0	5.5
50	2106081	4	2	0	0	4	10
51	2106083	1	0	0	0	0	1
52	2106087	0	2	0	1	0	3
53	2106089	2	1	2.5	3	0	8.5
54	2106090	5	3	0	4	3	15
55	2106093	2.5	0	1.5	0	0	4
56	2106071	1	3	0	4	2	10
57	2106084	1	0.5	1	4	1	7.5
58	2106086	1	1	0	1	0	3
59	2106092	3.5	1	0	4	4.5	13
60	2106094	1	3	4	3	4	15
61	2106096	4	5	4	3	0.5	16.5
62	2106097	5	4	3	4	0	16
63	2106099	4.5	5	0	3	0	12.5
64	2106100	4	3	0	3	2	12
65	2106101	3	5	0	3.5	0	11.5
66	2106102	2	0	0	1	0	3
67	2106103	4	5	2.5	2	2	15.5
68	2106104	3	3	0	1	1	8
69	2106105	4	5	0	0	0.5	9.5
70	2106107	2	4	1	3	0	10
71	2106108	5	5	3.5	1.5	5	20
72	2106109	4	4	1	3	4	16
73	2106110	1	0.5	3	1	0	5.5
74	2106112	4	4	3	3	5	19
75	2106113	0.5	2.5	0	0	0.5	3.5
76	2106116	4	4	0	0	4	12
77	2106118	2	5	0	0	4.5	11.5
78	2106119	4	4	0	0	5	13
79	2106120	5	0.5	0	0.5	4	10
80	2106122	0	3	0	0	0	3
81	2106123	5	1	0	3.5	4	13.5

82	2106124	4	2	0	4	0	10
83	2106125	1	0	0.5	3.5	0	5
84	2106127	0	2	0	4	0	6
85	2106128	0	0	0	3.5	0	3.5
86	2106129	5	4	5	5	5	24
87	2108007	2	0	0.5	1.5	0	4
88	2256001	0	2	0	0	0	2
89	2256002	2	0	4	3	0	9
90	2256003	4	2	0	2	2	10
91	2256004	0	2	0	0	0.5	2.5
92	2256005	4	4	4	3	1	16
93	2256006	0	0	1	0	0	1
94	2256007	4	5	0	2	5	16
95	2256008	0.5	4	0	0.5	0.5	5.5
96	2256009	2	4	0	4	0	10
97	2256010	1	4	0	2	3	10
98	2256011	1	1	3	2	1	8
99	2256012	1	2	2	2	0	7
100	2256013	4	4	4	4	0	16
101	2256014	0	4	5	2	0	11
102	2256015	1	3	4	3	0	11
103	2256016	4	3.5	0	0	1.5	9
104	2256017	4	4	3	0	3	14
105	2256018	NA	NA	NA	NA	NA	0
106	2256019	3	4	4	3	4	18
107	2256020	4.5	5	5	0.5	5	20
108	2256021	0	3	2	2	0	7
109	2256022	4	5	2.5	0	4.5	16
110	2256023	0	4	4	4	1	13
111	2256024	4	2	2.5	0.5	1.5	10.5
112	2256025	0	4	2	0	0	6
113	2256026	0	0	0.5	0.5	0.5	1.5
114	2256027	4	4	4	4	3	19
115	2256028	0	5	2.5	2.5	2.5	12.5
116	2256029	0	4	0	2	0	6
117	2256030	0	2	3.5	0	4.5	10
118	2256031	2	2	3	3	3	13
119	2256032	0	5	1	2	0.5	8.5
120	2256033	4	4	0	4	4	16
121	2256034	3	2	1	3.5	4	13.5
122	2256035	1	4	0	5	0	10
123	2256036	0.5	2.5	0	3.5	0	6.5
124	2256037	0	0	0	0	0	0
125	2256038	0	2.5	2	3.5	0	8
126	2256039	1	3	3	3	0	10
127	2256040	0	5	3.5	3.5	0	12
128	2256041	4	4	0	2	0	10

Questions	Q1(a)	Q1(b)	Q1(c)	Q1(d)	Q1(e)
CO	CO2	CO2	CO4	CO3	CO3
Marks	5	5	5	5	5
Threshold %	50				
Threshold Marks	2.5	2.5	2.5	2.5	2.5
No. of Students Above Threshold Marks	59	73	34	53	33
Total No. of Students in Class	128				
Percentage Attainment	46.09	57.03	26.56	41.41	25.78
CO Wise Average Percentage Attainment*	51.56		25.56	33.59	
Attainment Level**	2		1	2	

CO	Average Attainment Level**
CO1	
CO2	2
CO3	1
CO4	2
CO5	
CO6	

*Calulate CO wise Percentage Attainment Level Manually

**Enter the level of Attainment as per Below Range

0%- 33 % = 1

34%-66% =2

67%-100%=3

Enroll. No.

K. E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to SUK)

End Semester Examination Feb 2023

S.Y. B. Tech. Mechanical Engineering SEMESTER – III

Engineering Thermodynamics (ME2033)

QP No.
E114

Day & Date: – Wed., 8/2/2023

Time: – 10.30 to 1.30 pm.

Max Marks: 100

Instructions:
1. *All questions are compulsory.*
2. *Use of non-programmable calculator is allowed.*
3. *Assume suitable data if necessary*
4. *Use of steam table allowed*

			Marks	CO
Q.1	a)	Show that energy is a property of a system	08	CO1
		OR		
	a)	Apply steady flow energy equation (SFEE) to develop equation for steam turbine.		
	b)	Air flows steady at the rate of 0.5 kg/s through an air compressor entering at 7 m/s velocity, 100 kPa pressure and 0.95 m^3/kg specific volume and leaving at 5 m/s, 700 kPa and 0.19 m^3/kg respectively. The internal energy of the air leaving is 90 kJ/kg greater than that of air entering. Cooling water in the compressor jacket absorbs heat from the air at the rate of 58 kW. Compute a. the power input the compressor and b. ratio of inlet pipe diameter to the outlet pipe diameter.	07	CO1
Q.2	a)	Explain statements of second law of thermodynamics.	08	CO1
		OR		
	a)	Explain the Clausius inequality		
	b)	A Carnot engine absorbs 200J of heat from a reservoir at the temperature of the normal boiling point of water and rejects heat to a reservoir at the temperature of the triple point of water. Calculate the heat rejected, the work done by the engine and the thermal efficiency.	07	CO2
Q.3	a)	Derive the equation for availability (Exergy) of a finite body at temperature T.	08	CO3
		OR		
	a)	Derive the equation for availability (Exergy) of a non-flow process.		
	b)	Calculate the change in exergy when 20 kg of water at 95°C mix with 45 kg of water at 30°C, the pressure being taken as constant and the temperature of the corresponding being 20°C. C_p of water is 4.2 kJ/kgK.	07	CO3

Q.4	a)	Derive equation for internal energy of a gas mixture on mass and molar basis.	08	CO5

OR

a) Explain the following

1. Mole fraction
2. Dalton's law
3. Mass Fraction
4. Amagat's law

	b)	A gas mixture has the following composition on mole basis: 60 percent N_2 and 40 percent CO_2. Determine the gravimetric analysis of the mixture, its molar mass and gas constant. Repeat the above problem by replacing N_2 by O_2.	07	CO5
Q.5	a)	Calculate the missing properties of steam in the following table for water:	08	CO4

S. N.	T, ^{0}C	P, bar	h, kJ/kg	x	s, kJ/kg.K	Type of steam
1.		100	3100			
2.	500	90				
3.		0.4		0.9		
4.	30			0.9		

	b)	Define dry and wet steam. Calculate the dryness fraction of the steam when it expands from 20 bar (dry-saturated) pressure to 0.5 bar pressure isentropically.	08	CO4
	c)	Explain triple point of water.	04	CO4

OR

c) Write van der Waals equation of state and meaning of terms in it.

Q.6	a)	Explain the methods to improve efficiency of the Rankine cycle.	08	CO6
	b)	A simple Rankine cycle works between pressure 18 and 0.8 bar, the initial condition of steam being dry saturated. Calculate: i) The cycle efficiency ii) Work ratio ii) Specific steam consumption.	08	CO6
	c)	Draw P-v and T-s diagram Carnot vapor cycle?	04	CO6

OR

c) Draw P-v and T-s diagram for Diesel cycle.

ETH ⇒ Feb 2023

ESE-2023 [QP Code - E 114]

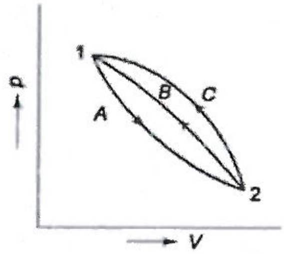
Date of Exam = 08/02/2023

Q 1 a) Consider a system which changes its state from state 1 to state 2 by following the path A, and returns from state 2 to state 1 by following the path B (So the system undergoes a cycle. Writing the first law for path A 02 Marks

$$Q_A = \Delta E_A + W_A$$

and for path B

$$Q_B = \Delta E_B + W_B$$



02 Marks

Fig. *Energy—a property of a system*

The processes A and B together constitute a cycle, for which

$$(\Sigma W)_{cycle} = (\Sigma Q)_{cycle}$$

or $$W_A + W_B = Q_A + Q_B$$

or $$Q_A - W_A = W_B - Q_B$$

02 Marks

From equations

$$\Delta E_A = -\Delta E_B$$

Similarly, had the system returned from state 2 to state 1 by following the path C instead of path B

$$\Delta E_A = -\Delta E_C$$

From equations

$$\Delta E_B = \Delta E_C$$

Therefore, it is seen that the change in energy between two states of a system is the same, whatever path the system may follow in undergoing that change of state. If some arbitrary value of energy is assigned to state 2, the value of energy at state 1 is fixed independent of the path the system follows. Therefore, energy has a definite value for every state of the system. Hence, it is a *point function and a property of the system.* 02 Marks

a) **OR**

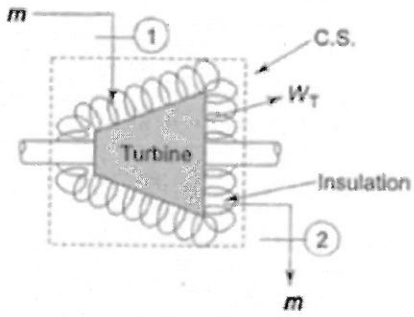
The general steady flow energy equation is

$$Q - W_x = (h_2 - h_1) + \frac{\overline{V}_2^2 - \overline{V}_1^2}{2} + g(Z_2 - Z_1)$$ 02 Marks

For Turbine

Turbines and engines give positive power output, whereas compressors and pumps require power input.

For a turbine which is well insulated, the flow velocities are often small, and the K.E. terms can be neglected. The S.F.E.E. then becomes



02 Marks

Fig. *Flow through a turbine*

$$h_1 = h_2 + \frac{dW_x}{dm}$$ 02 Marks

or $$\frac{W_x}{m} = (h_1 - h_2)$$

It is seen that work is done by the fluid at the expense of its enthalpy.

Similarly, for an adiabatic pump or compressor, work is done upon the fluid and W is negative. So the S.F.E.E. becomes

$$h_1 = h_2 - \frac{W_x}{m}$$

or $$\frac{W_x}{m} = h_2 - h_1$$ 02 Marks

The enthalpy of the fluid increases by the amount of work input.

b)

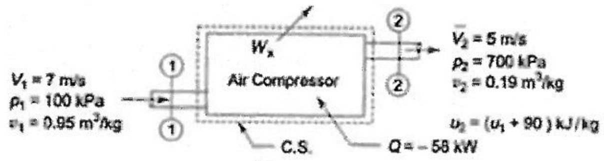


Fig.

02 Marks

(a) Writing the steady flow energy equation, we have

$$w\left(u_1 + p_1v_1 + \frac{V_1^2}{2} + Z_1g\right) + \frac{dQ}{d\tau}$$

$$= w\left(u_2 + p_2v_2 + \frac{V_2^2}{2} + Z_2g\right) + \frac{dW_x}{d\tau}$$

01 Marks

$$\therefore \frac{dW_x}{d\tau} = -w\left[(u_2 - u_1) + (p_2v_2 - p_1v_1) + \frac{V_2^2 - V_1^2}{2} + (Z_2 - Z_1)g\right] + \frac{dQ}{d\tau}$$

$$\therefore \quad \frac{dW_x}{d\tau} = -0.5\frac{kg}{s}\left[90\frac{kJ}{kg} + (7\times 0.19 - 1\times 0.95)100\frac{kJ}{kg}\right.$$

$$\left. + \frac{(5^2 - 7^2)\times 10^{-3}}{2}\frac{kJ}{kg} + 0\right] - 58\text{ kW}$$

$$= -0.5\,[90 + 38 - 0.012]\text{ kJ/s} - 58\text{ kW}$$

$$= -122\text{ kW}$$

02 Marks

Ans. (a)

Rate of work input is 122 kW.

01 Marks

(b) From mass balance, we have

$$w = \frac{A_1V_1}{v_1} = \frac{A_2V_2}{v_2}$$

$$\therefore \quad \frac{A_1}{A_2} = \frac{v_1}{v_2}\cdot\frac{V_2}{V_1} = \frac{0.95}{0.19}\times\frac{5}{7} = 3.57$$

01 Marks

$$\therefore \quad \frac{d_1}{d_2} = \sqrt{3.57} = 1.89$$

Ans. (b)

01 Marks

Q 2 a) i) There are many valid statements of the second law of thermodynamics. The use of the second law of thermodynamics is not limited to identifying the direction of processes. The second law also asserts that energy has *quality* as well as quantity. The first law is concerned with the quantity of energy and the transformations of energy from one form to another with no regard to its quality. Preserving the quality of energy is a major concern to engineers, and the second law provides the necessary means to determine the quality as well as the degree of degradation of energy during a process.

02 Marks

ii) with reference to the heat engine that, even under ideal conditions, a heat engine must reject some heat to a low temperature reservoir in order to complete the cycle. That is, no heat engine can convert all the heat it receives to useful work. This limitation on the thermal efficiency of heat engines forms the basis for the Kelvin–Planck statement of the second law of thermodynamics, which is expressed as follows:

iii) It is impossible for any device that operates on a cycle to receive heat from a single reservoir and produce a net amount of work.

02 Marks

That is, a heat engine must exchange heat with a low-temperature sink as well as a high-temperature source to keep operating.

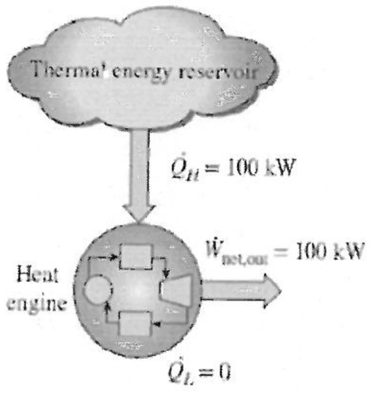
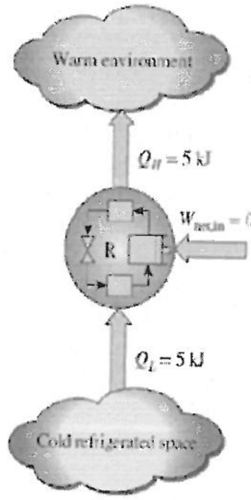


FIGURE
A heat engine that violates the Kelvin–Planck statement of the second law.



A refrigerator that violates the Clausius statement of the second law.

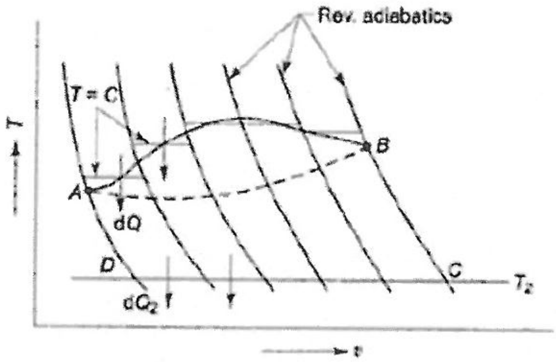
02 Marks

iv) There are two classic statements of the second law—the Kelvin–Planck statement, which is related to heat engines and discussed in the preceding section, and the Clausius statement, which is related to refrigerators or heat pumps.

v) The Clausius statement is expressed as follows:
It is impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a lower-temperature body to a higher-temperature body.
vi) It is common knowledge that heat does not, of its own volition, transfer from a cold medium to a warmer one. The Clausius statement does not imply that a cyclic device that transfers heat from a cold medium to a warmer one is impossible to construct. In fact, this is precisely what a common household refrigerator does. It simply states that a refrigerator cannot operate unless its compressor is driven by an external power source, such as an electric motor 02 Marks

a) **OR**

Let us consider a cycle *ABCD* (Fig.). Let *AB* be a general process, either reversible or irreversible, while the other processes in the cycle are reversible. Let the cycle be divided into a number of elementary cycles, as shown. For one of these elementary cycles



02 Marks

Fig. *Inequality of Clausius*

$$\eta = 1 - \frac{đQ_2}{đQ}$$

where $đQ$ is the heat supplied at T, and $đQ_2$ the heat rejected at T_2.

Now, the efficiency of a general cycle will be equal to or less than the efficiency of a reversible cycle.

$$\therefore \quad 1 - \frac{đQ_2}{đQ} \le \left(1 - \frac{đQ_2}{đQ}\right)_{rev}$$

or $$\frac{đQ_2}{đQ} \ge \left(\frac{đQ_2}{đQ}\right)_{rev}$$

or $$\frac{đQ}{đQ_2} \le \left(\frac{đQ}{đQ_2}\right)_{rev}$$

02 Marks

Since $$\left(\frac{đQ}{đQ_2}\right)_{rev} = \frac{T}{T_2}$$

$$\therefore \quad \frac{đQ}{đQ_2} \le \frac{T}{T_2}$$

or $\frac{đQ}{T} \le \frac{đQ_2}{T_2}$, for any process AB, reversible or irreversible.

For a reversible process

$$ds = \frac{đQ_{rev}}{T} = \frac{đQ_2}{T_2}$$

02 Marks

Hence, for any process *AB*

$$\frac{dQ}{T} \le ds$$

Then for any cycle

$$\oint \frac{dQ}{T} \le \oint ds$$

Since entropy is a property and the cyclic integral of any property is zero

$$\oint \frac{dQ}{T} \le 0$$

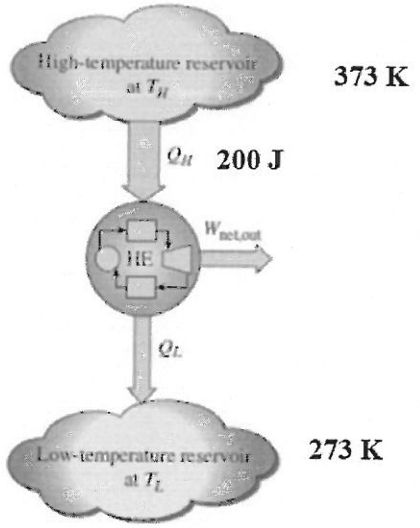
This equation is known as the *inequality of Clausius*. It *provides the criterion of the reversibility of a cycle.*

If $\oint \frac{dQ}{T} = 0$, the cycle is reversible,

$\oint \frac{dQ}{T} < 0$, the cycle is irreversible and possible 02 Marks

$\oint \frac{dQ}{T} > 0$, the cycle is impossible, since it violates the second law.

b)



01 Marks

Given :
Heat Input = Q_H = 200 J, Source Temperature = 373 K, Sink Temperature = 273 K

i) $Carnot\ Efficiency = 1 - \frac{T_L}{T_H} = 1 - \frac{273}{373} = 0.2680 = 26.80\%$ 02 Marks

ii) Efficiecny = Work/ Heat Input 02 Marks
0.2680 = W/200 = 53.61 J

By applying the first law of thermodynamics
QH-QL=W
QL = QH-W
iii) Heat Rejected = 200- 53.61=146.38 J

02 Marks

Q 3 a) Let us consider a hot gas of mass m_g at temperature T when the environmental temperature is T_0 (Fig.). Let the gas be cooled at constant pressure from state 1 at temperature T to state 3 at temperature T_0 and the heat given up by the gas, Q_1, be utilized in heating up reversibly a working fluid of mass m_{wf} from state 3 to state 1 along the same path so that the temperature difference between the gas and the working fluid at any instant is zero and hence, the entropy increase of the universe is also zero. The working fluid expands reversibly and adiabatically in an engine or turbine from state 1 to state 2 doing work W_E, and then rejects heat Q_2 reversibly and isothermally to return to the initial state 3 to complete a heat engine cycle.

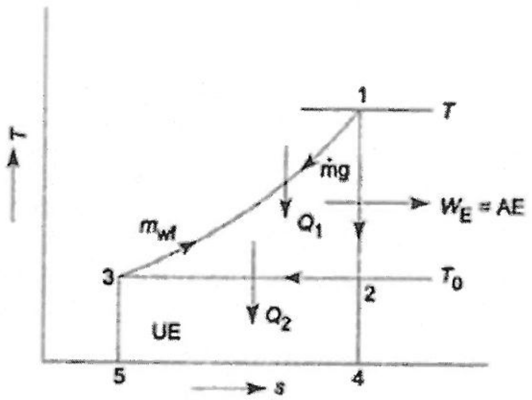


Fig. *Available energy of a finite energy source*

02 Marks

Here,

$$Q_1 = m_g c_{p_g}(T - T_0) = m_{wf} c_{p_{wf}}(T - T_0)$$
$$= \text{Area } 1\text{–}4\text{–}5\text{–}3\text{–}1$$

$\therefore$
$$m_g c_{p_g} = m_{wf} c_{p_{wf}}$$

$$\Delta S_{gas} = \int_T^{T_0} m_g c_{p_g} \frac{dT}{T} = m_g c_{p_g} \ln \frac{T_0}{T} \text{ (negative)}$$

02 Marks

$$\Delta S_{wf} = \int_{T_0}^{T} m_{wf} c_{p_{wf}} \frac{dT}{T} = m_{wf} c_{p_{wf}} \ln \frac{T}{T_0} \text{ (positive)}$$

$\therefore$
$$\Delta S_{univ} = \Delta S_{gas} + \Delta S_{wf} = 0$$

$$Q_2 = T_0 \Delta S_{wf} = T_0 m_{wf} c_{p_{wf}} \ln \frac{T}{T_0} = \text{Area } 2\text{–}4\text{–}5\text{–}3$$

$\therefore$ Available energy $= W_{max}$
$$= Q_1 - Q_2$$

02 Marks

$$= m_g c_{p_g} (T - T_0) - T_0 m_g c_{p_g} \ln \frac{T}{T_0}$$

$$= \text{Area 1–2–3–1}$$

Therefore, the available energy or exergy of a gas of mass m_g at temperature T is given by

$$AE = m_g c_{p_g} \left[(T - T_0) - T_0 \ln \frac{T}{T_0} \right]$$ 02 Marks

a) **OR**

Let us consider a closed system and denote its initial state by parameters without any subscript and the final dead state with subscript '0'. The availability of the system A, i.e., the maximum useful work obtainable as the system reaches the dead state, 02 Marks

$$A = (W_u)_{max} = E - E_0 + p_0 (V - V_0) - T_0(S - S_0)$$

$$= \left(U + \frac{m\mathbf{V}^2}{2} + mgz \right) - (U_0 + mgz_0) + p_0(V - V_0) - T_0(S - S_0)$$ 02 Marks

If K.E. and P.E. changes are neglected and for unit mass, the availability becomes

$$a = u - u_0 + p_0(v - v_0) - T_0 (s - s_0)$$

$$= (u + p_0 v - T_0 s) - (u_0 - p_0 v_0 - T_0 s_0)$$

$$= \phi - \phi_0$$ 02 Marks

where ϕ is the availability function of the closed system.

If the system undergoes a change of state from 1 to 2, the decrease in availability will be

$$a = (\phi_1 - \phi_0) - (\phi_2 - \phi_0)$$

$$= \phi_1 - \phi_2$$

$$= (u_1 - u_2) + p_0 (v_1 - v_2) - T_0(s_1 - s_2)$$ 02 Marks

This is the maximum useful work obtainable under the given surroundings.

b)

Solution The available energy of a system of mass m, specific heat c_p, and at temperature T, is given by

$$\text{A.E.} = mc_p \int_{T_0}^{T} \left(1 - \frac{T_0}{T}\right) dT$$

$\therefore$ $(\text{A.E.})_{20}$ = Available energy of 20kg of water at 95°C

$$= 20 \times 4.2 \int_{273+20}^{273+95} \left(1 - \frac{293}{T}\right) dT$$

$$= 84 \left[(368 - 293) - 293 \ln \frac{368}{293}\right]$$

$$= 690.671 \text{ kJ}$$

02 Marks

$(\text{A.E.})_{45}$ = Available energy of 45kg of water at 30^0 C

$$= 189 \left[(303\text{-}293) - 293 \ln \frac{303}{293}\right]$$

$$= 31.53 \text{ kJ}$$

Total available energy

$$(\text{A.E.})_{total} = (\text{A.E.})_{20} + (\text{A.E.})_{45}$$

$$= 690.671 + 31.53$$

$$= 722.208 \text{ kJ}$$

02 Marks

After mixing, if t is the final temperature

$$20 \times 4.2\,(95 - t) = 45 \times 4.2(t - 30)$$

$$\therefore \quad t = \frac{20 \times 95 + 45 \times 30}{20 + 45}$$

$$= 50^0 \text{ C}$$

Total mass after mixing = 20 + 45 = 65 kg

$(\text{A.E.})_{65}$ = Available energy of 65 kg of water at 50°C

$$= 4.2 \times 65 \left[(323 - 293) - 293 \ln \frac{323}{293}\right]$$

$$= 392.69 \text{ kJ}$$

02 Marks

∴ Decrease in available energy due to mixing

= Total available energy before mixing

− Total available energy after mixing 01 Marks

= 722.208-392.69

= 329.518 kJ

Q 4 a)

The internal energy u is assumed to be a function of T and v, i.e.

$$u = f(T, v)$$

$$du = \left(\frac{\partial u}{\partial T}\right)_v dT + \left(\frac{\partial u}{\partial v}\right)_T dv$$ 04 Marks

When gases at equal pressures and temperatures are mixed adiabatica work, as by inter-diffusion in a constant volume container, the first la that the internal energy of the gaseous system remains constant, and e: show that the temperature remains constant. Hence the internal e mixture of gases is equal to the sum of the internal energies of the components, each taken at the temperature and volume of the mixture (the 'partial' internal energies). This is also true for any of the therm properties like H, C_v, C_p, S, F and G and is known as *Gibbs theorem*. on a mass basis

$$mu_m = m_1u_1 + m_2u_2 + \ldots + m_cu_c$$

$$u_m = \frac{m_1u_1 + m_2u_2 + \cdots + m_cu_c}{m_1 + m_2 + \cdots + m_c}$$

04 Marks

a) **OR**

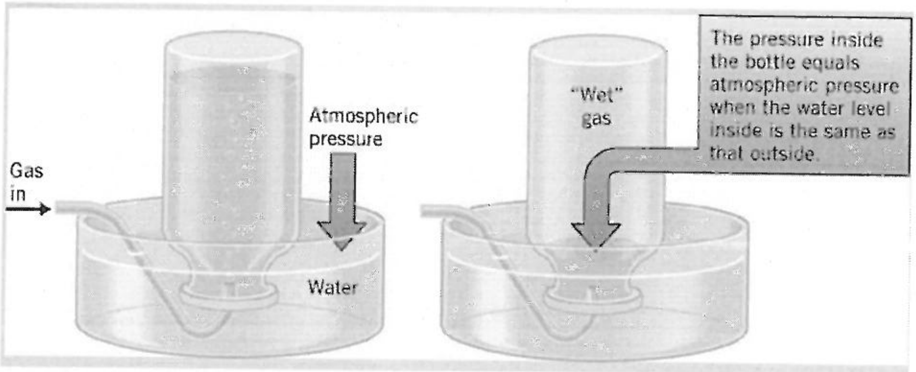
Mole fraction (molar analysis)

It is the ratio of the number of moles of a given component to the total moles of all components 02 Marks

$$y_i = \frac{n_A}{n_A + n_B + \ldots + n_Z}, \quad n_i = \text{moles of } i$$

Dalton's law of partial pressures:

It states: the total pressure of a mixture of gases is the sum of their individual partial pressures 02 Marks



Mass fraction (Gravimetric analysis)

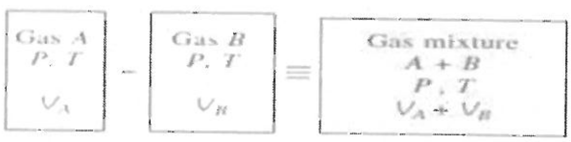
It is the ratio of the mass of the component to the mass of the mixture

$$m_f = \frac{m_A}{m_m},$$ 02 Marks

Amagat's law of additive volumes:

The volume of a gas mixture is equal to the sum of the volumes each gas would occupy if it existed alone at the mixture temperature and pressure

- $V_m = \sum_{i=1}^{k} V_i(T_m : P_m)$ $\quad V_i$ componentvolume
- Note: that equ exact for ideal gases, approximate for real gases
- $\frac{V_i}{V_m}$:=volume fraction



02 Marks

b) Given –
Molar mass of N_2 = 2X14=28

Molar mass of O_2 = 2X16 = 32
Molar mass of CO_2 = 1X12+2X16 = 44 — 01 Marks
Composition on mole basis
60% N_2 and 40% CO_2
Hence,
Molar mass =

$$M_m = \sum y_i \times M_i = 0.60 \times 28 + 0.40 \times 44 = 34.4 \frac{kg}{kmol}$$

03 Marks

Now Gas Constant =

$$R = \frac{R_u}{M_m} = \frac{8.314}{34.4} = 0.2416 \frac{kJ}{kgK}$$

Composition on mole basis
60% O_2 and 40% CO_2
Hence,
Molar mass =

$$M_m = \sum y_i \times M_i = 0.60 \times 32 + 0.40 \times 44 = 36.8 \frac{kg}{kmol}$$

Now Gas Constant =

$$R = \frac{R_u}{M_m} = \frac{8.314}{36.8} = 0.225 \frac{kJ}{kgK}$$

03 Marks

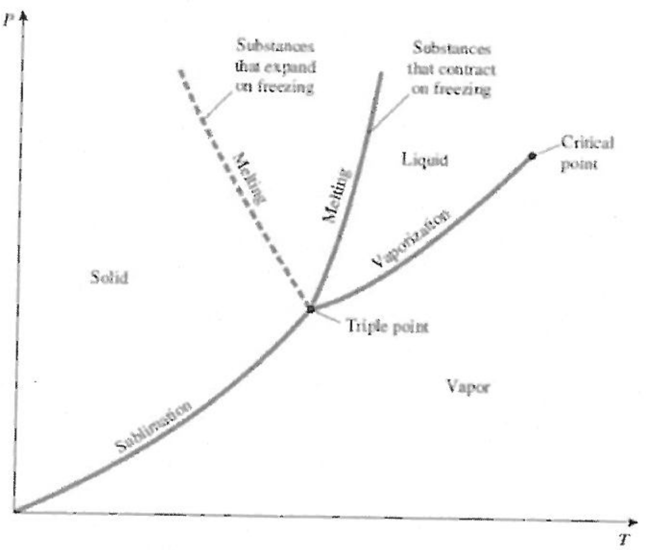
Q 5 a)

Sr. No.	T ^{0}C	P, bar	h, kJ/kg	x	s, kJ/kgK	Type of steam
1	400	100	3100	1	6.599	Superheated
2	500	90	3386.8	1	6.66	Superheated
3	75.89	0.4	2404.98	0.9	7.0065	Wet
4	30	0.042	2313.33	0.9	7.6532	Wet

0.5 Marks For each answer

b) **Dry Steam –**
When steam is free from water vapour then it is called as Dry Steam — 02 Marks
Wet Steam
The steam which contains the water vapour are known as wet steam
Given:
P1 = 20 bar (Dry Saturated), P2 =0.5 bar — 02 Marks
S1 = 6.337 kJ/kgK
As expansion is isentropic hence,
S1=S2
S2 = 6.337 kJ/kgK — 02 Marks
Also
S2= Sf+x*Sfg
Where
Sf=1.091 kJ/kgK
Sfg=6.504 kJ/kgK
6.337=1.091+x*6.504
x = 0.80 — 02 Marks

c)



02 Marks

The triple point of a substance is the temperature and pressure at which the three phases (gas, liquid, and solid) of that substance coexist in thermodynamic equilibrium. 01 Marks

The triple point of water is used to define the Kelvin(K), the base unit of thermodynamic temperature in the International System of Units (SI). The triple point of water is 273.16 K, 0.01∘ C, or 32.018∘ F 01 Marks

OR

- It is given by, 02 Marks

$$\left(P+\frac{a}{v^2}\right)(v-b) = RT$$

- Van der Waals equation of state considers two effects which were not considered in ideal-gas equation of state. The term a/v^2 accounts for intermolecular forces of attraction and b accounts for volume occupied by the gas molecules.
- The constants a and b are given by, 02 Marks

$$a = \frac{27R^2T^2_{cr}}{64Pcr} \text{ and } b = \frac{RT_{cr}}{8Pcr}$$

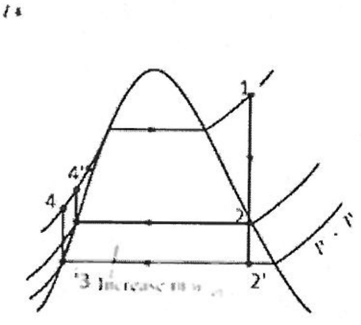
Q 6 a)

Increasing Efficiency of Rankine Cycle

02 Marks

Thermal efficiency of the ideal Rankine cycle can be increased by: (a) Increasing the average temperature at which heat is transferred to the working fluid in the boiler, or (b) decreasing the average temperature at which heat is rejected from the working fluid in the condenser.

Lowering the Condenser Pressure



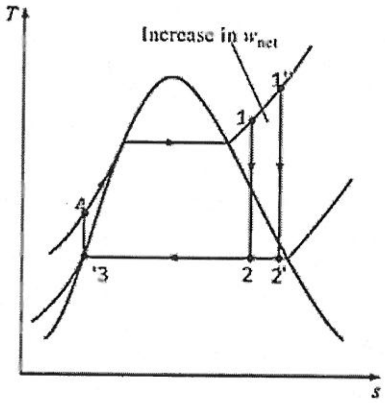
The condensers of steam power plants usually operate well **below** the atmospheric pressure. There is a lower limit to this pressure depending on the temperature of the cooling medium.

02 Marks

Side effect: Lowering the condenser pressure increases the **moisture content** of the steam at the final stages of the turbine – can cause **blade damage**, decreasing isentropic efficiency.

The effect of lowering the condenser pressure on the ideal Rankine cycle.

Superheating the Steam to High Temperatures



FIGURE

The effect of superheating the steam to higher temperatures on the ideal Rankine cycle.

Superheating the steam increases both the **net work output** and **heat input** to the cycle. The overall effect is an increase in thermal efficiency of the cycle.

02 Marks

Superheating to higher temperatures will decrease the **moisture content** of the steam at the turbine exit, which is desirable – avoid erosion of turbine blades.

The superheating temperature is limited by metallurgical considerations. Presently the **highest** steam temperature allowed at the turbine inlet is about **620°C**.

Increasing the Boiler Pressure

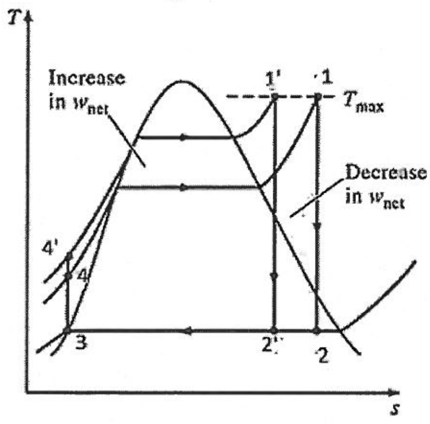


FIGURE
The effect of increasing the boiler pressure on the ideal Rankine cycle.

Increasing the boiler pressure raises the average temperature at which heat is transferred to the steam. This, in turns increases the **thermal efficiency** of the cycle.

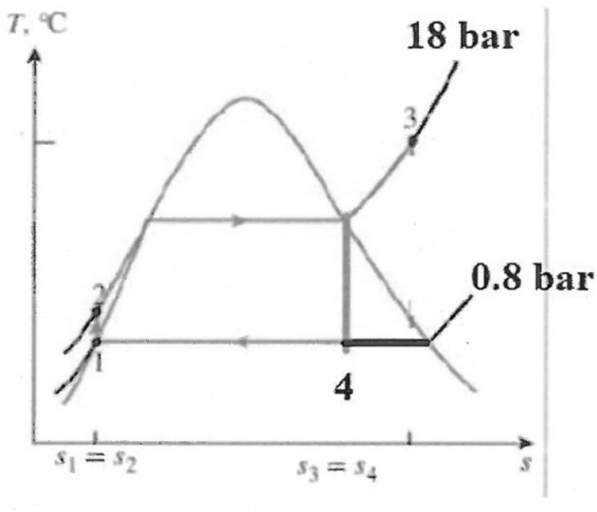
<u>Note:</u>

For a fixed turbine inlet temperature, the cycle shifts to the left and the **moisture content** of steam at the turbine exit increases.

This side effect can be corrected by **reheating** the steam.

02 Marks

b)



01 Marks

Boiler Pressure = P2 = P3 = 18 bar
Condenser Pressure = P1 = P4 = 0.8 bar
At state 3
h3= hg at 18 bar = 2794.8 kJ/kg
s3 = sg at 18 bar = 6.375 kJ/kgK

At state 4
s3 =s4
s4 = 6.375 kJ/kgK
also
s4 @0.18 bar = (sf+x*sfg) @0.18 bar

6.375 = 0.804+x*7.142
x = 0.78
Now
h4 =hf4+x*hfg4
= 242+0.78*2363.9 = 2085.84 02 Marks

At state 1
h1 = hf @ 0.18 bar = 242 kJ/kg, v1 = vf @ 0.18 bar = 0.001016

Now W_p = v1*(P2-P1)*100 = 0.001016*(18-0.8)*100= 1.8105 kJ/kg

At state 2

W_p= h2-h1

h1 = h2+W_p

h2 = 242+1.8105 =243.81

Cycle Analysis

Turbine Work = Wt = h3- h4 = 2794.8-2085.84 = 708.96 kJ/kg

Pump Work = 1.8105 kJ/kg

Net Work = Wt-Wp = 708.96-1.8105 = 707.14 kJ/kg 02 Marks

Heat Input = h3-h2 =2794.8 -243.81=2550.99

Answer 1 =

Cycle Efficiency = Wnet/Heat Input = 707.14/2550.99 = 0.2772 = 27.72% 01 Marks

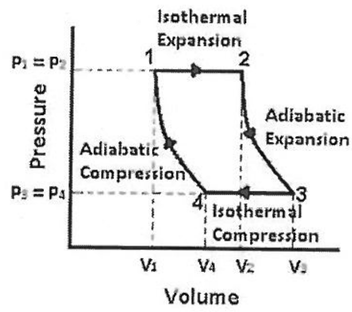
Answer 2 =

Work Ratio = Wnet/Wt = 707.14/708.96 = 0.99 01 Marks

Answer 3 =

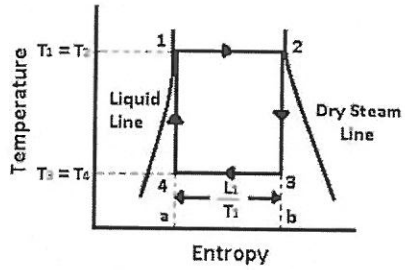
Specific Steam Consumption = 3600/Wnet = 5.09 kg/kWh 01 Marks

c) Carnot Vapour Cycle P-V Diagram



02 Marks

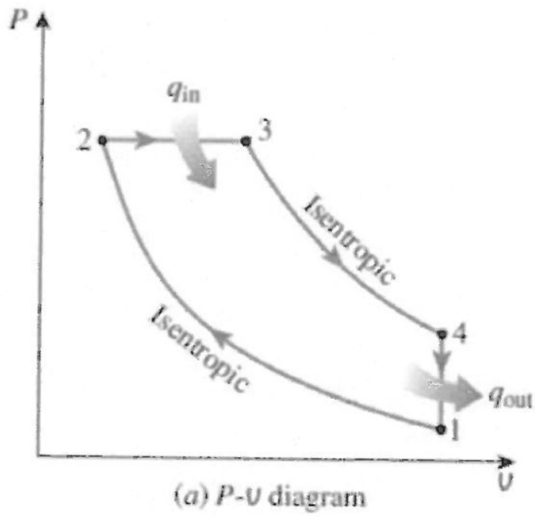
Carnot Vapour Cycle T-S Diagram



02 Marks

OR

a) P-v Diagram for Diesel Cycle

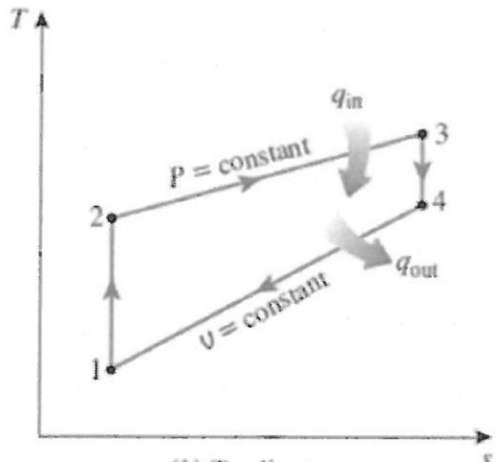


(a) P-υ diagram

02 Marks

T-s Diagram for Diesel Cycle

02 Marks



(*b*) *T*-*s* diagram

KE Society's

Rajarambapu Institute of Technology, Rajaramnagar

Department of Mechanical Engineering

Result Analysis: Attainment of COs

Examination: ESE/2022-23	Class:S Y B Tech.	Semester III
Program: Mechanical Engineering	SH 1133 Engineering Thermodynamics	

	Question	Q1(a)	Q1(b)	Q2(a)	Q2(b)	Q3(a)	Q3(b)	Q4(a)	Q4(b)	Q5(a)	Q5(b)	Q5(c)	Q6(a)	Q6(b)	Q6(c)	Total (100)
	CO	CO1	CO1	CO1	CO2	CO3	CO3	CO5	CO5	CO4	CO4	CO4	CO6	CO6	CO6	
	Marks	8	7	8	7	8	7	8	7	8	8	4	8	8	4	
	PRN Number															
1	2106001	1	1	0	0	0	0.5	0	0	4	0.5	0	0	0	2	9
2	2106002	5	0	3	0	5	0	4	0	3	0	3	3	0	2	28
3	2106003	8	1	3	1	3	0	8	1	6.5	0	3.5	4	0	4	43
4	2106005	0	0	1	0	0	0	3	0	3	0	0	5	5	2	19
5	2106008	NA	NA	2	0	7	4	7	1	4	8	3	2	0	3	41
6	2106009	2	0	7	0	0	0	5	0	4	1	3	0	4	2	28
7	2106010	1	0	6	7	8	5	7	1	1	0	4	7	1	4	52
8	2106011	5	5	5	6	6	6	0	0	5	1	2	6	4	2	53
9	2106013	0	0.5	2	0	0	0.5	4	0	0	0	2	1	1	0	11
10	2106014	7	0	6	0	7	0	5	0	0	0	4	7	0	4	40
11	2106018	7	0.5	2	0	1	6	8	2	5	0	0	6	4	0	41.5
12	2106019	6	4	5	0	4	0	5	0	5	0	3	5	3	0	40
13	2106021	6	0	6	0	8	0	6	0	6	0	4	8	0	3	47
14	2106022	6	5	4	0	0	0	2	0	5	2	3	0	0	1	28
15	2106023	7	4	8	7	8	6	6	3	3.5	4	4	4	5	2	71.5
16	2106025	7	7	6	6	7	0	4	5	6	0	0	2	6	3	59
17	2106026	1	4	4	7	3	0	7	0	5	0	0	0	6	4	41
18	2106027	0	5	2	5	2	0	4	0	6	0	2	0	0	3	29
19	2106029	0	2	2	5	1	0	6	0	4.5	0	3	0	0.5	2	26
20	2106030	8	5	3	0	7	6	4	0	4	5	3	7	8	3	63
21	2106032	5	1	NA	NA	NA	NA	6	0	0	0	2	0	0	2	16
22	2106035	5	3	2	0	0	0	1	0	3	0	3	6	0	3	26
23	2106037	5	2	2.5	5	1	0	6	7	6.5	2.5	3	2	4	4	50.5
24	2106039	0	0	3	0	5	2	5	0	4	2	2	0	0	2	25
25	2106040	5	0	2	0	5	3	6	0	3	0	4	0	0	1	29
26	2106041	7	0	2	0	2	0	2	0	6	0	2	2	2	1	26
27	2106042	8	4	4	0	6	0	7	0	6.5	0	4	3	6	3	51.5
28	2106044	7	5	6	2	1	1	6	6	2	3	2	2	4	0	47
29	2106045	8	3	3	0.5	6	7	6.5	0.5	6.5	7	3	3	6	4	64
30	2106047	4	0	3	0	0	0	0	0	0	0	0	2	0	1	10
31	2106048	6	4	1	0	4	7	7	2	6.5	8	4	3	8	4	64.5

32	2106049	0	0	3	5	4	4	4	0	4	2	0	0	0	1	27
33	2106051	5	4	6	2	7	7	7	0	6.5	6	0	1	7	4	62.5
34	2106052	7	6	7	0	7	0	5	6	6	5	3	0	5	3	60
35	2106055	8	6	7	0	8	7	7	4	7.5	8	4	7	8	3	84.5
36	2106056	0	0	0	0	0	0	0	0	2	0	1	0	0	1	4
37	2106057	8	0	5	0	3	2	8	0	4	2	4	3	0	4	43
38	2106058	3	4	2	0	1	6	6	0	6	0	0	0	0	1	29
39	2106059	7	0	7	0	0	0.5	8	7	7.5	2	4	5	7	4	59
40	2106060	5	0	4	4	0	0	4	0	6	0	3	0	3	1	30
41	2106065	2	3	7	0	5	0	6	2	4.5	2	3.5	5	0	0	40
42	2106068	7	7	5	0	6	6	6	0	6	1	2	2	0	2	50
43	2106072	7	4	1	0	0.5	4	7	2	3	0	2	4	4	3	41.5
44	2106074	0	6	4	0	7	6	6	0	4	3	2	0	1	2	41
45	2106077	5	5	6	0	3	4	6	2	6	2	4	4	0	4	51
46	2106079	8	4	3	0	2	4	6	1	5	1	0	2	0	4	40
47	2106081	8	4	5	0	6	3	6	0	4	0	4	4	0	4	48
48	2106083	5	0	5	0	0	0	4	0	4	2	3	1	0	0	24
49	2106087	4	3	5	1	1	1	7	2	5	2	4	2	2	2	41
50	2106089	5	0	5	0	6	6	5	5	4	2	3	3	0	1	45
51	2106090	6	7	7	0	4	7	8	4	7	2	4	7	0	2	65
52	2106093	7	0	4	0	0	0	5	4	7	5	2	3	0	3	40
53	2106071	7	2	4	2	4	4	7	4	6	8	4	3	7	2	64
54	2106084	2	4	5	0	0	5	5	5	6	6	3	7	5	2	55
55	2106086	5	3	7	3	8	0.5	7	5	5.5	4	4	3	0	4	59
56	2106092	6	0	5	0	3	4	4	2	5	3	3	5	0	2	42
57	2106094	8	0	4	0	7	3	5	2	1	5	0	2	6	1	44
58	2106096	6	5	4	4	7	5	5	4	6	5	2	6	5	2	66
59	2106097	4	4	6	4	3	4	4	2	7.5	2	3	0	0	2	45.5
60	2106099	4	0	2	0	7	1	3	0	5	0	2	4	0	2	30
61	2106100	4	0	7	0	8	4	7	0	4	0	4	5	0	4	47
62	2106101	6	2	0	0	0	7	5	4	6	6	0	0	8	3	47
63	2106102	7	0.5	6.5	0	0	4	7	4	5	6	4	4	8	4	60
64	2106103	6	5	3	0	0	5	4	4	5	2	2	6	7	3	52
65	2106104	7	0	6	0	4	4	4	0	4	8	0	4	6	3	50
66	2106105	6	0	5	0	0	1	3	1	5	5	3	7	3	3	42
67	2106107	8	5	8	7	8	7	8	5	6.5	6	4	0	5	4	81.5
68	2106108	6	0	6	5	0	6	3	0	4	0	3	0	7	0	40
69	2106109	8	0.5	4	7	0	6	3	0	6	0	4	4	7	2	51.5
70	2106110	5	0	4	5	6	0	5	0	5	0	3	5	0	2	40
71	2106112	4	6	7	4	8	2	6	2	2	0	3	0	0	1	45
72	2106113	5	0	0	0	0	0	5	0	5	0	3	4	0	2	24
73	2106116	7	1	6	0	2	7	6	2	6	2	1	3	4	4	51
74	2106118	6	6	6	0	6	6	4	5	6	2	2	3	5	1	58
75	2106119	0	2	8	0	2	4	7	4	4.5	0	4	4	0	4	43.5
76	2106120	6	6	2	0	6	6	0	0	5	2	2	4	1	1	41
77	2106122	2	0	NA	NA	8	6	NA	NA	4	0	0	NA	NA	NA	20
78	2106123	5	0	5	0	3	0	4	0	0	0	0	3	0	2	22
79	2106124	4	2	7	0	2	0	6	0	5	2	1	2	5	4	40
80	2106125	0	0	0	0	0	0	0	0	0	0	2	0	0	2	4
81	2106127	5	0	7	0	0	3	5	3	5	3	2	0	5	2	40
82	2106128	0	0	0	4	1	2	2	0	2	0	0	3	0	2	16
83	2106129	7	0	8	0	8	5	8	7	4	0	4	4	4	4	63
84	2108007	4	0	4	0	0	5	3	0	2	2	3	3	3	1	30
85	2256001	0.5	0.5	NA	NA	0	3	4	0	5	0	0	NA	NA	NA	13
86	2256002	6	0	4	0	6	6	5	7	6	0	2	4	6	3	55
87	2256003	8	3	4	4	0	3	6	3	4.5	2	4	3	5	2	51.5
88	2256004	6	0	3	0	0	0	0	0	5	0	2	4	2	1	23
89	2256005	4	2	5	4	4	4	6	5	6	0	4	4	0	4	52
90	2256006	5	0	2	0	5	6	2	0	5	0	0	1	0	0	26
91	2256007	7	5	8	0	8	7	8	7	5	5	4	4	8	4	80
92	2256008	6	2	2	0	0	0	4	0	4	2	3	1	0	3	27
93	2256009	7	0	6	0	8	4	7	4	5	0	4	4	5	2	56
94	2256010	5	0	3	0	5	5	3	0	3	1	3	1	0	1	30
95	2256011	8	0	8	0	8	0	8	0	6.5	8	2	5	5	4	62.5
96	2256012	6	0	5	0	0	0	3	0	6	2	3	3	0	3	31
97	2256013	7	0.5	7	7	0	4	7	4	3.5	2	4	2	4	4	56
98	2256014	5	3	3	0	0	0	4	0	5	0	3	0	6	4	33
99	2256015	4	0	3	0	6	0	6	0	5	0	0	0	0	2	26

100	2256016	6	5	6	2	3	5	6	0	6	6	3	4	7	2	61
101	2256017	8	0	7	0	4	5	6	2	6.5	2	2	0	6	2	50.5
102	2256018	0	0	5	0	0	6	0	0	0	0	0	0	0	0	11
103	2256019	8	0	7	2	8	7	8	4	6.5	6	4	4	6	4	74.5
104	2256020	7	0	7	0	7	7	7	7	6	6	3	4	8	4	73
105	2256021	8	0	8	0	0	5	6	2	6	2	4	3	7	4	55
106	2256022	5	0	7	0	7	7	7	5	6	0	2	5	6	3	60
107	2256023	7	3	7	2	0	5	6	4	1.5	1	1	2	4	4	47.5
108	2256024	4	5	6	0	5	6	6	2	6	0	3	0	6	2	51
109	2256025	7	0	7	0	NA	NA	NA	NA	NA	NA	NA	0	0	4	18
110	2256026	6	0	3	0	1	0	4	0	0	3	0	2	0	1	20
111	2256027	5	3	7	3	1	5	6	5	6.5	2	0	3	4	4	54.5
112	2256028	5	0	5	0	6	7	4	0	5	2	1	0	3	2	40
113	2256029	8	0.5	1	0	1	5	6	2	6.5	8	0	0	6	4	48
114	2256030	5	0	5	0	6	0	5	2	7	0	2	6	2	0	40
115	2256031	6	2	6	4	7	4	6	3	6.5	2	4	3	2	4	59.5
116	2256032	6	0	0	0	1	7	4	4	6	5	3	2	7	2	47
117	2256033	6	0	8	0	8	6	7	0	6.5	6	4	4	7	4	66.5
118	2256034	7	2	7	3	6	5	5	2	6	3	4	3	4	2	59
119	2256035	6	0	2	0	0	0	6	0	5	0	0	4	0	2	25
120	2256036	5	0	4	0	5	0	4	0	5	2	3	4	5	3	40
121	2256037	4	0	7	0	8	6	8	2	6	2	4	4	8	2	61
122	2256038	6	0	3	0	6	6	4	0	6	2	3	6	0	2	44
123	2256039	NA	NA	5	0	8	6	7	0	5	0	2	3	0	4	40
124	2256040	6	0	1	0	6	7	6	0	5	1	2	0	7	2	43
125	2256041	7	0.5	7	0	8	6	8	6	6.5	8	3	0	8	4	72
126	2006003	6	0	4	0	0	0	2	7	7	0	3	2	7	2	40
127	2006012	5	0	7	0	7	4	7	0	6.5	0	0	8	8	4	56.5
128	2006021	5	0	0	0	6	5	4	0	5	0	0	5	0	0	30
129	2006027	6	0	7	0	8	6	6	0	6.5	2	4	8	0	4	57.5
130	2006028	3	0	4	0	3	0	7	6	7	3	3	3	0	1	40
131	2006038	6	0	NA	NA	NA	NA	4	0	6	1	3	6	0	3	29
132	2006070	4	0	5	2	6	6	4	0	6	0	2	5	4	4	48
133	2006075	7	6	8	2	7	5	6	0	6.5	2	4	8	0	4	65.5
134	2006083	6	0	5	0	4	5	4	0	6	0	3	5	0	2	40
135	2006105	7	7	8	0	8	7	7	0	0	0	4	8	0	4	60

Question	Q1(a)	Q1(b)	Q2(a)	Q2(b)	Q3(a)	Q3(b)	Q4(a)	Q4(b)	Q5(a)	Q5(b)	Q5(c)	Q6(a)	Q6(b)	Q6(c)
CO	CO1	CO1	CO1	CO2	CO3	CO3	CO5	CO5	CO4	CO4	CO4	CO6	CO6	CO6
Marks	8	7	8	7	8	7	8	7	8	8	4	8	8	4
Threshold %	50													
Threshold Marks	4	3.5	4	3.5	4	3.5	4	3.5	4	4	2	4	4	2
No. of Students Above Threshold Marks	111	35	88	22	70	74	111	34	109	28	103	57	61	104
Total No. of Students in Class	135													
Percentage Attainment	82.22	25.93	65.19	16.30	51.85	54.81	82.22	25.19	80.74	20.74	76.30	42.22	45.19	77.04
CO Wise Average Percentage Attainment*	57.78			16.30	53.33		59.26		53.70			54.81		
Attainment Level**	2			1	2		2		2			2		

CO	CO wise Attainment Level**
CO1	2
CO2	1
CO3	2
CO4	2
CO5	2

Calulate CO wise Percentage Attainment Level Manually

***Enter the level of Attainment as per Below Range*

0%- 33 % = 1

34%-66% =2

67%-100%=3

_______________ forms the basis for development of mercury tube thermometer

_______________ forms the basis for development of mercury tube thermometer

- First law of thermodynamics
- Second law of thermodynamics
- Zeroth law of thermodynamics
- None of the mentioned

_______________ forms the basis for development of mercury tube thermometer

_______________ forms the basis for development of mercury tube thermometer

- First law of thermodynamics
- Second law of thermodynamics
- Zeroth law of thermodynamics
- None of the mentioned

A cyclic heat engine operates between a source temperature of 927 degree C ...

A cyclic heat engine operates between a source temperature of 927 degree C and a sink temperature of 27 degree C. What will be the maximum efficiency of the heat engine?

- 1
- 0.8
- 0.75
- 0.7

A machine which can supply mechanical work continuously without consumption ...

A machine which can supply mechanical work continuously without consumption of any energy is called as

- Perpetual Motion Machine of the First kind (PMM1)
- Perpetual Motion Machine of the Second kind (PMM2)
- Perpetual Motion Machine of the Third kind (PMM3)
- none of the mentioned

A machine which can supply mechanical work continuously without consumption ...

A machine which can supply mechanical work continuously without consumption of any energy is called as

- Perpetual Motion Machine of the First kind (PMM1)
- Perpetual Motion Machine of the Second kind (PMM2)
- Perpetual Motion Machine of the Third kind (PMM3)
- none of the mentioned

A process that passes through number of equilibrium states is called as

A process that passes through number of equilibrium states is called as

- Reversible process
- Irreversible process
- None of the mentioned
- Isentropic process

A process that passes through number of equilibrium states is called as

A process that passes through number of equilibrium states is called as

- Reversible process
- Irreversible process
- None of the mentioned
- Isentropic process

A quasi-static process has main characteristics as it is

A quasi-static process has main characteristics as it is

- a stationary process
- an infinitely slow process
- a random process

○ a spontaneous process

A quasi-static process has main characteristics as it is

A quasi-static process has main characteristics as it is

- ○ a stationary process
- ○ an infinitely slow process
- ○ a random process
- ○ a spontaneous process

A refrigerator and heat pump operates between same temperature limits. If the...

A refrigerator and heat pump operates between same temperature limits. If the COP of the refrigertor is 4, what is the COP of heat pump?

- ○ 3
- ○ 5
- ○ 4
- ○ 3.4

A system in which no mass can enter or leave the system and no energy can ...

A system in which no mass can enter or leave the system and no energy can enter or leave the system is called as

- ○ Open system
- ○ Closed system
- ○ Isolated system
- ○ None of the mentioned

A system in which no mass can enter or leave the system and no energy can ...

A system in which no mass can enter or leave the system and no energy can enter or leave the system is called as

- ○ Open system
- ○ Closed system
- ○ Isolated system
- ○ None of the mentioned

According to first law of thermodynamics

According to first law of thermodynamics

- ○ work done by a system is equal to heat transferred by the system
- ○ total internal energy of a system during a process remains constant
- ○ internal energy, enthalpy and entropy during a process remain constant
- ○ total energy of a system remains constant

According to first law of thermodynamics

According to first law of thermodynamics

- ○ work done by a system is equal to heat transferred by the system
- ○ total internal energy of a system during a process remains constant
- ○ internal energy, enthalpy and entropy during a process remain constant
- ○ total energy of a system remains constant

An air-conditioner provides 1 kg/s of air at 15 degree C cooled from outside ...

An air-conditioner provides 1 kg/s of air at 15 degree C cooled from outside atmospheric air at 35 degree C. Estimate the amount of power needed to operate the air-conditioner.

- ○ 1.09 kW
- ○ 1.19 kW
- ○ 1.29 kW
- ○ 1.39 kW

Closed system is also called as

Closed system is also called as

- ○ Control volume

ETH – ISE-2 22-23

Q1. Study the refrigeration system and perform the first law and second law analysis on the system by using following data.

Group 1 – use R12 as refrigerant

Group 2 – R22

Group 3 – R134a

Sr. No.	Description	Symbol	Unit	Quantity
1	Condensing pressure	Pc	PSI	150
2	Evaporating Pressure	Pe	PSI	45
3	Rotameter flow rate	m	LPH	20
4	Condenser Inlet Temp	T1	^0C	52
5	Condenser Outlet Temp	T2	^0C	30
6	Evaporator Inlet Temp	T3	^0C	2
7	Evaporator outlet Temp	T4	^0C	13

Q2. Study the steam power plant and perform the first law and second law analysis on the system by using following data.

Group 4

	Observation Table for Steam Power Plant			
Sr. No.	Description	Symbol	Unit	Quantity
	Boiler Section			
1	fuel consumption	mf	kg/hr	36
2	Calorific Value	LHV	KJ/kg	45000
3	Water Inlet Temperature	T1	^0C	27
4	Steam Temperature	T2	^0C	192
5	Steam Pressure	Psteam	bar	11.5
	Turbine Section			
1	Exhaust Pressure	Pexhast	bar	0.23
2	Exhaust Temperature	T3	^0C	98
	Generator Section			
1	Current	I	A	4.36
2	Voltage	V	V	230
	Condenser Section			

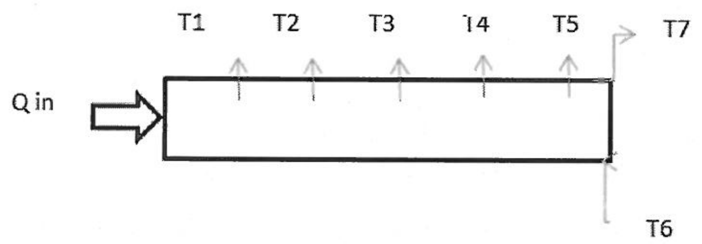
1	Cooling water inlet temperature	T4	^0C	30
2	Cooling water outlet temperature	T5	^0C	36

Q3. By using the following data perform the first law and second law analysis

Group 5

Dia of the metal rod = 25 mm
Distance between the adjacent thermocouple = 50 mm
mass flow rate of water = 0.023 kg/s
Thermal conductivity k = 385 W/mK

Temperature at different point along the thermocouple mounted on the rod					Temperature for the inlet and outlet water	
T1	T2	T3	T4	T5	T6	T7
52	49	45	42	39	27	29



Group 6

Dia of the metal rod = 30 mm
Distance between the adjacent thermocouple = 60 mm
mass flow rate of water = 0.023 kg/s
Thermal conductivity k = 385 W/mK

Temperature at different point along the thermocouple mounted on the rod					Temperature for the inlet and outlet water	
T1	T2	T3	T4	T5	T6	T7
52	49	45	42	39	27	29

Q4. Study the IC Engine and perform the first law and second law analysis on the system by using following data.

Group 7 – Load 1

Group 8 – Load 2

Group 9 – Load 3

Group 10 – Load 4

Sr. No.	Description	Quantity			
		Load 1	Load 2	Load 3	Load 4
1	Net Torque in kN- m	0.0104	0.0209	0.031	0.002967
2	Speed in RPM	1590	1585	1540	1610
3	Temp of Inlet trough jacket	25	25	25	25
4	Temp ofoutlet trough jacket	36	39	40	33
5	Fuel Consumption (kg/s)	0.000249	0.000327	0.000425	0.000202
6	Water flow rate in jacket(kg/s)	0.149254	0.140845	0.126582	0.15873
7	Tempearture of inlet water to calorimeter	25	25	25	25
8	Tempearture of outlet water to calorimeter	39	43	47	30
9	Temperature for the exhaust gas inlet	145	180	220	110
10	Temperature for exhaust gas outlet	85	100	115	60
11	Water flow rate in calorimeter	0.055866	0.051282	0.05102	0.081301

Q 5

Study the steam power plant and perform the first law and second law analysis on the system by using following data.

Group 11

	Observation Table for Steam Power Plant			
Sr. No.	Description	Symbol	Unit	Quantity
	Boiler Section			
1	fuel consumption	mf	kg/hr	40

2	Calorific Value	LHV	KJ/kg	45500
3	Water Inlet Temperature	T1	^0C	27
4	Steam Temperature	T2	^0C	220
5	Steam Pressure	Psteam	bar	12
	Turbine Section			
1	Exhaust Pressure	Pexhast	bar	0.5
2	Exhaust Temperature	T3	^0C	98
	Generator Section			
1	Current	I	A	4.36
2	Voltage	V	V	230
	Condenser Section			
1	Cooling water inlet temperature	T4	^0C	30
2	Cooling water outlet temperature	T5	^0C	36

ISE

KE Society's

Rajarambapu Institute of Technology, Rajaramnagar

Department of Mechanical Engineering

Result Analysis: Attainment of COs

Examination: ISE/2022-23	Class: S Y B Tech.	Semester III
Program: Mechanical Engineering	Engneernig Thermodynamics	

	Exam	ISE1		ISE2		ISE3		Total (20)
	CO	CO1	CO2	CO3	CO4	CO5	CO6	
	Marks	5	4	5	4	1	1	
	PRN Number							
1	2006052	2	1	1	1	1	1	7
2	2006096	2	1	1	1	1	1	7
3	2106001	4	3	4	3	1	1	16
4	2106002	4	2	4	3	1	1	15
5	2106003	3	2	3	2	1	1	12
6	2106005	3	3	3	2	1	1	13
7	2106008	3	2	3	2	1	1	12
8	2106009	3	2	3	2	1	1	12
9	2106010	3	3	3	3	1	1	14
10	2106011	4	3	3	3	1	1	15
11	2106013	4	4	4	3	1	1	17
12	2106014	3	3	3	3	1	1	14
13	2106018	3	2	3	2	1	1	12
14	2106019	3	2	2	2	1	1	11
15	2106021	3	2	3	2	1	1	12
16	2106022	2	2	3	2	1	1	11
17	2106023	4	3	4	3	1	1	16
18	2106025	3	3	3	3	1	1	14
19	2106026	3	3	3	3	1	1	14
20	2106027	3	3	3	3	1	1	14
21	2106029	3	3	3	3	1	1	14
22	2106030	4	4	4	3	1	1	17
23	2106032	3	3	3	3	1	1	14
24	2106034	3	2	2	2	1	1	11
25	2106035	3	3	3	2	1	1	13
26	2106037	4	3	4	3	1	1	16
27	2106039	3	3	3	2	1	1	13
28	2106040	3	2	3	2	1	1	12
29	2106041	4	3	3	3	1	1	15
30	2106042	3	3	3	3	1	1	14
31	2106044	3	3	3	3	1	1	14
32	2106045	3	3	3	2	1	1	13
33	2106047	4	4	4	3	1	1	17
34	2106048	3	3	3	2	1	1	13
35	2106049	3	2	3	2	1	1	12
36	2106051	3	3	3	3	1	1	14
37	2106052	3	3	3	3	1	1	14
38	2106055	3	3	3	3	1	1	14
39	2106056	4	3	4	3	1	1	16
40	2106057	3	2	3	2	1	1	12

41	2106058	3	3	3	3	1	1	14
42	2106059	4	3	4	3	1	1	16
43	2106060	4	3	3	3	1	1	15
44	2106065	3	2	3	2	1	1	12
45	2106068	4	3	3	3	1	1	15
46	2106071	3	3	3	2	1	1	13
47	2106084	4	2	4	2	1	1	14
48	2106086	3	2	3	3	1	1	13
49	2106092	3	3	3	2	1	1	13
50	2106094	4	3	4	2	1	1	15

51	2106096	3	2	3	3	1	1	13
52	2106097	3	3	3	2	1	1	13
53	2106099	3	3	3	2	1	1	13
54	2106100	2	2	2	2	1	1	10
55	2106101	3	3	3	3	1	1	14
56	2106102	3	3	3	2	1	1	13
57	2106103	3	3	4	3	1	1	15
58	2106104	3	2	3	2	1	1	12
59	2106105	3	3	3	3	1	1	14
60	2106107	3	2	3	2	1	1	12
61	2106108	3	2	3	3	1	1	13
62	2106109	3	3	3	3	1	1	14
63	2106110	3	2	3	2	1	1	12
64	2106112	4	3	4	3	1	1	16
65	2106113	3	2	3	2	1	1	12
66	2106116	4	3	3	3	1	1	15
67	2106118	2	2	3	2	1	1	11
68	2106119	3	2	3	2	1	1	12
69	2106120	3	2	2	2	1	1	11
70	2106122	4	3	3	3	1	1	15
71	2106123	3	2	2	2	1	1	11
72	2106124	3	2	3	2	1	1	12
73	2106125	2	3	2	2	1	1	11
74	2106127	4	3	3	3	1	1	15
75	2106128	3	2	3	2	1	1	12
76	2106129	3	2	3	2	1	1	12
77	2108007	3	2	3	2	1	1	12
78	2256001	4	3	4	3	1	1	16
79	2256002	3	2	3	3	1	1	13
80	2256003	3	2	3	3	1	1	13
81	2256004					1	1	2
82	2256005	3	2	3	3	1	1	13
83	2256006	3	3	3	3	1	1	14
84	2256007	3	2	3	2	1	1	12
85	2256008	2	2	3	2	1	1	11
86	2256009	3	2	2	2	1	1	11
87	2256010	3	3	3	3	1	1	14
88	2256011	4	3	3	3	1	1	15
89	2256012	2	2	3	3	1	1	12
90	2256013	3	2	3	3	1	1	13
91	2256014	3	2	3	3	1	1	13
92	2256015	3	2	2	2	1	1	11
93	2256016	3	2	3	3	1	1	13
94	2256017	4	3	3	3	1	1	15
95	2256018	3	3	3	3	1	1	14
96	2256019	3	2	3	3	1	1	13
97	2256020	4	3	4	3	1	1	16
98	2256021	3	2	3	3	1	1	13
99	2256022	3	2	3	3	1	1	13
100	2256023	2	2	2	2	1	1	10
101	2256024	3	2	2	2	1	1	11
102	2256025	2	2	2	2	1	1	10
103	2256026	3	2	3	2	1	1	12
104	2256027	3	3	3	3	1	1	14
105	2256028	2	2	3	2	1	1	11
106	2256029	3	2	3	2	1	1	12
107	2256030	3	3	3	3	1	1	14
108	2256031	3	2	3	2	1	1	12

109	2256032	3	2	3	2	1	1	12
110	2256033	3	3	3	3	1	1	14
111	2256034	4	3	4	3	1	1	16
112	2256035	3	2	3	2	1	1	12
113	2256036	3	2	3	3	1	1	13
114	2256037	3	2	3	3	1	1	13
115	2256038	3	2	3	2	1	1	12
116	2256039	3	2	3	2	1	1	12
117	2256040	3	2	3	2	1	1	12
118	2256041	3	2	3	3	1	1	13

Exam	ISE1		ISE2		ISE3		
CO	CO1	CO2	CO3	CO4	CO5	CO6	
Marks	5	4	5	4	1	1	
Threshold %	50						
Threshold Marks	2.5	2	2.5	2	0.5	0.5	0
No. of Students Above Threshold Marks	106	115	104	115	117	117	
Total No. of Students in Class	128						
Percentage Attainment	82.81	89.84	81.25	89.84	91.41	91.41	
CO Wise Average Percentage Attainment*	82.81	89.84	81.25	89.84	91.41	91.41	
Attainment Level**	3	3	3	3	3	3	

CO	Average Attainment Level**
CO1	3
CO2	3
CO3	3
CO4	3
CO5	3
CO6	3

*Calulate CO wise Percentage Attainment Level Manually

**Enter the level of Attainment as per Below Range

0%- 33 % = 1

34%-66% =2

67%-100%=3

K.E.Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated to SUK)

Unit Test-I

S. Y. B. Tech. Mechanical Engineering Semester- III

Course Name: Engineering Thermodynamics

Course Code: ME2134

Enroll No

Q.P.Code

Day &Date:..

Time: ....

Max. Marks- 25

Instructions: 1) *Figures to the right indicate full marks.*
2) *Assume suitable data if necessary and mention it clearly.*
3) *Use of steam table is allowed.*

Q.1 Solve the following **Marks**

(a) Derive general steady flow energy equation as per the first law of thermodynamics. **CO1** **05**

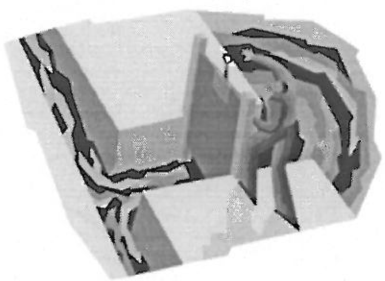
(b) Prove that energy is a property of the systems with examples **CO1** **05**

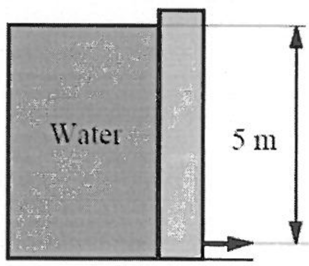
(c) Explain Kelvin Planks statements of the second law of thermodynamics. **CO2** **05**

OR

(c) Explain Clausius statements of the second law of thermodynamics? **CO2** **05**

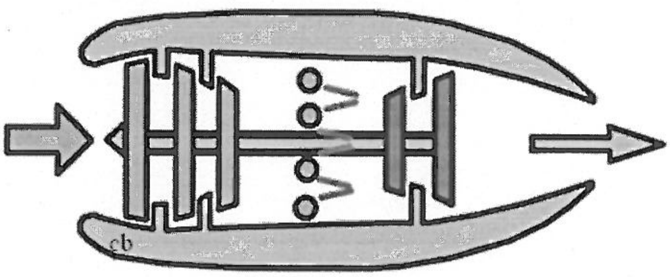
(d) A sluice gate dams water up 5 m. There is a small hole at the bottom of the gate so liquid water at 20oC comes out of a 1 cm diameter hole. Neglect any changes in internal energy and find the exit velocity and mass flow rate. **CO1** **05**





OR

(d) Air at 20 m/s with 5 kg/s flows into a jet engine and it flows out at 500 m/s. What is the change (power) in flow of kinetic energy? **CO1** **05**



(e) Develop equation for COP of Refrigerator and Heat Pump with layouts. **CO1** **05**

Enroll No

K.E.Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated to SUK)

Unit Test-I

S. Y. B. Tech. Mechanical Engineering Semester- III

Course Name: Engineering Thermodynamics

Course Code: ME2032

Q.P.Code

Day &Date:..

Time: .... **Max. Marks- 25**

Instructions: 1) *Figures to the right indicate full marks.*

2) *Assume suitable data if necessary and mention it clearly.*

3) *Use of steam table is allowed.*

Q.1	Solve **Any Five** of the following			**Marks**
	(a)	Apply SFEE to turbine and heat exchanger and develop equation for the same.	**CO1**	**05**
	(b)	Illustrate with figure equation for COP of heat pump and refrigerator	**CO2**	**05**
	(c)	Explain the difference between extensive and intensive properties of the systems with examples	**CO1**	**05**
	(d)	Develop the equation for efficiency of the heat engine	**CO2**	**05**
	(e)	Write the limitation of the first law of the Thermodynamics	**CO2**	**05**
	(f)	In a common room, for comfort, temperature conditions are maintained in winter by circulating hot water through a piping system. The water enters the system at 3 bar pressure and $50^{O}C$ temperature with an enthalpy of 240 kJ/kg and leaves at 2.5 bar, and $30^{O}C$ with an enthalpy of 195 kJ/kg. The exit of water is 15 m above its entry. The water supplies 30 MJ/h heat to the room. Calculate the quantity of water circulated through the pipe per minute. Assume there is no pump work in the system and change in kinetic energy is negligible.	**CO1**	**05**

Enroll No

K.E.Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated to SUK)

Unit Test-II

S. Y. B. Tech. Mechanical Engineering Semester- III

Course Name: Engineering Thermodynamics

Course Code: ME2033

Q.P.Code

Day &Date:..

Time: ....

Max. Marks- 25

Instructions: 1) *Figures to the right indicate full marks.*

2) *Assume suitable data if necessary and mention it clearly.*

3) *Use of steam table is allowed.*

Q.1 Solve the following. **Marks**

(a)	What did you understand by mole fraction, mass fraction , Avogadro's principle and Dalton's law of partial pressure?	**CO4**	**05**
(b)	Describe Carnot cycle and obtain expression for its efficiency as applied to a heat engine. -OR- Show that entropy is a property of the system.	**CO2**	**05**
(c)	An inventor claims to have develop a heat engine that receives 750 kJ of heat from a source at 550 K and produces 460 kJ of net work while rejecting the waste heat to a sink at 290 K. Is this a reasonable claim? Why? -OR- A heat source at 800 K loses 2000 kJ of heat to a sink at (a) 500 K and (b) 750 K. Determine which heat transfer process is more irreversible.	**CO2**	**05**
(d)	A 500 kg iron block is initially at 200°C and is allowed to cool to 27°C by transferring heat to the surrounding air at 27°C. Determine the reversible work and the irreversibility for this process.	**CO3**	**05**
(g)	Derive an equation for the exergy of the heat input of cycle.	**CO3**	**05**

Enroll No

K.E.Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated to SUK)

UT 2 Open Book Examination

Second Year B.Tech. Mechanical Engineering Semester- III

Course Name: Engineering Thermodynamics Course Code: ME2032

Q.P.Code

Day &Date: Tuesday, 27th Oct, 2020

Time: 3.00 pm to 5.30 pm (2.5 hrs)

Max Marks- 25

Instructions: 1) *Figures to the right indicate full marks.*

2) *Assume suitable data if necessary and mention it clearly.*

3) *Use of steam table is allowed.*

Q.1	Solve the following		Marks
(a)	A rigid tank and a frictionless piston cylinder device initially contains 12 kg of an ideal gas each at the same temperature, pressure and volume. It is desired to raise the temperatures of both systems by 15^0C. Determine the amount of extra heat that must be supplied to the gas in the cylinder, which is maintained at constant pressure to achieve this result. Assume the molar mass of the gas is 25.	**CO5**	**06**
(b)	Design a heating system for a swimming pool that is 2 m deep, 25m long, and 25m wide. Your client desires that the heating system be large enough to raise the water temperature by 5 + last one digit of your roll number (e.g. if your roll number is 1806033 then increase in temperature is 5+3=8^0C) in 3 hr. The rate of heat loss from the water to the air at the outdoor design conditions is determined to be 960 W/m^2, and the heater must also be able to maintain the heated temperature of water at those conditions. Heat losses to the ground are expected to be small and can be disregarded. The heater considered is a natural gas furnace whose efficiency is 80 percent. What heater size (in kW input) would you recommend to your client?	**CO5**	**07**
(c)	A mixture of gases consists of 0.1 kg of Oxygen, 1 kg of Carbon dioxide, 0.5 kg of helium. The mixture is expanded from 1000 kPa and 327^0C to 100 kPa in an adiabatic steady flow turbine of 90 percent isentropic efficiency. Calculate second law efficiency and exergy destruction during the expansion process. Take $T_0 = 25^0$C.	**CO3**	**06**
(d)	A well-insulated heat exchanger is to heat water (c_p = 4.18 kJ/kg.^{0}C) from 25^0C to 60^0C at a rate of 0.4 kg/s. The heating is to be accomplished by geothermal water (c_p = 4.31 kJ/kg.^{0}C) available at 140^0C at a mass flow rate of 0.3 kg/s. The inner tube is thin-walled and has a diameter of 0.6 cm. Determine a) the rate of heat transfer and b) the rate of exergy destruction in the heat exchanger.	**CO3**	**06**

sharad.patil@ritindia.edu (9970700875)

K.E.Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated to SUK)

Unit Test-II

S. Y. B. Tech. Mechanical Engineering Semester- III

Course Name: Engineering Thermodynamics

Course Code: ME2032

Enroll No

Q.P.Code

Day &Date:..

Time: .... **Max. Marks- 25**

Instructions: 1) *Figures to the right indicate full marks.*

2) *Assume suitable data if necessary and mention it clearly.*

3) *Use of steam table is allowed.*

Q.1	Solve **Any Five** of the following			**Marks**
(a)	Explain principle of increase in entropy.		**CO2**	**05**
(b)	Illustrate with figure equation for availability of open (steady flow) system		**CO3**	**05**
(c)	Explain the following 1. Mole fraction 2. Mass Fraction 3. Dalton's law 4. Amagat's law 5. Universal gas constant		**CO5**	**05**
(d)	Calculate the decrease in exergy when 25 kg of water at 95°C mix with 35 kg of water at 35°C, the pressure being taken as constant and the temperature of the corresponding being 15°C. Cp of water is 4.2 kJ/kgK.		**CO3**	**05**
(e)	One kg of ice at 0°C is mixed with 10 kg of water at 30°C. Determine the unavailable energy and the net increase in the entropy when the system reaches common temperature. Assume that surrounding temperature is 10°C. Take specific heat of water as 4.18 kJ/kg.K and specific heat of ice as 2.1 kJ/kg.K, latent heat of fusion as 333.5 kJ/kg.		**CO3**	**05**
(f)	Consider a gas mixture that consists of 4 kg of O_2, 5.5 kg of N_2 and 10.5 kg of CH_4. Determine (a) the mass fraction of each component, (b) the mole fraction of each component, and (c) the average molar mass and gas constant of the mixture.		**CO5**	**05**

Online checks

U- 146043	R.S.Kadam Signature of Student	Signature of Invigilator 04/01/23

K. E. Society's

RAJARAMBAPU INSTITUTE OF TECHNOLO

RAJARAMNAGAR

(An Autonomous Institute affiliated to Shivaji University, Kolhapur

CLASS & BRANCH.: (S.Y. mechanical) **UNIT TEST NO.:** 01

PERMANENT REGISTRATION NO. (PRN) : 2256007 **Q. P. CODE :** UT152

COURSE NAME : ETH **COURSE CODE :** ME2033

DAY & DATE : 04/01/2023 **NO. OF SUPPLEMENT** ___

Que. No.	Marks						Sub Total
	a	b	c	d	e	f	
1							
2							
3							
4							
5							
6							
	Total Marks Obtained						

Signature of Examiner ______________________

IMPORTANT NOTICE

As per Maharashtra Act No. XXXI of 1982 (7&8) whoever is found in or near an examination hall by the invigilator or any other person appointed to supervise the conduct of examination, copying answers to the question paper at the examination, from any book, notes or answer papers of other candidates, or appearing at the examination for any other candidate or using any other unfair means shall, on conviction, be punished with imprisonment for a term which may extend to six months, or with fine which may extend to five thousand rupees or with both. Whoever abets any offence under this act shall be punishable with the punishment provided for the offence.

INSTRUCTIONS

1. The answer book supplied to examinees is sufficient for writing answers. The supplement shall be supplied only after the verification by the invigilator.
2. It is necessary to write the Question No.and Sub Question No. before answer.
3. Write the complete answer in sequential manner and then start the next question in readable handwriting.
4. Answer in an illegible and undecipherable handwriting are liable to be marked as zero.
5. Use of blue color ink only (except diagrams) is permitted.
6. The candidate should not take any books/notes, log table, scribbling pads, cell phones, programmable calculators or any kind of reference material in to the examination hall. The candidate should make sure that he/she has no unauthorized book or paper in the examination hall with him or in his or her desk. he/she should have identity card, and hall ticket. The candidate should not write anything on the hall ticket, identity card, calculator and question paper,
7. **The candidate should see that the invigilator has appended his/her signature at the specified space on the answer book as and when he/she receives answer book.**
8. A warning bell shall be given 10 minutes before the commencement of the examination. All the candidates shall take their possession of seats. Another bell shall be given at the beginning of the examination when question paper shall be distributed. **No candidate shall be admitted after 30 minutes of the commencement of examination and shall not be allowed to leave the examination hall before 60 minutes after the commencement of examination. No candidate should leave his/her seat during last 10 minutes. Warning bell shall be given 10 minutes before the closing time and final bell is given at the end of the examination. Then all the candidates should stop writing or revising the answer and should hand over the answer book to the invigilator immediately.**
9. Any candidate appearing for UG/PG examination is liable to be charged for committing malpractice in the following cases:
   a. Bringing in the examination hall or being found in possession of portions of a book manuscript, programmable calculator any other matter, which is not permissible to be brought into the examination hall.
   b. Having found any written matter on scribbling pad, question paper, calculator, any part of the body, handkerchief, cloths, socks, instruments box, scales etc.
   c. Disclosing identity by writing any words or making any peculiar marks on the papers of answer books,
   d. Copying from the material or matter or answer of another candidate or similar aid or assistance rendered from another candidate within the examination hall.
   e. Communication with any candidate or any other person inside or outside examination hall with a view to take assistance or aid to write answer in the examination.
   f. Making any request of representation or offers by threat for inducement or inducing to invigilator or and any another official or officer of the institute or college for favors in the examination hall or the examiner in the answer script.
   g Smuggling out or smuggling in or tearing of the answer scripts sheets or supplementary sheets or inserting papers within or outside the examination hall into the answer book or running away along with the answer script from the examination hall or premises.
   H Impersonating or allowing any other person to impersonate to answer in his/her place in the examination hall.
   I. Supply of copying material inside or from outside the examination hall.
   j. Bringing mobile phone to the examination hall.
   k. Unruly behaviour inside or near the examination hall.

Q. No.		
Q1)		
	a)	

→ control mass:

It is the control mass system on mixed mass. The mass is not transfee on the boudry. The energy is in or out from this boundy

control volume:

It is control value system It The volume is transfee is boundry from in or out. and theie energy passing to the boundry to in or out.

Q. No.

c)

→ Given data

$U_1 = 800 \text{ KJ}$

$Q = -500 \text{ KJ}$

$W = -100 \text{ KJ}$

Find the final internal energy = ?

$\therefore U_2 = ?$

① According to first law of thermodynamic

$Q = \Delta U + W$

$\Delta U = Q - W$

$(U_2 - U_1) = Q - W$

$U_2 - 800 = -500 + 100$

$U_2 = -500 + 100 + 800$

$U_2 = 400 \text{ KJ}$

The final internal energy is $U_2 = 400 \text{ KJ}$

Q. No.

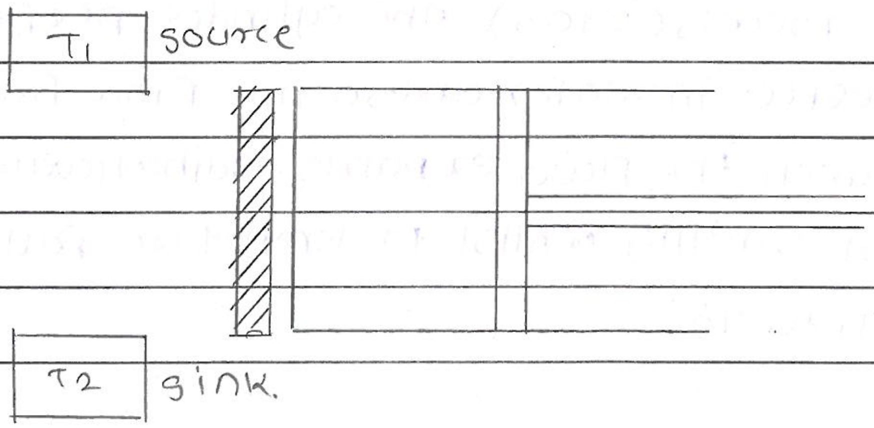
d)

⇒ carnot cycle and obtain expression for its efficiency as applied to a heat engine

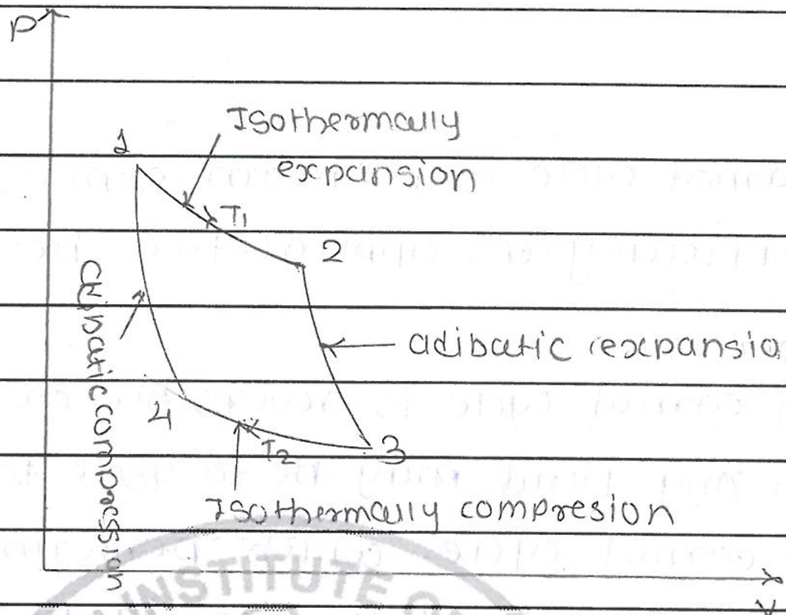
i) carnot cycle is reversible or Ideal cycle.

ii) Any fluid may be to used to operate carnot cycle which performed the engine cylinder head to suposly to alternative to ~~pe~~ performed perfect conductor or perfect insulator of heat.

iii) Heat causes to the flow of the cylinder to the application high temprature source. to the cylinder head during expansion. and flow of the cylinder to the application of low temprature source to the cylinder head during compression.



Q. No.



carnot engine cycle

steges.

① process (1 to 2): Heat energy source is applied to Heat Q_1 is taken to whilst fluid expands. Isotheemally and riversibility at given constant ~~@~~ high temprature

② process (2 to 3): The cylindee peeformed the peefect insulator ~~and~~ so not flow from heat taken. the fluid expands. adibatically and rivesibility whilst to tempratuse falls from T_1 to T_2

Q. No.

process (3 to 4): ~~Coted~~ cold energy source is applied to Heat Q_2 is taken to whilst fluid compression. Isothermally and riversibility at g constant low tempreture

process (4 to 1): The cylinder performed perfect insulator. so not flow from heat taken to fluid compression, adibatically and riversibility ~~at~~ whilst tempreture raise from t_2 to T_1

The first law of thermodynamic is work is equal to the different between. Heat ~~sourcee~~ ~~of the sin~~ energy source of e heat energy of the sink

$W = q_H - q_L$

$\eta = \frac{\text{work done}}{\text{Heat energy source}}$

$\eta = \frac{q_H - q_L}{q_H}$

$\eta = \frac{T_H - T_L}{T_H}$

Q. No.

$$\eta = 1 - \frac{T_L}{T_H}$$

9)

⟹ Steady flow ~~eqn~~ energy eqn

① According to nozzle

$$u_1 + P_1V_1 + \frac{V_1^2}{2} + gz_1 + \omega = u_2 + P_2V_2 + \frac{V_2^2}{2} + gz_2 + q$$

becomes the eqn

$$u_1 + P_1V_1 + \frac{V_1^2}{2} = u_2 + P_2V_2 + \frac{V_2^2}{2}$$

The Isothermal energy and flow energy is collective called. The entholpy is denoted by the h

$$\therefore h_1 + \frac{V_1^2}{2} = h_2 + \frac{V_2^2}{2}$$

$$\frac{2 \times h_1 + V_1^2}{2} = \frac{2 \times h_2 + V_2^2}{2}$$

Q. No.

$$2 \times h_1 + v_1^2 = 2 \times h_2 + v_2^2$$

~~$v_2^2 = v_1^2 \times 2 +$~~

$$v_2 = \sqrt{v_1^2 + 2(h_2 - h_1)}$$

this is nozzle eqn

(2) According to turbine

$$u_1 + p_1 v_1 + \frac{v_1^2}{2} + g z_1 + w = u_2 + p_2 v_2 + \frac{v_2^2}{2} + g z_2 + q$$

becomes eqn

$$u_1 + p_1 v_1 = u_2 + p_2 v_2 + q$$

the turbine gives work output $w \neq 0$

i) the insulated heat transfer from the fluid to surrounding nigligible ∴ $q = 0$

ii) change potential energy is nigligible $z_1 \simeq z_2$

iii) change in kinetic energy is nigligible.

$$w = h_1 - h_2$$

this the turbine eqn

Q. No.

b)

⇒ Heat and work are path function

i) Heat and work are the dependent variable is known as path function

ii) Heat and work are dependent on the time so heat and work is path function. Heat is increase and work is also is increase at an inital point

iii) Heat and work is also in increases.

$W = q_1 - q_2$

Q. No.

d)

⇒ cop of heat pump and refrigerator

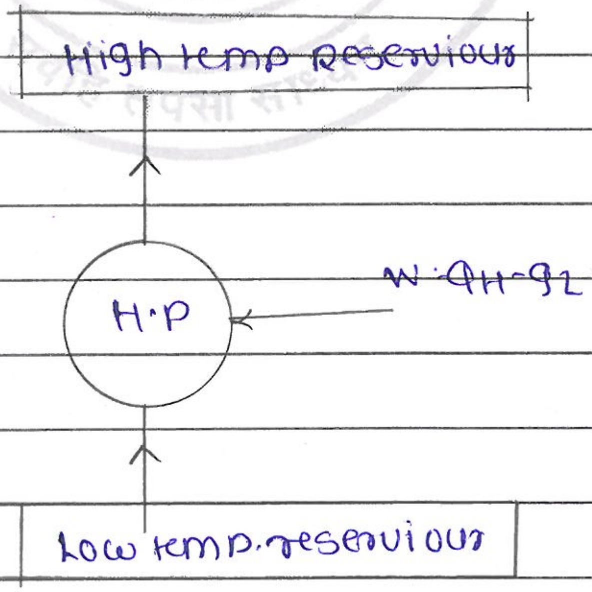
Heat pump:

i) The heat pump is device to maintain temp of this system to atmospheric temprature below

ii) Heat pump is transferred from heat energy source from low temp ~~sou~~ source to high temp source. with the help of external work

iii) evaporated is located by outside the room

iv) condense is located by inside the room



v) $COP_{HP} = \frac{Q_H}{Q_H - Q_L} = \frac{T_H}{T_H - T_L} = 1 -$

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

U- 146044	Sankett Signature of Student	Signature of Invigilator

K. E. Society's

RAJARAMBAPU INSTITUTE OF TECHNOLOGY
RAJARAMNAGAR
(An Autonomous Institute affiliated to Shivaji University, Kolhapur)

CLASS & BRANCH.: SY B-Tech Mechanical **UNIT TEST NO.:** 1

PERMANENT REGISTRATION NO. (PRN) : 2256008 **Q. P. CODE :** UT 152

COURSE NAME : Engineering Thermodynamics **COURSE CODE :** ME 2033

DAY & DATE : Wedensday 4/1/2023 **NO. OF SUPPLEMENT** ___

Que. No.	Marks						Sub Total
	a	b	c	d	e	f	
1							
2							
3							
4							
5							
6							
	Total Marks Obtained						

Signature of Examiner ______________________________

IMPORTANT NOTICE

As per Maharashtra Act No. XXXI of 1982 (7&8) whoever is found in or near an examination hall by the invigilator or any other person appointed to supervise the conduct of examination, copying answers to the question paper at the examination, from any book, notes or answer papers of other candidates, or appearing at the examination for any other candidate or using any other unfair means shall, on conviction, be punished with imprisonment for a term which may extend to six months, or with fine which may extend to five thousand rupees or with both. Whoever abets any offence under this act shall be punishable with the punishment provided for the offence.

INSTRUCTIONS

1. The answer book supplied to examinees is sufficient for writing answers. The supplement shall be supplied only after the verification by the invigilator.
2. It is necessary to write the Question No.and Sub Question No. before answer.
3. Write the complete answer in sequential manner and then start the next question in readable handwriting.
4. Answer in an illegible and undecipherable handwriting are liable to be marked as zero.
5. Use of blue color ink only (except diagrams) is permitted.
6. The candidate should not take any books/notes, log table, scribbling pads, cell phones, programmable calculators or any kind of reference material in to the examination hall. The candidate should make sure that he/she has no unauthorized book or paper in the examination hall with him or in his or her desk. he/she should have identity card, and hall ticket. The candidate should not write anything on the hall ticket, identity card, calculator and question paper,
7. **The candidate should see that the invigilator has appended his/her signature at the specified space on the answer book as and when he/she receives answer book.**
8. A warning bell shall be given 10 minutes before the commencement of the examination. All the candidates shall take their possession of seats. Another bell shall be given at the beginning of the examination when question paper shall be distributed. **No candidate shall be admitted after 30 minutes of the commencement of examination and shall not be allowed to leave the examination hall before 60 minutes after the commencement of examination. No candidate should leave his/her seat during last 10 minutes. Warning bell shall be given 10 minutes before the closing time and final bell is given at the end of the examination. Then all the candidates should stop writing or revising the answer and should hand over the answer book to the invigilator immediately.**
9. Any candidate appearing for UG/PG examination is liable to be charged for committing malpractice in the following cases:
   - a. Bringing in the examination hall or being found in possession of portions of a book manuscript, programmable calculator any other matter, which is not permissible to be brought into the examination hall.
   - b. Having found any written matter on scribbling pad, question paper, calculator, any part of the body, handkerchief, cloths, socks, instruments box, scales etc.
   - c. Disclosing identity by writing any words or making any peculiar marks on the papers of answer books,
   - d. Copying from the material or matter or answer of another candidate or similar aid or assistance rendered from another candidate within the examination hall.
   - e. Communication with any candidate or any other person inside or outside examination hall with a view to take assistance or aid to write answer in the examination.
   - f. Making any request of representation or offers by threat for inducement or inducing to invigilator or and any another official or officer of the institute or college for favors in the examination hall or the examiner in the answer script.
   - g Smuggling out or smuggling in or tearing of the answer scripts sheets or supplementary sheets or inserting papers within or outside the examination hall into the answer book or running away along with the answer script from the examination hall or premises.
   - H Impersonating or allowing any other person to impersonate to answer in his/her place in the examination hall.
   - I. Supply of copying material inside or from outside the examination hall.
   - j. Bringing mobile phone to the examination hall.
   - k. Unruly behaviour inside or near the examination hall.

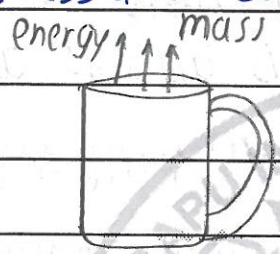
Q. No.

Q. 1

a)i) Control volume -

Control volume means open system in this system mass and energy both are transfer.

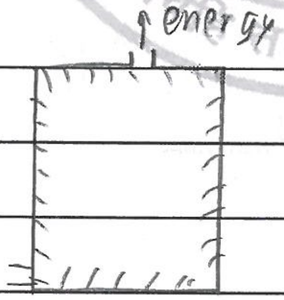
eg; ~~Pressure cooker~~ Cup of tea



ii) Control Mass -

Control mass means closed system in this system only energy is transfer & mass is does not transfer.

eg. Pressure cooker



Q. No.

b) Path function -

In this function means which are dependent variable is called as path function.

∴ Heat and work are depended on time so, Heat & work is path function. Heat increase then work is also is also increase and at intial point.

c) $u_1 = 800 kJ$

$Q_{loss} = 500 kJ$

$W_{pad} = 100 kJ$

$u_2 = ?$

$\Delta E = \Delta E_{in} - \Delta E_{out}$

$u_2 - u_1 = W_{pad} - Q_{loss}$

$u_2 - 800 = 100 - 500$

$u_2 - 800 = -400$

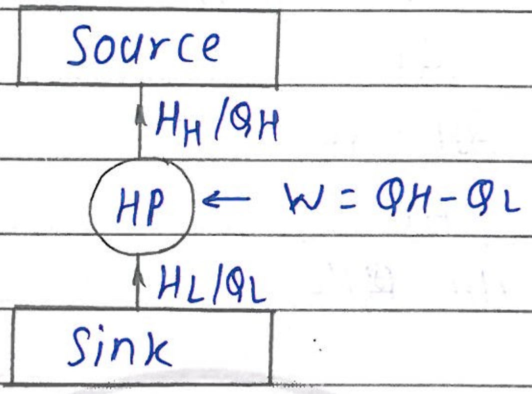
$u_2 = -400 + 800$

$\boxed{u_2 = 400 kJ}$

∴ The final internal energy of the fluid is 400 kJ.

Q. No.

d) i) Heat pump



$$COP_{HP} = \frac{\text{desire heating effect}}{\text{work supply}}$$

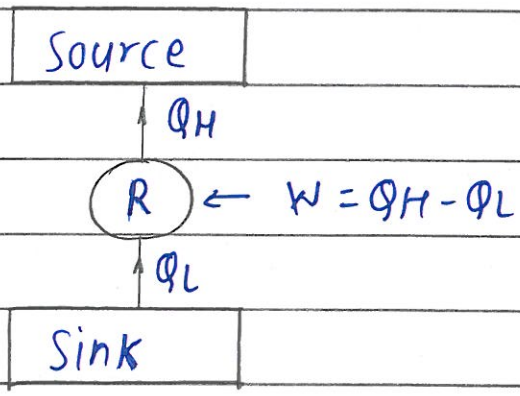
$$= \frac{Q_H}{Q_H - Q_L}$$

$$= \frac{H_H}{H_H - H_L}$$

or

$$COP_{HP} + 1 = COP_R$$

ii) Refrigerator



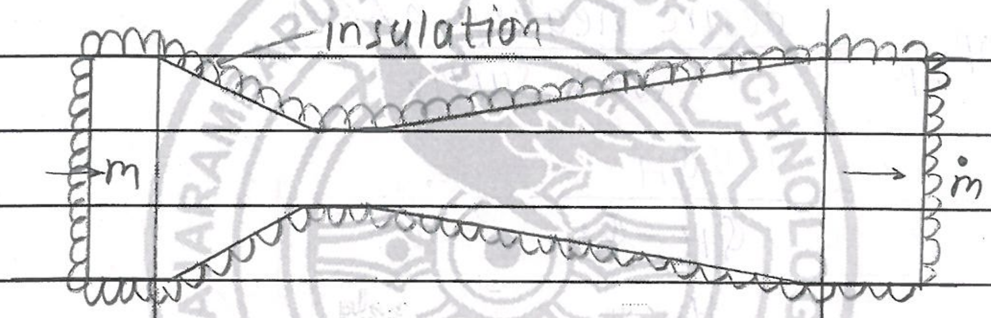
Q. No.

$$COP_R = \frac{\text{desire cooling effect}}{\text{Work supply}}$$

$$= \frac{Q_L}{Q_H - Q_L}$$

$$= \frac{H_L}{H_H - H_L}$$

g)i) Nozzle



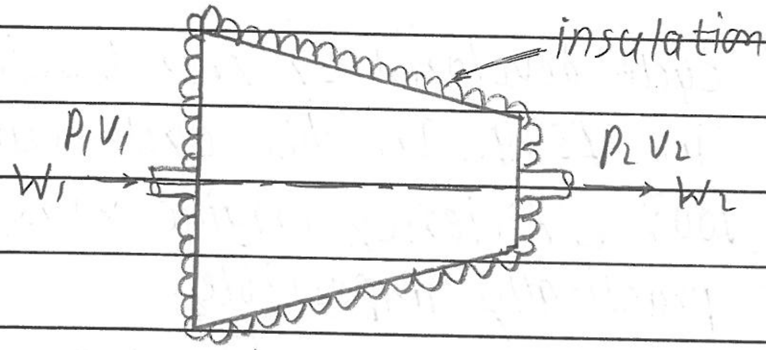
~~$V_2 = \sqrt{V_1 (h_1 - 2h_2)}$~~

~~$V_2 = \sqrt{V_1^2 + 2(h_2 - h_1)}$~~

$$\boxed{V_2 = \sqrt{V_1^2 + 2(h_2 - h_1)}}$$

Q. No.

ii) Turbine



$W_1 = W_2$

~~W =~~ $P_1V_1 \times 2g = P_2V_2 \times 2g$

$W = h_1 - h_2$

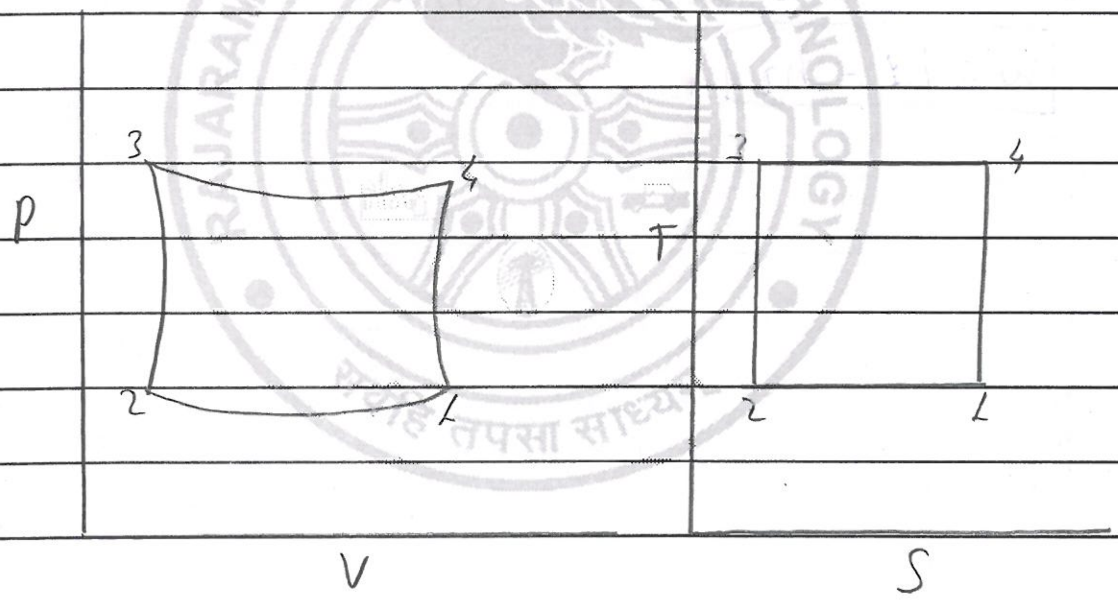
$\boxed{W = h_1 - h_2}$

Q. No.

d) Carnot cycle

Carnot cycle developed by french scienties Sadi carnot in 1839.. In this cycle carnot state that 100% efficiency engine work. This cycle is practically impossible.

In this 4 process is 2 is ~~isentropic~~ isothermal and 2 is adabatic



Process 1-2
isothermal heat addition

Process 2-3
adabatic ~~expansion~~ compression

Q. No.

process 3 - 4
isothermal heat rejection

process 4 - 1
adiabatic expansion.

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

U- 134840	Signature of Student	Signature of Invigilator

K. E. Society's

RAJARAMBAPU INSTITUTE OF TECHNOL[OGY]

RAJARAMNAGAR

(An Autonomous Institute affiliated to Shivaji University, Kolhap[ur])

Paste QR Code

CLASS & BRANCH.: S.Y. mechanical UNIT TEST NO.: II

PERMANENT REGISTRATION NO. (PRN) : 2106104 Q. P. CODE : UT19

COURSE NAME : Engineering Thermodynamics. COURSE CODE : ME2033

DAY & DATE : 21-12-22 NO. OF SUPPLEMENT ____

Que. No.	Marks						Sub Total
	a	b	c	d	e	f	
1							
2							
3							
4							
5							
6							
	Total Marks Obtained						

Signature of Examiner ____________________

IMPORTANT NOTICE

As per Maharashtra Act No. XXXI of 1982 (7&8) whoever is found in or near an examination hall by the invigilator or any other person appointed to supervise the conduct of examination, copying answers to the question paper at the examination, from any book, notes or answer papers of other candidates, or appearing at the examination for any other candidate or using any other unfair means shall, on conviction, be punished with imprisonment for a term which may extend to six months, or with fine which may extend to five thousand rupees or with both. Whoever abets any offence under this act shall be punishable with the punishment provided for the offence.

INSTRUCTIONS

1. The answer book supplied to examinees is sufficient for writing answers. The supplement shall be supplied only after the verification by the invigilator.
2. It is necessary to write the Question No.and Sub Question No. before answer.
3. Write the complete answer in sequential manner and then start the next question in readable handwriting.
4. Answer in an illegible and undecipherable handwriting are liable to be marked as zero.
5. Use of blue color ink only (except diagrams) is permitted.
6. The candidate should not take any books/notes, log table, scribbling pads, cell phones, programmable calculators or any kind of reference material in to the examination hall. The candidate should make sure that he/she has no unauthorized book or paper in the examination hall with him or in his or her desk. he/she should have identity card, and hall ticket. The candidate should not write anything on the hall ticket, identity card, calculator and question paper,
7. **The candidate should see that the invigilator has appended his/her signature at the specified space on the answer book as and when he/she receives answer book.**
8. A warning bell shall be given 10 minutes before the commencement of the examination. All the candidates shall take their possession of seats. Another bell shall be given at the beginning of the examination when question paper shall be distributed. **No candidate shall be admitted after 30 minutes of the commencement of examination and shall not be allowed to leave the examination hall before 60 minutes after the commencement of examination. No candidate should leave his/her seat during last 10 minutes. Warning bell shall be given 10 minutes before the closing time and final bell is given at the end of the examination. Then all the candidates should stop writing or revising the answer and should hand over the answer book to the invigilator immediately.**
9. Any candidate appearing for UG/PG examination is liable to be charged for committing malpractice in the following cases:
   a. Bringing in the examination hall or being found in possession of portions of a book manuscript programmable calculator any other matter, which is not permissible to be brought into the examination hall.
   b. Having found any written matter on scribbling pad, question paper, calculator, any part of the body, handkerchief, cloths, socks, instruments box, scales etc.
   c. Disclosing identity by writing any words or making any peculiar marks on the papers of answer books,
   d. Copying from the material or matter or answer of another candidate or similar aid or assistance rendered from another candidate within the examination hall.
   e. Communication with any candidate or any other person inside or outside examination hall with a view to take assistance or aid to write answer in the examination.
   f. Making any request of representation or offers by threat for inducement or inducing to invigilator or and any another official or officer of the institute or college for favors in the examination hall or the examiner in the answer script.
   g Smuggling out or smuggling in or tearing of the answer scripts sheets or supplementary sheets or inserting papers within or outside the examination hall into the answer book or running away along with the answer script from the examination hall or premises.
   H Impersonating or allowing any other person to impersonate to answer in his/her place in the examination hall.
   I. Supply of copying material inside or from outside the examination hall.
   j. Bringing mobile phone to the examination hall.
   k. Unruly behaviour inside or near the examination hall.

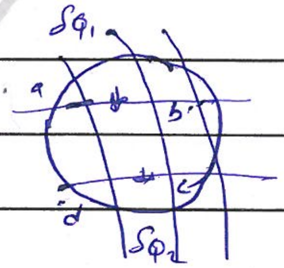
Q. No. 1

a]

~~It is impossible to create a divice which work on thermodynamic cycle. & to do~~ a absorb a heat ~~&~~ ~~convert~~ ~~convert & equivalent to work without charging~~ From

It is impossible to create a divice which work on thermodynamic cycle & to do a heat ~~trans~~ absorb or ~~transfer~~ from Low ~~to~~ temperature body to high temperature body. ~~without char~~

$$\eta = 1 - \frac{\delta Q_2}{\delta Q_1}$$



$$= 1 - \frac{\delta T_2}{\delta T_1}$$

$$\therefore \frac{\delta Q_2}{\delta Q_1} = \frac{\delta T_2}{\delta T_1} = \frac{\delta Q_2}{\delta T_2} = \frac{\delta Q_1}{\delta T_1}$$

if we have δQ_2 -ve & δQ_1 +ve

$$\therefore \frac{\delta Q_1}{\delta T_1} = \frac{-\delta Q_2}{\delta T_2}$$

Q. No.

$$\therefore \frac{\delta Q_1}{\delta T_1} + \frac{\delta Q_2}{\delta T_2} = 0$$

similarly we have

$$\frac{\delta Q_3}{\delta T_3} + \frac{\delta Q_4}{\delta T_4} = 0$$

If we ~~at~~ compare this eqn

$$\therefore \frac{\delta Q_1}{\delta T_1} + \frac{\delta Q_2}{\delta T_2} + \frac{\delta Q_3}{\delta T_3} + \frac{\delta Q_4}{\delta T_4} = 0$$

$$\oint \frac{\delta Q}{\delta T} = 0$$

Q. No. 7

b

b) T_H = 800 k

Q_L = 2000 kJ

sink = 500 ; 750 k

S_{gen} = Surronding - System

$(S_{gen})_a = -\frac{2000}{800} + \frac{2000}{500} = 1.5$

$(S_{gen})_b = -\frac{2000}{800} + \frac{2000}{750} = 0.16$

$(S_{gen})_b$ is mon irreversable

6

Q. No.	
d)	
	$T_0 = 200°C$
	$T_0 = 27°C$
	~~T_2 ... °C~~ 446
	$C_p = 0.4$ kJ/kgK
	$m = $ ~~20~~ 5200 kg
	$= mC_p\Delta T$
	$= 500 \times 0.4 \times 173$
	$= 34600$

Q. No.

Q. No.

9) ⇒ Flow system

flow energy = pv

flow = $v(p - p_0)$

energy of flow system & heat capacity body

$\psi = x_{nonflow} + x_{flow}$

$= \phi + x_{flow}$

$= (u - u_0) + p_0(v - v_0) - T_0(s - s_0) + \frac{v^2}{2} + gz + v(p - p_0)$

$\psi = (H - h_0) + T_0(s - s_0) + \frac{v^2}{2} + gz$

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

U- 134841

Signature of Student

Signature of Invigilator

K. E. Society's

RAJARAMBAPU INSTITUTE OF TECHNOLOGY
RAJARAMNAGAR

(An Autonomous Institute affiliated to Shivaji University, Kolhapur)

Paste QR Code

CLASS & BRANCH.: S.Y. Btech, Mechanical **UNIT TEST NO.:** 2

PERMANENT REGISTRATION NO. (PRN) : 2106105 **Q. P. CODE :** UT19

COURSE NAME : Engineering Thermodynamics **COURSE CODE :** ME2023

DAY & DATE : Wed, 21/12/2022 **NO. OF SUPPLEMENT** ___

Que. No.	Marks						Sub Total
	a	b	c	d	e	f	
1							
2							
3							
4							
5							
6							
	Total Marks Obtained						

Signature of Examiner ______________________

IMPORTANT NOTICE

As per Maharashtra Act No. XXXI of 1982 (7&8) whoever is found in or near an examination hall by the invigilator or any other person appointed to supervise the conduct of examination, copying answers to the question paper at the examination, from any book, notes or answer papers of other candidates, or appearing at the examination for any other candidate or using any other unfair means shall, on conviction, be punished with imprisonment for a term which may extend to six months, or with fine which may extend to five thousand rupees or with both. Whoever abets any offence under this act shall be punishable with the punishment provided for the offence.

INSTRUCTIONS

1. The answer book supplied to examinees is sufficient for writing answers. The supplement shall be supplied only after the verification by the invigilator.
2. It is necessary to write the Question No.and Sub Question No. before answer.
3. Write the complete answer in sequential manner and then start the next question in readable handwriting.
4. Answer in an illegible and undecipherable handwriting are liable to be marked as zero.
5. Use of blue color ink only (except diagrams) is permitted.
6. The candidate should not take any books/notes, log table, scribbling pads, cell phones, programmable calculators or any kind of reference material in to the examination hall. The candidate should make sure that he/she has no unauthorized book or paper in the examination hall with him or in his or her desk. he/she should have identity card, and hall ticket. The candidate should not write anything on the hall ticket, identity card, calculator and question paper,
7. **The candidate should see that the invigilator has appended his/her signature at the specified space on the answer book as and when he/she receives answer book.**
8. A warning bell shall be given 10 minutes before the commencement of the examination. All the candidates shall take their possession of seats. Another bell shall be given at the beginning of the examination when question paper shall be distributed. **No candidate shall be admitted after 30 minutes of the commencement of examination and shall not be allowed to leave the examination hall before 60 minutes after the commencement of examination. No candidate should leave his/her seat during last 10 minutes. Warning bell shall be given 10 minutes before the closing time and final bell is given at the end of the examination. Then all the candidates should stop writing or revising the answer and should hand over the answer book to the invigilator immediately.**
9. Any candidate appearing for UG/PG examination is liable to be charged for committing malpractice in the following cases:
   a. Bringing in the examination hall or being found in possession of portions of a book manuscript, programmable calculator any other matter, which is not permissible to be brought into the examination hall.
   b. Having found any written matter on scribbling pad, question paper, calculator, any part of the body, handkerchief, cloths, socks, instruments box, scales etc.
   c. Disclosing identity by writing any words or making any peculiar marks on the papers of answer books,
   d. Copying from the material or matter or answer of another candidate or similar aid or assistance rendered from another candidate within the examination hall.
   e. Communication with any candidate or any other person inside or outside examination hall with a view to take assistance or aid to write answer in the examination.
   f. Making any request of representation or offers by threat for inducement or inducing to invigilator or and any another official or officer of the institute or college for favors in the examination hall or the examiner in the answer script.
   g Smuggling out or smuggling in or tearing of the answer scripts sheets or supplementary sheets or inserting papers within or outside the examination hall into the answer book or running away along with the answer script from the examination hall or premises.
   H Impersonating or allowing any other person to impersonate to answer in his/her place in the examination hall.
   I. Supply of copying material inside or from outside the examination hall.
   j. Bringing mobile phone to the examination hall.
   k. Unruly behaviour inside or near the examination hall.

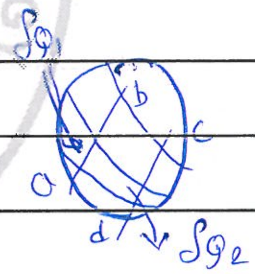
Q. No.

Que 1

~~It is thermodynamics cycle.~~

~~It is device which a~~

device operating is in thromodynamics cycle to prodeuce no effect on other than transfer.



$$\eta_{rev} = 1 - \frac{\delta Q_2}{\delta Q_1}$$

$$\eta_{rev} = 1 - \frac{\delta T_2}{\delta T_2}$$

$$\therefore \frac{\delta Q_2}{\delta Q_1} = \frac{\delta T_2}{\delta T_1}$$

~~where~~ ~~δQ~~ $\therefore \frac{\delta Q_2}{\delta T_2} = \frac{\delta Q_1}{\delta T_1}$

4

Q. No.

when $\delta Q_1 = +ve$ & $\delta Q_2 = -ve$

$$\frac{\delta Q_1}{\delta T_1} = -\frac{\delta Q_2}{\delta T_2}$$

$$\frac{\delta Q_1}{\delta T_1} + \frac{\delta Q_2}{\delta T_2} = 0$$

when ~~element~~ in another element.

$$\frac{\delta Q_3}{\delta T_3} + \frac{\delta Q_4}{\delta T_4} = 0$$

Equation is

$$\frac{\delta Q_1}{\delta T_1} + \frac{\delta Q_2}{\delta T_2} + \frac{\delta Q_3}{\delta T_3} + \frac{\delta Q_4}{\delta T_4} = 0$$

~~For reversible process.~~

$$\oint \frac{\delta Q_{rev}}{T} = 0$$

For reversible process.

$$\oint \frac{\delta Q_{rev}}{T} = 0$$

For irreversible process

$$\oint \frac{\delta Q_{irr}}{T} \leq 0$$

Q. No.

1 (b) =>

$Q_H = 750\, kJ \quad T_H = 550\, K$

~~$Q_L = 500$~~

$Q_L = 260\, kJ \quad T_L = 290\, K$

Reasonable claim = ?

6

Q. No.

Q1

(b) $Q_H = 800K$

$Q_L = 2000KJ$

Sink at 500K & 750K

$Sink_A = 500K$ · $Sink_B = 750K$

Sink A $= \frac{-2000}{800} + \frac{2000}{500} = 1.5$

~~Sgen = Ssurr - Ssystem~~ $S_{gen} = S_{surr} - S_{system}$

$Sink_B = \frac{-2000}{800} + \frac{2000}{750} = 0.166$

The body B is less than body A.

Body B is more irreversible.

~~Body B is~~

Q. No.

Que 1

(d) =) Mass = m = 500 kg

$T_1 = 200^\circ c = 473 K$

$T_2 = 27^\circ c = 300 K$

$T_0 = 27^\circ c = 300 K$

$CP = 0.9 KJ/KgK$

Determine reversible work & irreversibility = ?

$W_{net} = Q_H - Q_L$

$\Delta S = \frac{Q}{T}$

8

Q. No.

Q 1 (a)

⇒ Exergy of a finite heat capacity body.

Plane sur

Flow energy = PV

$X_{flow} = V(P - P_0)$

energy of flow system

= X non flow + X flow

$Y = \phi + X_{flow}$

$= (U - U_0) + P_0(V - V_0)$

$- T_0(S - S_0)$

$+ \frac{V^2}{2} + gz$

$+ V(P - P_0)$

= U(- U_0) + P_0 [illegible] ...

Q. No.

(C) => ① Mole fraction =>

② Mass fraction =>

③ Avagadro's Principle =>

④ Dalton's law of partial pressure =>

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

Q. No.

U- 134828

Signature of Student

Signature of Invigilator

K. E. Society's

RAJARAMBAPU INSTITUTE OF TECHNC

RAJARAMNAGAR

(An Autonomous Institute affiliated to Shivaji University, Kol

Paste QR Code Here

CLASS & BRANCH.: S.Y.B.Tech Mechanical UNIT TEST NO.: II

PERMANENT REGISTRATION NO. (PRN) : 2106071 Q. P. CODE : UT19

COURSE NAME : Engineering Thermodynamics COURSE CODE : ME2033

DAY & DATE : Wednesday, 21-12-2022 NO. OF SUPPLEMENT ___

Que. No.	Marks						Sub Total
	a	b	c	d	e	f	
1							
2							
3							
4							
5							
6							
	Total Marks Obtained						

Signature of Examiner ______________________

IMPORTANT NOTICE

138828

As per Maharashtra Act No. XXXI of 1982 (7&8) whoever is found in or near an examination hall by the invigilator or any other person appointed to supervise the conduct of examination, copying answers to the question paper at the examination, from any book, notes or answer papers of other candidates, or appearing at the examination for any other candidate or using any other unfair means shall, on conviction, be punished with imprisonment for a term which may extend to six months, or with fine which may extend to five thousand rupees or with both. Whoever abets any offence under this act shall be punishable with the punishment provided for the offence.

INSTRUCTIONS

1. The answer book supplied to examinees is sufficient for writing answers. The supplement shall be supplied only after the verification by the invigilator.
2. It is necessary to write the Question No.and Sub Question No. before answer.
3. Write the complete answer in sequential manner and then start the next question in readable handwriting.
4. Answer in an illegible and undecipherable handwriting are liable to be marked as zero.
5. Use of blue color ink only (except diagrams) is permitted.
6. The candidate should not take any books/notes, log table, scribbling pads, cell phones, programmable calculators or any kind of reference material in to the examination hall. The candidate should make sure that he/she has no unauthorized book or paper in the examination hall with him or in his or her desk. he/she should have identity card, and hall ticket. The candidate should not write anything on the hall ticket, identity card, calculator and question paper,
7. **The candidate should see that the invigilator has appended his/her signature at the specified space on the answer book as and when he/she receives answer book.**
8. A warning bell shall be given 10 minutes before the commencement of the examination. All the candidates shall take their possession of seats. Another bell shall be given at the beginning of the examination when question paper shall be distributed. **No candidate shall be admitted after 30 minutes of the commencement of examination and shall not be allowed to leave the examination hall before 60 minutes after the commencement of examination. No candidate should leave his/her seat during last 10 minutes. Warning bell shall be given 10 minutes before the closing time and final bell is given at the end of the examination. Then all the candidates should stop writing or revising the answer and should hand over the answer book to the invigilator immediately.**
9. Any candidate appearing for UG/PG examination is liable to be charged for committing malpractice in the following cases:
   a. Bringing in the examination hall or being found in possession of portions of a book manuscript, programmable calculator any other matter, which is not permissible to be brought into the examination hall.
   b. Having found any written matter on scribbling pad, question paper, calculator, any part of the body, handkerchief, cloths, socks, instruments box, scales etc.
   c. Disclosing identity by writing any words or making any peculiar marks on the papers of answer books,
   d. Copying from the material or matter or answer of another candidate or similar aid or assistance rendered from another candidate within the examination hall.
   e. Communication with any candidate or any other person inside or outside examination hall with a view to take assistance or aid to write answer in the examination.
   f. Making any request of representation or offers by threat for inducement or inducing to invigilator or and any another official or officer of the institute or college for favors in the examination hall or the examiner in the answer script.
   g Smuggling out or smuggling in or tearing of the answer scripts sheets or supplementary sheets or inserting papers within or outside the examination hall into the answer book or running away along with the answer script from the examination hall or premises.
   H Impersonating or allowing any other person to impersonate to answer in his/her place in the examination hall.
   I. Supply of copying material inside or from outside the examination hall.
   j. Bringing mobile phone to the examination hall.
   k. Unruly behaviour inside or near the examination hall.

Q. No.

Q. 1]

a] Clausius theorem :-

Clausius theorem state that, there is not possible of ~~carnot~~ operate carnot cycle at all state & the heat transfer from higher temp. to lower temperature.

There is no heat engine have thermal efficiency 100%.

Violation of clausius theorem is used in second law of thermodynamics.

Q. No.

Q. No.

b) Given :

$Q_{TH} = 750\ kJ$

$T_1 = 550\ K$

$Q_{TL} = 260\ KJ$

$T_2 = 290\ K$

~~$T = 800\ K$~~

~~$Q_{TL} = 2000\ KJ$~~

~~$T_1 = 500\ K$~~

~~$T_2 = 750\ K$~~

$m_{TH} Cp. T_1 = m_{TL} Cp. T_2$

$750 \times 550 = 260 \times 290$

$412500 > 75400$

$T_H > T_L$

i) $\eta = 1 - \frac{T_L}{T_H}$ OR $= \frac{T_H - T_L}{T_H}$

$= 1 - \frac{260}{750}$ OR $= \frac{750 - 260}{750}$

$= 0.65$ OR $= 0.65$

ii) $\eta = 1 - \frac{T_H}{T_L}$ OR $= \frac{T_L - T_H}{T_L}$

$=$ ~~1.58~~ -1.88 OR $=$ ~~1.58~~ -1.88

Therefore it is reasonable claime because Sgen is always greater than 0 & it is positive. And irreversible heat engine is ~~great~~ always effi. lower than reversible heat engine. And, Here the TH is

Q. No.

greater than T_L.
so the it is reasonable claim.

OR

b) Given :-

$T_o = 800\,K$

$m_1 = 200\,kJ$

$T_1 = 500\,K$

$T_2 = 750\,K$

Process (a) is more irreversible than process (b).

Q. No.

c) mole fraction, Avagadro's principle & Dalton's law of partial pressure are the different properties in thermodynamics. from this we understand that there are constant terms in all above properties. such as in Avagadro's principle there is constant Avagadro no. etc. These are very important properties in thermodynamics.
mole fraction is the ratio of no. of moles & total moles.
In all above terms pressure, mass are the ~~properties~~ terms used.
Mass & pressure are constantly used.

Q. No.

d)

$m_i = 500\ kg$

$T_0 = 200°C = 200 + 273 = 473\ K$

$T_f = 27°C = 27 + 273 = 300\ K$

$T_{atm} = 27°C = 27 + 273 = 300\ K.$

$C_p = 0.4\ kJ/kgK$

$W_{rev} = ?$

$I_{rrev} = ?$

$$E_1 = m\,C_p\left[(T_0 - T_{atm}) - T_{atm}\ln\left[\frac{T_0}{T_{atm}}\right]\right]$$

$$= 500 \times 0.4\left[(473 - 300) - 300\ln\left[\frac{473}{300}\right]\right]$$

$$= 200[(173) - 59.32]$$

$$= 200(113.68)$$

$$= 22736$$

~~OR~~

$$E_1 = m\,C_p\left[(T_f - T_{atm}) - T_{atm}\ln\left[\frac{T_f}{T_{atm}}\right]\right]$$

$$= 500 \times 0.4\left[(300 - 300) - 300\ln\left[\frac{300}{300}\right]\right]$$

$$= 200[0]$$

$$= ~~200~~\ 0$$

$E_1 - E_2 = 22736 - ~~200~~\ 0 = 22~~9~~736.$

5.23 / 15

Div - B.

Applied Thermodynamics ISE Test 1
SY BTech Mechanical Div A&B

Name - Revati Patil   Roll No. 1606096.

0.33

1. A metal rod is shaped into a ring with a small gap. If this is heated
(A) the length of the rod will increase
(B) the gap will decrease
(C) the gap will increase
(D) the diameter of the ring will increase in the same ratio as the length of the rod

0.5

2. A gas with $\frac{c_p}{c_v} = \gamma$ goes from an initial state (p_1, V_1, T_1) to a final state (p_2, V_2, T_2) through an adiabatic process. The work done by the gas is
(A) $\frac{nR(T_1 - T_2)}{\gamma - 1}$
(B) $\frac{p_1V_1 - p_2V_2}{\gamma - 1}$
(C) $\frac{p_1V_1 - p_2V_2}{\gamma + 1}$
(D) $nRT\ (T_1 - T_2)$

0.25

3. A gas may expand either adiabatically or isothermally. A number of p–V curves are drawn for the two process over different ranges of pressure and volume. It will be found that
(A) two adiabatic curves do not intersect
(B) two isothermal curves do not intersect
(C) an adiabatic curve and an isothermal curve may intersect
(D) the magnitude of the slope of an isothermal curve for the same value of pressure and volume

0.5

4. A gas expands such that its initial and final temperature are equal. Also, the process followed by the gas traces a straight line on the p–V diagram
(A) the temperature of the gas remains constant throughout
(B) the temperature of the gas first increase and then decrease
(C) the temperature of the gas first decrease and then increase
(D) the straight line has a negative slope.

0

5. Two gases have the same initial pressure, volume and temperature. They expand to the same final volume, one adiabatically and the other isothermal.
(A) the final temperature is greater for the isothermal process
(B) the final pressure is greater for the isothermal process
(C) the work done by the gas is greater for the isothermal process.
(D) all the above options are incorrect

0.33

6. In the previous question, if the two gases are compressed to the same final volume
(A) the final temperature is greater for the adiabatic process
(B) the final pressure is greater for the adiabatic process
(C) the work done on the greater for the adiabatic process
(D) all the above options incorrect

0.5

7. The first law of thermodynamics incorporates the concepts of
(A) conservation of energy
(B) conservation of heat
(C) conservation of work
(D) equivalence of heat and work

1

8. A vessel contains 1 mole of O_2 at a temperature T. The pressure of gas is P. An identical vessel containing 1 mole of the gas at a temperature 2T has pressure of
(A) P
(B) 2P
(C) 3P
(D) 4P

0.25

9. For an ideal gas,
(A) the change in internal energy in a constant pressure process from temperature T_1 to T_2 is equal to $nC_v(T_2 - T_1)$, where C_v is the molar heat capacity at constant volume and n is the number of moles of the gas
(B) the change in internal energy of the gas and the work done by the gas are equal in magnitude in an adiabatic process
(C) the internal energy does not change in an isothermal process
(D) no heat is added or removed in an adiabatic process

10. The molar heat capacity for an ideal gas
(A) is zero for an adiabatic process
(B) is infinite for an isothermal process
(C) depends only on the nature of the gas for a process in which either volume or pressure is constant
(D) is equal to the product of the molecular weight and specific heat capacity for any process

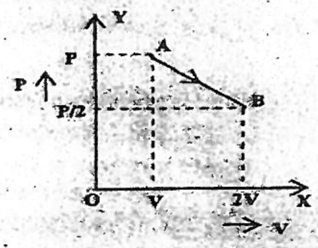
11. C_p is always greater than C_v for a gas. Which of the following statements provide, partly or wholly, the reason for this?
(A) no work done by a gas at constant volume
(B) When a gas absorbs heat at constant pressure, its volume must change
(C) for the same change in temperature, the internal energy of a gas changes by a smaller amount at constant volume than at constant change
(D) the internal energy of an ideal gas is a function only of its temperature

12. A system undergoes a cyclic process in which it absorbs Q_1 heat and gives out Q_2 heat. The efficiency of the process is η and the work done is W.
(A) $W = Q_1 - Q_2$
(B) $\eta = \frac{W}{Q_1}$
(C) $\eta = \frac{Q_2}{Q_1}$
(D) $\eta = 1 - \frac{Q_2}{Q_1}$

13. When an enclosed perfect gas is subjected to an adiabatic process:
(A) its total internal energy does not change
(B) its total internal energy changes
(C) its pressure varies inversely as a certain power of its volume
(D) the product of its pressure and volume is directly proportional to its absolute temperature.

14. In the isothermal expansion of an ideal gas:
(A) there is no change in the temperature of the gas
(B) there is no change in the internal energy of the gas
(C) the work done by the gas is equal to the heat supplied to the gas
(D) the work done by the gas is equal to the change in its internal energy.

15. An ideal gas is taken from the state A (pressure P, volume V) to the state B (pressure P/2, volume 2V) along a straight line path in the P–V diagram. Select the correct statement (s) from the following



(A) The work done by the gas in the process A to B exceeds the work that would be done by it, if the system were taken from A to B along the isotherm.
(B) In the T–V diagram, the path AB becomes a part of parabola.
(C) In the P–T diagram, the path AB becomes a hyperbola.
(D) In going from A to B, then temperature T of the gas first increase maximum volume and then decrease.

4.63/15

Applied Thermodynamics ISE Test 1
SY BTech Mechanical Div A&B

Name - Omkar Bhaskar patil   Roll No. 1606095
DIV - B

1. A metal rod is shaped into a ring with a small gap. If this is heated
(A) the length of the rod will increase
(B) the gap will decrease
(C) the gap will increase
(D) the diameter of the ring will increase in the same ratio as the length of the rod

0.33

2. A gas with $\frac{C_p}{C_v} = \gamma$ goes from an initial state (p_1, V_1, T_1) to a final state (p_2, V_2, T_2) through an adiabatic process. The work done by the gas is
(A) $\frac{nR(T_1 - T_2)}{\gamma - 1}$ (B) $\frac{p_1V_1 - p_2V_2}{\gamma - 1}$
(C) $\frac{p_1V_1 - p_2V_2}{\gamma + 1}$ (D) $nRT\ (T_1 - T_2)$

0

3. A gas may expand either adiabatically or isothermally. A number of p–V curves are drawn for the two process over different ranges of pressure and volume. It will be found that
(A) two adiabatic curves do not intersect
(B) two isothermal curves do not intersect
(C) an adiabatic curve and an isothermal curve may intersect
(D) the magnitude of the slope of an isothermal curve for the same value of pressure and volume

0.25

4. A gas expands such that its initial and final temperature are equal. Also, the process followed by the gas traces a straight line on the p–V diagram
(A) the temperature of the gas remains constant throughout
(B) the temperature of the gas first increase and then decrease
(C) the temperature of the gas first decrease and then increase
(D) the straight line has a negative slope.

0.

5. Two gases have the same initial pressure, volume and temperature. They expand to the same final volume, one adiabatically and the other isothermal.
(A) the final temperature is greater for the isothermal process
(B) the final pressure is greater for the isothermal process
(C) the work done by the gas is greater for the isothermal process.
(D) all the above options are incorrect

0.33

6. In the previous question, if the two gases are compressed to the same final volume
(A) the final temperature is greater for the adiabatic process
(B) the final pressure is greater for the adiabatic process
(C) the work done on the greater for the adiabatic process
(D) all the above options incorrect

0

7. The first law of thermodynamics incorporates the concepts of
(A) conservation of energy   (B) conservation of heat
(C) conservation of work   (D) equivalence of heat and work

0.5

8. A vessel contains 1 mole of O_2 at a temperature T. The pressure of gas is P. An identical vessel containing 1 mole of the gas at a temperature 2T has pressure of
(A) P   (B) 2P
(C) 3P   (D) 4P

1

9. For an ideal gas,
(A) the change in internal energy in a constant pressure process from temperature T_1 to T_2 is equal to $nC_v(T_2 - T_1)$, where C_v is the molar heat capacity at constant volume and n is the number of moles of the gas
(B) the change in internal energy of the gas and the work done by the gas are equal in magnitude in an adiabatic process
(C) the internal energy does not change in an isothermal process
(D) no heat is added or removed in an adiabatic process

0.25

10. The molar heat capacity for an ideal gas
(A) is zero for an adiabatic process
(B) is infinite for an isothermal process
(C) depends only on the nature of the gas for a process in which either volume or pressure is constant
(D) is equal to the product of the molecular weight and specific heat capacity for any process

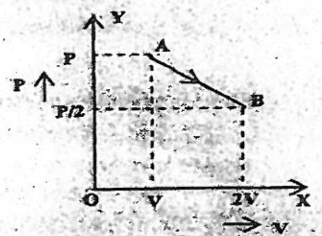
11. C_p is always greater than C_v for a gas. Which of the following statements provide, partly or wholly, the reason for this?
(A) no work done by a gas at constant volume
(B) When a gas absorbs heat at constant pressure, its volume must change
(C) for the same change in temperature, the internal energy of a gas changes by a smaller amount at constant volume than at constant change
(D) the internal energy of an ideal gas is a function only of its temperature

12. A system undergoes a cyclic process in which it absorbs Q_1 heat and gives out Q_2 heat. The efficiency of the process is η and the work done is W.
(A) $W = Q_1 - Q_2$
(B) $\eta = \frac{W}{Q_1}$
(C) $\eta = \frac{Q_2}{Q_1}$
(D) $\eta = 1 - \frac{Q_2}{Q_1}$

13. When an enclosed perfect gas is subjected to an adiabatic process:
(A) its total internal energy does not change
(B) its total internal energy changes
(C) its pressure varies inversely as a certain power of its volume
(D) the product of its pressure and volume is directly proportional to its absolute temperature.

14. In the isothermal expansion of an ideal gas:
(A) there is no change in the temperature of the gas
(B) there is no change in the internal energy of the gas
(C) the work done by the gas is equal to the heat supplied to the gas
(D) the work done by the gas is equal to the change in its internal energy.

15. An ideal gas is taken from the state A (pressure P, volume V) to the state B (pressure P/2, volume 2V) along a straight line path in the P–V diagram. Select the correct statement (s) from the following



(A) The work done by the gas in the process A to B exceeds the work that would be done by it, if the system were taken from A to B along the isotherm.
(B) In the T–V diagram, the path AB becomes a part of parabola.
(C) In the P–T diagram, the path AB becomes a hyperbola.
(D) In going from A to B, then temperature T of the gas first increase maximum volume and then decrease.

Course: Engg Thermodynamics ME2032 Class: S Y B Tech Mechanical Div A

ISE 1 MCQ quiz on Moodle

Quiz sample questions

A in which no mass can enter or leave the system and no energy can enter or ...

A in which no mass can enter or leave the system and no energy can enter or leave the system is called as

- Open system
- Closed system
- Isolated system
- None of the mentioned

A machine which can supply mechanical work continuously without consumption ...

A machine which can supply mechanical work continuously without consumption of any energy is called as

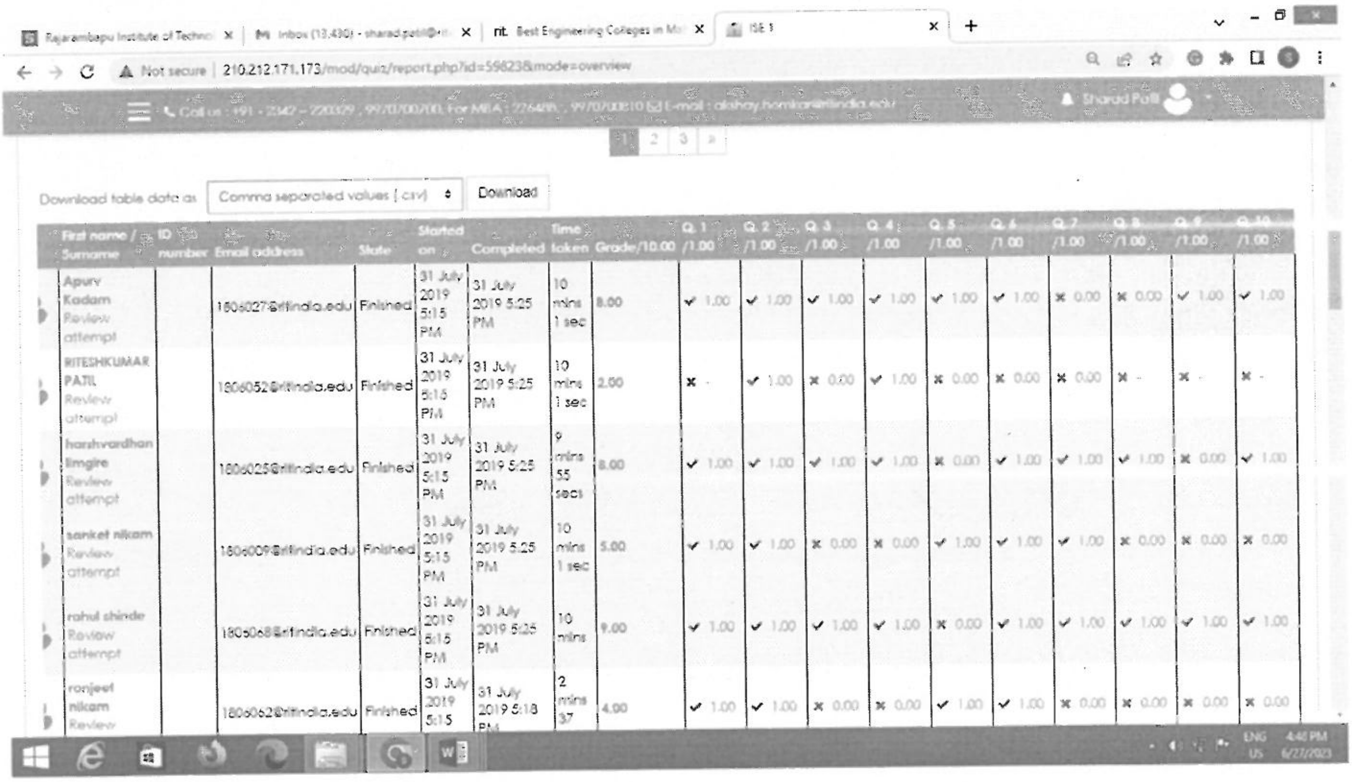
- Perpetual Motion Machine of the First kind (PMM1)
- Perpetual Motion Machine of the Second kind (PMM2)
- Perpetual Motion Machine of the Third kind (PMM3)
- none of the mentioned

A process that passes through number of equilibrium states is called as

A process that passes through number of equilibrium states is called as

- Reversible process
- Irreversible process
- None of the mentioned
- Isentropic process

Quiz assessment

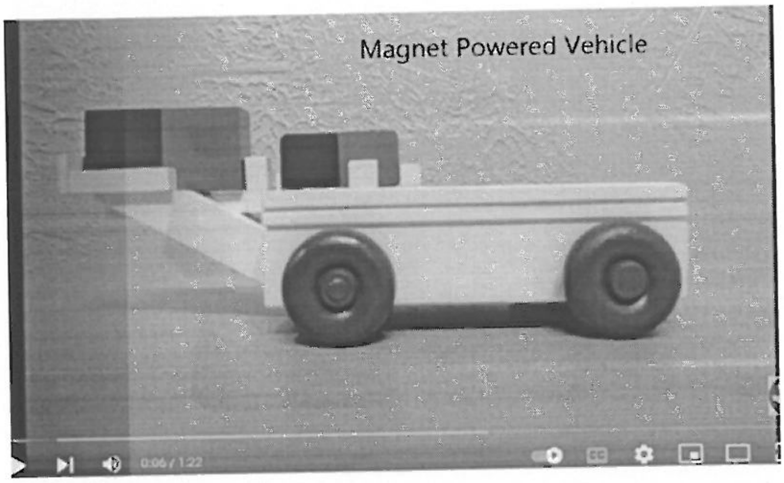


Download table data as: Comma separated values (.csv) Download

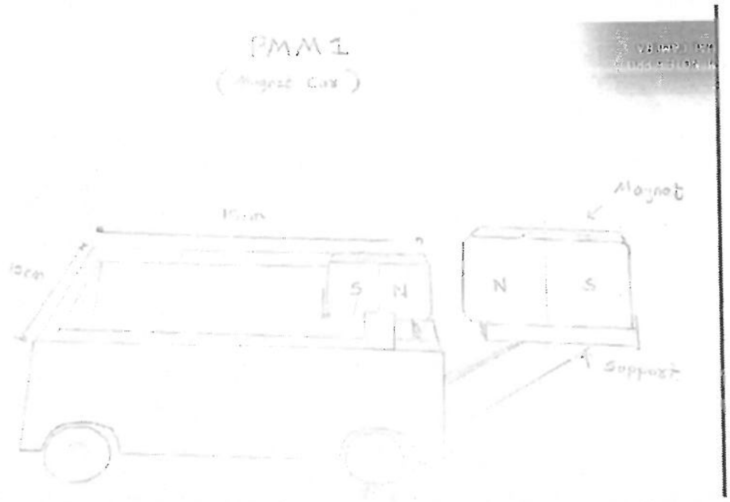
First name / Surname	ID number	Email address	State	Started on	Completed	Time taken	Grade/10.00	Q. 1 /1.00	Q. 2 /1.00	Q. 3 /1.00	Q. 4 /1.00	Q. 5 /1.00	Q. 6 /1.00	Q. 7 /1.00	Q. 8 /1.00	Q. 9 /1.00	Q. 10 /1.00
Apurv Kadam Review attempt		1806027@ritindia.edu	Finished	31 July 2019 5:15 PM	31 July 2019 5:25 PM	10 mins 1 sec	8.00	✔ 1.00	✔ 1.00	✔ 1.00	✔ 1.00	✔ 1.00	✔ 1.00	✖ 0.00	✖ 0.00	✔ 1.00	✔ 1.00
RITESHKUMAR PATIL Review attempt		1806052@ritindia.edu	Finished	31 July 2019 5:15 PM	31 July 2019 5:25 PM	10 mins 1 sec	2.00	✖ -	✔ 1.00	✖ 0.00	✔ 1.00	✖ 0.00	✖ 0.00	✖ 0.00	✖ -	✖ -	✖ -
harshvardhan limgire Review attempt		1806025@ritindia.edu	Finished	31 July 2019 5:15 PM	31 July 2019 5:25 PM	9 mins 55 secs	8.00	✔ 1.00	✔ 1.00	✔ 1.00	✔ 1.00	✖ 0.00	✔ 1.00	✔ 1.00	✔ 1.00	✖ 0.00	✔ 1.00
sanket nikam Review attempt		1806009@ritindia.edu	Finished	31 July 2019 5:15 PM	31 July 2019 5:25 PM	10 mins 1 sec	5.00	✔ 1.00	✔ 1.00	✖ 0.00	✖ 0.00	✔ 1.00	✔ 1.00	✔ 1.00	✖ 0.00	✖ 0.00	✖ 0.00
rahul shinde Review attempt		1806068@ritindia.edu	Finished	31 July 2019 5:15 PM	31 July 2019 5:25 PM	10 mins	9.00	✔ 1.00	✔ 1.00	✔ 1.00	✔ 1.00	✖ 0.00	✔ 1.00	✔ 1.00	✔ 1.00	✔ 1.00	✔ 1.00
ranjeet nikam Review		1806062@ritindia.edu	Finished	31 July 2019 5:15	31 July 2019 5:18 PM	2 mins 37	4.00	✔ 1.00	✔ 1.00	✖ 0.00	✖ 0.00	✔ 1.00	✔ 1.00	✖ 0.00	✖ 0.00	✖ 0.00	✖ 0.00

ISE 2 PBL :PPM concept and working model realization

a) PPM concept



b) CAD Modeling of the Concept:



c) Video presentation on model developed, Link: https://www.youtube.com/watch?v=DUE2X0LjXe8&t=87s

_______________ forms the basis for development of mercury tube thermometer

_______________ forms the basis for development of mercury tube thermometer

- First law of thermodynamics
- Second law of thermodynamics
- Zeroth law of thermodynamics
- None of the mentioned

_______________ forms the basis for development of mercury tube thermometer

_______________ forms the basis for development of mercury tube thermometer

- First law of thermodynamics
- Second law of thermodynamics
- Zeroth law of thermodynamics
- None of the mentioned

A cyclic heat engine operates between a source temperature of 927 degree C ...

A cyclic heat engine operates between a source temperature of 927 degree C and a sink temperature of 27 degree C. What will be the maximum efficiency of the heat engine?

- 1
- 0.8
- 0.75
- 0.7

A machine which can supply mechanical work continuously without consumption ...

A machine which can supply mechanical work continuously without consumption of any energy is called as

- Perpetual Motion Machine of the First kind (PMM1)
- Perpetual Motion Machine of the Second kind (PMM2)
- Perpetual Motion Machine of the Third kind (PMM3)
- none of the mentioned

A machine which can supply mechanical work continuously without consumption ...

A machine which can supply mechanical work continuously without consumption of any energy is called as

- Perpetual Motion Machine of the First kind (PMM1)
- Perpetual Motion Machine of the Second kind (PMM2)
- Perpetual Motion Machine of the Third kind (PMM3)
- none of the mentioned

A process that passes through number of equilibrium states is called as

A process that passes through number of equilibrium states is called as

- Reversible process
- Irreversible process
- None of the mentioned
- Isentropic process

A process that passes through number of equilibrium states is called as

A process that passes through number of equilibrium states is called as

- Reversible process
- Irreversible process
- None of the mentioned
- Isentropic process

A quasi-static process has main characteristics as it is

A quasi-static process has main characteristics as it is

- a stationary process
- an infinitely slow process
- a random process

- a spontaneous process

A quasi-static process has main characteristics as it is

A quasi-static process has main characteristics as it is

- a stationary process
- an infinitely slow process
- a random process
- a spontaneous process

A refrigerator and heat pump operates between same temperature limits. If the...

A refrigerator and heat pump operates between same temperature limits. If the COP of the refrigertor is 4, what is the COP of heat pump?

- 3
- 5
- 4
- 3.4

A system in which no mass can enter or leave the system and no energy can ...

A system in which no mass can enter or leave the system and no energy can enter or leave the system is called as

- Open system
- Closed system
- Isolated system
- None of the mentioned

A system in which no mass can enter or leave the system and no energy can ...

A system in which no mass can enter or leave the system and no energy can enter or leave the system is called as

- Open system
- Closed system
- Isolated system
- None of the mentioned

According to first law of thermodynamics

According to first law of thermodynamics

- work done by a system is equal to heat transferred by the system
- total internal energy of a system during a process remains constant
- internal energy, enthalpy and entropy during a process remain constant
- total energy of a system remains constant

According to first law of thermodynamics

According to first law of thermodynamics

- work done by a system is equal to heat transferred by the system
- total internal energy of a system during a process remains constant
- internal energy, enthalpy and entropy during a process remain constant
- total energy of a system remains constant

An air-conditioner provides 1 kg/s of air at 15 degree C cooled from outside ...

An air-conditioner provides 1 kg/s of air at 15 degree C cooled from outside atmospheric air at 35 degree C. Estimate the amount of power needed to operate the air-conditioner.

- 1.09 kW
- 1.19 kW
- 1.29 kW
- 1.39 kW

Closed system is also called as

Closed system is also called as

- Control volume

	Group Members	
	Roll No.	Name
	2006049	Omkar Basavraj Ainapure
	2006062	Atharv Ajay Mahajan
	2006064	Prathmesh Mahadev Patil
	2006065	Sujit Shrikrishna Patil
	2006066	Shreesumera Premraj Jaaju
Group 1	2006050	Shailendra Dattatray Patange
	2006054	Jaykumar Sandeep Jadhav
	2006048	Prathmesh Rahul Kamble
	2006044	Yash Rajendra Kumbhar
	2006043	Rohan Ramesh Chavan
	2006067	Prathamesh Shashikant Petare
Group 2	Optional	Rohan Santosh Padale
	2006005	Suraj Satish jadhav
	2006011	Ashraf Bhola gavandi
	2006022	Sanket Dadaso Patil
	2006034	Sagar Sanjay Jadhav
	2006036	Prathamesh Vikas Patil
Group 3	Optional	
	2006004	Shreeyash Ashokrao Jadhav
	2006020	Amarsinh Sanjay Patil
	2006030	Nikhil Vitthal Jadhav
	2006032	Atharv Mahesh Ubale
	2006056	Sourabh Hanamantrao Patil
Group 4	2006009	Harshwardhan Deepak Patil
	2006015	Gourav Anil Chavan
	2006046	Kaushik Deepak Kole
	2006055	Junaid Mouzam Desai
	2006007	Anurag Vijaykumar Dharav
	2006013	Abhijeet Jitendra Kale
Group 5	2006045	Dnyaneshwar Hange
	2006006	Samarjeet Virajit Ghorpade
	2006008	Kedar Sanjay Hajare
	2006012	Niranjan Shivaji Khandagale
	2006002	Jayraj Prataprao Patil
	2006027	Ajay Suresh Jadhav
Group 6	2006023	Prathamesh Dattatray Mhetre
	2006019	Aniket Vijay damkale
	2006051	Adarsh Anant Bhosle
	2006053	shubhekshan Sunil Gurjar
	2006057	Pranav Avinash Patil
	2006061	Mayuresh Vijay Mali
Group 7	2006047	kedar Rajendra Kadam
	2005059	Bhushan Vinayak Koparde
	2006001	Prajyot Ramesh Desai
	2006010	Pratik Vikas Pawar
	2006021	Vinit Vyankatrao kale

	2006039	Varad Sharad shinde
Group 8	2006033	sanket Maruti Desai
	2006016	Gauri Tukaram Ghanwat
	2006026	shraddha Maruti Yedage
	2006058	pooja vikas Ijare
	2006017	SALUNKHE PRATIK RAVIKANT
	2006018	PADALE ROHAN SANTOSH
Group 9		
	2006003	chinmay pramod more
	2006042	sanket shashikant adsul
	2006028	PAWAR KISHOR RAJENDRA
	2006031	MORE SHIVAM VINOD
	2006035	KUMBHAR NIKITA SANJAY
Group 10	Optional	
	2006037	THORAT SHREYA BHIMRAO
	2006038	KATKAR AASHUTOSH DIPAK
	2006041	PATIL SHIVANI DILIP
	2006052	JADHAV ROHAN PARSHURAM
	2006025	PATIL PRADYUMNA PRASHANT
Group 11	Optional	

Q1. Study the refrigeration system and perform the first law and second law analysis on the system by using following data.

Group 1 – use R12 as refrigerant

Group 2 – R22

Group 3 – R134a

Sr. No.	Description	Symbol	Unit	Quantity
1	Condensing pressure	Pc	PSI	150
2	Evaporating Pressure	Pe	PSI	45
3	Rotameter flow rate	m	LPH	20
4	Condenser Inlet Temp	T1	^0C	52
5	Condenser Outlet Temp	T2	^0C	30
6	Evaporator Inlet Temp	T3	^0C	2
7	Evaporator outlet Temp	T4	^0C	13

Q2. Study the steam power plant and perform the first law and second law analysis on the system by using following data.

Group 4

	Observation Table for Steam Power Plant			
Sr. No.	Description	Symbol	Unit	Quantity
	Boiler Section			
1	fuel consumption	mf	kg/hr	36
2	Calorific Value	LHV	KJ/kg	45000
3	Water Inlet Temperature	T1	^0C	27
4	Steam Temperature	T2	^0C	192
5	Steam Pressure	Psteam	bar	11.5
	Turbine Section			
1	Exhaust Pressure	Pexhast	bar	0.23
2	Exhaust Temperature	T3	^0C	98
	Generator Section			
1	Current	I	A	4.36
2	Voltage	V	V	230
	Condenser Section			

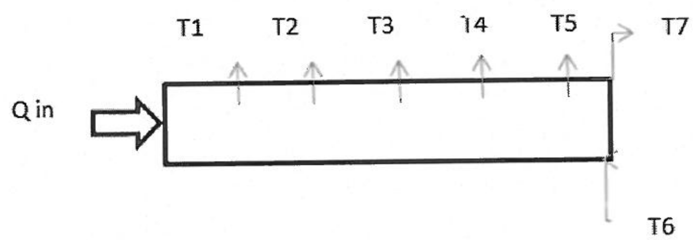
1	Cooling water inlet temperature	T4	^0C	30
2	Cooling water outlet temperature	T5	^0C	36

Q3. By using the following data perform the first law and second law analysis

Group 5

Dia of the metal rod = 25 mm
Distance between the adjacent thermocouple = 50 mm
mass flow rate of water = 0.023 kg/s
Thermal conductivity k = 385 W/mK

Temperature at different point along the thermocouple mounted on the rod					Temperature for the inlet and outlet water	
T1	T2	T3	T4	T5	T6	T7
52	49	45	42	39	27	29



Group 6

Dia of the metal rod = 30 mm
Distance between the adjacent thermocouple = 60 mm
mass flow rate of water = 0.023 kg/s
Thermal conductivity k = 385 W/mK

Temperature at different point along the thermocouple mounted on the rod					Temperature for the inlet and outlet water	
T1	T2	T3	T4	T5	T6	T7
52	49	45	42	39	27	29

Q4. Study the IC Engine and perform the first law and second law analysis on the system by using following data.

Group 7 – Load 1

Group 8 – Load 2

Group 9 – Load 3

Group 10 – Load 4

Sr. No.	Description	Quantity			
		Load 1	Load 2	Load 3	Load 4
1	Net Torque in kN- m	0.0104	0.0209	0.031	0.002967
2	Speed in RPM	1590	1585	1540	1610
3	Temp of Inlet trough jacket	25	25	25	25
4	Temp ofoutlet trough jacket	36	39	40	33
5	Fuel Consumption (kg/s)	0.000249	0.000327	0.000425	0.000202
6	Water flow rate in jacket(kg/s)	0.149254	0.140845	0.126582	0.15873
7	Tempearture of inlet water to calorimeter	25	25	25	25
8	Tempearture of outlet water to calorimeter	39	43	47	30
9	Temperature for the exhaust gas inlet	145	180	220	110
10	Temperature for exhaust gas outlet	85	100	115	60
11	Water flow rate in calorimeter	0.055866	0.051282	0.05102	0.081301

Q 5

Study the steam power plant and perform the first law and second law analysis on the system by using following data.

Group 11

	Observation Table for Steam Power Plant			
Sr. No.	Description	Symbol	Unit	Quantity
	Boiler Section			
1	fuel consumption	mf	kg/hr	40

2	Calorific Value	LHV	KJ/kg	45500
3	Water Inlet Temperature	T1	^0C	27
4	Steam Temperature	T2	^0C	220
5	Steam Pressure	Psteam	bar	12
Turbine Section				
1	Exhaust Pressure	Pexhast	bar	0.5
2	Exhaust Temperature	T3	^0C	98
Generator Section				
1	Current	I	A	4.36
2	Voltage	V	V	230
Condenser Section				
1	Cooling water inlet temperature	T4	^0C	30
2	Cooling water outlet temperature	T5	^0C	36

EXPT. NO :
DATE : / /

210602 2

first law of thermodynamics (conservation of energy) analysis

The first law of thermodynamics states that energy can neither be created nor destroyed, but it can be converted from one form to another. For an internal combustion engine system, energy is converted from the chemical energy of the fuel to the thermal energy of the engine and the exhaust gases, as well as to mechanical energy that drives the engine.

Based on the given data, the energy input to the system is the chemical energy of the fuel, which can be calculated as follows:

Q_in = Fuel consumption * Calorific value of fuel

The energy output of the system is the thermal energy of the engine and the exhaust gases, as well as the mechanical energy output The thermal energy of the engine and the exhaust gases can be calculated as follows:

Q_out = (Temperature_outlet_jacket - Temperature_inlet_jacket
* Mass flow rate * Sepecific heat capacity of water

The mechanical energy output can be calculated using the net torque and speed of the engine.

EXPT. NO

DATE: / /

Second law of thermodynamics (Entropy) analysis

The second law of thermodynamics states that the entropy of a closed system will always increase over time. This law can be used to calculate the thermal efficiency of an internal combustion engine system, which is defined as the ratio of the useful work output to the total energy input.

The thermal efficiency of the engine can be calculated as follows:

n = (Mechanical energy output) / (Energy input - waste heat)

Waste heat is the energy that is lost as heat in the exhaust gases and the cooling water, which can be calculated as follows.

Waste heat = (Temperature_exhaust_outlet - Temperature_exhaust_inlet) * Mass flow rate * specific heat capacity of exhaust gases +
(Temperature_outlet_water - Temperature_inlet_water) * Mass flow rate * specific heat capacity of water.

Thermodynamics

SY MECHANICAL

Sr. No.	Student Name	Enroll. No.
1.	Sanika sunil suryavanshi	2106021
2.	Niyati Anil chougale	2106032
3.	Avantika Dipak More	2106047

ONTENT

irst law of Thermodynamic

econd law of Thermodynamic

hermal Conductivity

ntropy generation in heat transfer

lumerical

irst law of rmodynamic

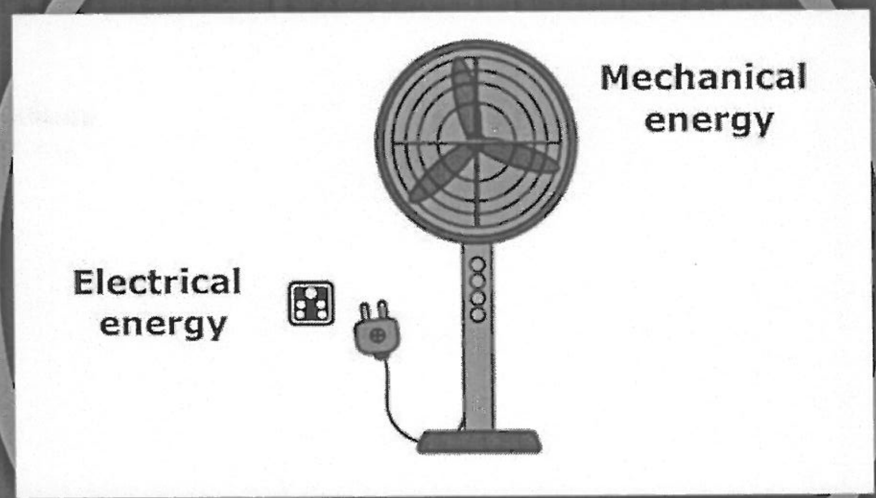
can neither be created nor can yed but transformation of one another form can be ”

internal energy of a system is eat added to system minus the by the system

$$=Q - W$$

HEAT ADDED TO SYSTEM

WORKDONE BY SYSTEM



Conversion of electrical energy into mechanical energy.

on a table will melt on it's own.

Second law of thermodynamics

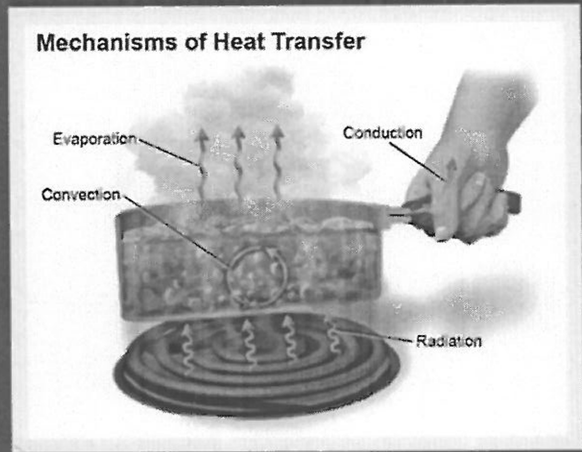
- The second law of thermodynamics can be stated in three ways.
- **Second law of thermodynamics for heat engine (Kelvin Planck's statement)**
- **Second law of thermodynamics for heat pump/refrigerator (Clausius's statement)**
- **Second law of thermodynamics based on entropy**
- **Kelvin Planck's statement:**
- ***"It is impossible to construct a device (operating in a cycle) which works on a single heat source and converts all of its heat completely in to work"***
- **Clausius's statement:**
- ***It is impossible to construct a device (operating in a cycle) that can transfer heat from cold body to the hot body without absorbing any work."***
- **Entropy**
- ***In all the spontaneous processes, the entropy of the universe increases."***

ıal Conductivity

ɪtivity can be defined as the rate at which heat is transferred by conduction through a unit
rea of a material, when a temperature gradient exits perpendicular to the area.

ductivity
eat transferred
ween two isothermal plans
ace
in temperature

nal conductivity is watts per meter-kelvin ($Wm^{-1}K^{-1}$).



ty is actually about the conduction of heat or transfer of heat. 2) Pouring of hot tea in a cup will make the cup of
use of the heat transfer from tea to the cup. 3)Transfer of heat from iron to shirt while pressing is also a good

IAL CONDUCTIVITY AND WHY IS IT IMPORTANT?

ty is a property that describes how well heat flows through a substance. The higher the thermal conductivity, the
onducts heat.

py generation

amic system, the entropy generation is the amount of entropy which is created generally during irreversible eans of heat flow through a thermal resistance, fluid flow through a flow resistance, diffusion, Joule heating, friction urfaces, fluid viscosity within a system etc.

eration rate (S_{gen}) is associated with the losses in a process, and can be defined as entropy balance equation for a as follows:

$$\underbrace{S_{in} - S_{out}}_{\substack{\text{Net entropy transfer} \\ \text{by heat and mass}}} + \underbrace{S_{gen}}_{\substack{\text{Entropy} \\ \text{generation}}} = \underbrace{\Delta S_{system}}_{\substack{\text{Change} \\ \text{in entropy}}} \quad \text{(kJ/K)}$$

easure of the energy dispersal in the system. We see evidence that the universe tends toward highest entropy many es. A campfire is an example of entropy. The solid wood burns and becomes ash, smoke and gases, all of which utwards more easily than the solid fuel.

ence between entropy and entropy generation?

eration is a measure of the magnitudes of the irreversibilities present during the process. Entropy is a measure of der or randomness of a system, and the second law states that entropy can be created but it cannot be destroyed.

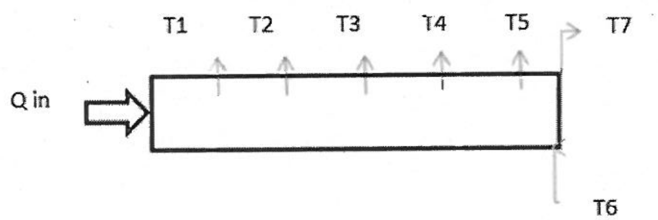
eneration be zero?

cs' second law states that the rate of generation of entropy within a system must be greater than or equal to zero.

he metal rod = 30 mm
e between the adjacent thermocouple = 60

ow rate of water = 0.023 kg/s
l conductivity k = 385 W/mK

perature at different point along the thermocouple mounted on the rod					Temperature for the inlet and outlet water	
	T2	T3	T4	T5	T6	T7
52	49	45	42	39	27	29



$(1,2) = \frac{-3}{60\times10^{-3}} = -50$

$(2,3) = \frac{-4}{60\times10^{-3}} = -66$

$(3,4) = \frac{-3}{60\times10^{-3}} = -50$

$(4,5) = \frac{-3}{60\times10^{-3}} = -50$

(avg) = -54

A. $\frac{dt}{dx}$ - mcpΔT = losses

$35\times 7.06 \times -54) - (0.023 \times 420 \times 2) = losses$

sses= 1.4×10^{5}

ficiency = $\frac{mcp\Delta T}{K.A. \frac{dt}{dx}}$ = -19.13%

d law efficiency

$\Delta S\ gen = \frac{Q}{52+273} - \frac{Q}{39+273}$

= -18

```
P1 = 1*10^5, P2 = 8.3*10^5, T1 = 288, Cp = 0.88, m = 0.05, v2 = 0.004
```

```
P1 = 100000
P2 = 8.3000e+05
T1 = 288
Cp = 0.8800
m = 0.0500
v2 = 0.0040
```

```
R = 8.314/44
```

```
R = 0.1890
```

```
Cv = Cp + R
```

```
Cv = 1.0690
```

```
% Using perfect gas equation at state 1
v1 = (m*R*T1)/P1
```

```
v1 = 2.7209e-05
```

```
% at state 2
T2 = (P2*v2)/(m*R)
```

```
T2 = 3.5141e+05
```

```
T2 = 351.41
```

```
T2 = 351.4100
```

```
% change in entropy
S = (Cp*log(T2/T1)) - (R*log(P2/P1))
```

```
S = -0.2248
```

```
% for given mass
Ms = S*m
```

```
Ms = -0.0112
```

Entropy

```
#include<stdio.h>
#include<math.h>
int main()
{
   float v1,v2,v3,T1,T2,T3,p1,p2;
printf("Enter volume v1:\n");
scanf("%f",&v1);
printf("Enter temperature T1 in kelvin\n");
scanf("%f",&T1);
printf("Enter temperature T2 in kelvin\n");
scanf("%f",&T2);
printf("Enter pressure p1 in N/M2\n");
scanf("%f",&p1);
p2=p1;
printf("\nAt state 1\n p1v1=mRT1\n");
float m=(p1*v1)/(287*T1);
printf("\nMass = %f\n",m);
printf("\nAt state 2\n p2v2=mRT2\n");
v2=(m*287*T2)/p2;
printf("v2= %f\n",v2);
float num=T2/T1;
double ln=log(num);
float S=1.005*ln;
printf("\nChange in entropy during process 1-2 = %f KJ/Kg.k\n",S);
float S1=m*S;
printf("\nFor given mass S=%f\n",S1);
v2=v3;
T3=T1;
float num1=(T3/T2);
double ln1=log(num1);
```

```
float S2=0.718*ln1;
printf("\nChange in entropy during process 2-3=%fKJ/kg.k\n",S2);
printf("\nFor given mass S2= %f\n",m*S2);
float S3=S2+S1;
printf("\nNet entropy change = %f KJ\n",S3);
float Q1=m*1.005*(T2-T1);
printf("\nHeat flow during process 1-2 \n = %f KJ\n",Q1);
float Q2=m*0.718*(T3-T2);
printf("\nHeat flow during process 2-3 \n = %f KJ",Q2);
printf("\nNet heat flow = %f KJ\n",Q1+Q2);
return 0;
}
```

2

```
#include<stdio.h>
#define pi 3.14
int main()
{
        float D,pin,tin,tout,vin;
printf("Enter Diameter in meter \n");
scanf("%f",&D);
printf("Enter pin in kpa\n");
scanf("%f",&pin);
printf("Enter velocity Vin in m/s\n");
scanf("%f",&vin);
printf("Enter Tin\n");
scanf("%f",&tin);
printf("Enter Tout\n");
scanf("%f",&tout);
```

```
float Vin=(pi*D*D*vin)/4;
printf("\nVin = %f m3/s\n",Vin);
printf("\nBy using perfect gas relation\n pv=RT\n");
float rin=pin/(0.287*tin);
printf("rin = %f kg/m3\n",rin);
float mo=rin*Vin;
printf("mo= %f\n",mo);
printf("\nAt the outlet \n mo(out)=mo(in)\n");
printf("\nmout=min %f\n",mo);
float mout=mo;
float pout=pout/(0.287*tout);
float Vout1=mo*4;
float Vout2=(pi*D*D*pout);
float Vout=Vout1/Vout2;
printf("\nVout = %f m3/s\n",Vout);
float V0out=pi*D*D*Vout/4;
printf("v(out)= %f m3/s",V0out);
return 0;
}
```

Availibility:

```
#include<stdio.h>
#include<math.h>
int main()
{
  float Tw1,Tw2,To1,To2;
  float cpw=4.18,cpo=2.6;
printf("Enter temperature for Water:\n");
printf("Enter temperature Tw1 in kelvin\n");
scanf("%f",&Tw1);
printf("Enter temperature Tw2 in kelvin\n");
scanf("%f",&Tw2);
printf("Entr temperature for Oil:\n");
printf("Enter temperature To1 in kelvin\n");
scanf("%f",&To1);
printf("Enter temperature To2 in kelvin\n");
scanf("%f",&To2);
float Tw=Tw2-Tw1;
float To=To1-To2;
float Tatm=350;
printf("Using energy balance equation\n Mw.CPw(Tw2-Tw1)=Mo CPo(To1-To2)\n");
float Mw=(To*2.6*1)/(Tw*4.18);
printf("Mw = %f Kg/sec\n",Mw);
float T=Tw1/Tatm;
float T1=Tw1-Tatm;
float T2=Tatm*log(T);
float T3=T1-T2;
float AE=Mw*cpw*T3;
printf("\nA.E of water before heat exchange = %f kg/sec\n",AE);
float T21=Tw2/Tatm,t1=Tw2-Tatm,t2=Tatm*log(T21);
float t3=t1-t2;
```

```c
float AE2=Mw*cpw*t3;
printf("\nA.E of water After heat exchange = %f kg/sec\n",AE2);
float to=To1-Tatm,j2=To1/Tatm,t=Tatm*log(j2);
float AEo=cpo*(to-t);
printf("\nA.E of oil before heat exchange = %f kJ/sec\n",AEo);
float t5=To2-Tatm,j23=To2/Tatm,t12=Tatm*log(j23);
float AE1=cpo*(t5-t12);
printf("\nA.E of oil After heat exchange = %f kJ/sec\n",AE1);
float A=AE+AEo;
printf("\nTotal A.E before heat exchange = %f kJ/sec\n",A);
float A1=AE2+AE1;
printf("\nTotal A.E After heat exchange = %f kJ/sec\n",A1);
printf("\nDecrease in A.E = %f kj/sec\n",A-A1);
return 0;
}
```

1. If refrigerator is places iside the well insulated room with open door, thn what is its effect on room air temperature?
A. Increses B. Decreases C. Remains same D. None of these

2. The ___________ forms of energy are those a system possesses as a whole with respect to some outside reference frame
A. macroscopic B. microscopic

3. The ___________ forms of energy are those related to the molecular structure of a system and the degree of the molecular activity
A. macroscopic B. microscopic

4. The sum of all the microscopic forms of energy is called the ___________ of a system.
A. kinetic energy B. potential energy C. internal energy D. None of these

5. A large exhaust fan in a lab room keeps the pressure inside at 10 cm water relative vacuum to the hallway? What is the net force acting on the door measuring 1.9 m by 1.1 m?
A. 2020 N B. 2030 N C. 2040 N D. 2050 N

6. A 5 m long vertical tube having cross sectional area 200 cm^2 is placed in a water. It is filled with 15°C water, with the bottom closed and the top open to 100 kPa atmosphere. How much water is present in tube?
A. 99.9 kg B. 109.9 kg C. 89.9 kg D. 79.9 kg

7. Work done by a system is taken to be
A. positive B. negative C. zero D. varies according to situation

8. Work done on a system is taken to be
A. positive B. negative C. zero D. varies according to situation

9. The specific energy, e=E/m is an extensive property.
A. true B. false

10. (m*g*z) gives the
A. macroscopic kinetic energy B. microscopic kinetic energy
C. macroscopic potential energy D. microscopic potential energy

11. In a constant volume process, internal energy change is equal to
A. heat transferred B. work done C. zero D. none of the mentioned

12. The enthalpy and internal energy are the function of temperature for
A. all gases B. steam C. water D. ideal gas

13. A system undergoing change in state from A to B along path 'X' receives 100 J heat and does 40 J work. It returns to state A from B along path 'Y' with work input of 30 J. Calculate the heat transfer involved along the path 'Y'.

A. – 60 J   B. 60 J   C. – 90 J   D. 90 J

14. The portion of the internal energy of a system associated with the kinetic energies of the molecules is called the

A. Sensible energy   B. macroscopic kinetic energy   C. macroscopic potential energy   D. microscopic potential energy

15. The internal energy associated with the phase of a system is called the

A. latent energy   B. macroscopic kinetic energy   C. macroscopic potential energy   D. microscopic potential energy

16. The tremendous amount of energy associated with the strong bonds within the nucleus of the atom itself is called

A. nuclear energy   B. macroscopic kinetic energy   C. macroscopic potential energy   D. microscopic potential energy

18. In adiabatic process heat transfer is

A. zero   B. positive   C. negative   D. none of the mentioned

19. The specific gravity of a liquid has

A. the same unit as that of mass density   B. the same unit as that of weight density

C. the same unit as that of specific volume   D. no unit

20. In which type of matter, one won't find a free surface?

A. Solid   B. Liquid   C. Gas   D. Fluid

First Law of Thermodynamics

Problem 1

3. Carbon dioxide passing through a heat exchanger at a rate of 50 kg/hr is to be cooled down from 800°C to 50°C. Determine the rate of heat removal assuming flow of gas to be of steady and constant pressure type. Take c_p = 1.08 kJ/kg K.

Problem 2

10. In a cinema hall with seating capacity of 500 persons the comfort conditions are created by circulating hot water through pipes in winter season. Hot water enters the pipe with enthalpy of 80 kcal/kg and leaves the pipe with enthalpy of 45 kcal/kg. The difference in elevation of inlet pipe and exit pipe is 10 m with exit pipe being higher than inlet pipe. Heat requirement per person is 50 kcal/hr. Estimate the quantity of water circulated per minute, neglecting changes in velocity.

Problem 3

* In a steady flow system, a substance flows at a rate of 5 kg/sec. It enters the system at 6 bar, velocity 300 m/s internal energy 2000 kJ/kg and sp. volume 0.38 m³/kg. It leaves the system at a pressure of 1.5 bar, velocity 150 m/s, internal energy 1600 kJ/kg and sp. volume of 1.26 m³/kg. During its passage through the system, the substance losses 80 kJ/kg of heat to the surroundings. Determine the power of the system, stating whether it is from or to the system. Neglect any changes in PE.

Problem 4

In a steady flow device 135 kJ work is done by each kg of fluid. The sp. volume of the fluid, pressure and velocity at the inlet are 0.37 m³/kg, 600 kPa and 16 m/s resp. The inlet is 32m above floor level. The discharge is at floor level. The discharge conditions are 0.62 m³/kg, 100 kPa and 270 m/s. The total heat loss between inlet and outlet is 9 kJ/kg of the fluid. In flowing apparatus, does the sp. internal energy increase or decrease and by how much?

Problem 5

In a steady flow device the inlet and outlet conditions are given below. Determine the heat loss/gain by the system.

Property	Inlet	Outlet
Pressure (bar)	10	8.93
Sp. enthalpy (kJ/kg)	2827	2341
velocity (m/s)	20	120
Elevation (m)	3.2	0.5

Fluid flow rate through the device is 2.1 kg/s. The work output of the device is 750 kW.

Problem 6

At the inlet to a convergent-divergent nozzle the enthalpy of the fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end the enthalpy is 2757 kJ/kg. The nozzle is horizontal and the heat loss during the flow is negligible. Find ⓐ velocity of the fluid at the exit of the nozzle, ⓑ if the inlet area is 0.1 m^2 and the sp. volume at the inlet is 0.187 m^3/kg find the mass flow rate of the fluid, and ⓒ if the sp. volume at the outlet is 0.498 m^3/kg. Find the area at the exit of the nozzle.

Problem 7

- Air flows steadily at the rate of 0.5 kg/s through an air compressor, entering at 7 m/s velocity, 100 kPa pressure and 0.95 m³/kg sp. volume and leaving at 5 m/s, 700 kPa and 0.19 m³/kg, respectively. The internal energy of the air leaving is 90 kJ/kg greater than that of air entering. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW. Compute (a) the power input to the compressor, and (b) ratio of inlet pipe diameter to the outlet pipe diameter.

Problem 8

Determine the power available from a steam turbine with following details;
Steam flow rate = 1 kg/s
Velocity at inlet and exit = 100 m/s and 150 m/s
Enthalpy at inlet and exit = 2900 kJ/kg, 1600 kJ/kg
Change in potential energy may be assumed negligible. [1293.75 kW]

Problem 9

5–8 A hair dryer is basically a duct of constant diameter in which a few layers of electric resistors are placed. A small fan pulls the air in and forces it through the resistors where it is heated. If the density of air is 1.20 kg/m³ at the inlet and 1.05 kg/m³ at the exit, determine the percent increase in the velocity of air as it flows through the dryer.

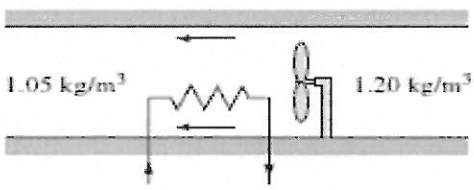


FIGURE P5–8

Problem 10

5–15 Air enters a 28-cm diameter pipe steadily at 200 kPa and 20°C with a velocity of 5 m/s. Air is heated as it flows, and leaves the pipe at 180 kPa and 40°C. Determine (*a*) the volume flow rate of air at the inlet, (*b*) the mass flow rate of air, and (*c*) the velocity and volume flow rate at the exit.

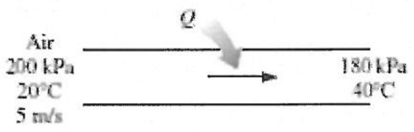


FIGURE P5–15

Problem 11

5–30 Air enters an adiabatic nozzle steadily at 300 kPa, 200°C, and 30 m/s and leaves at 100 kPa and 180 m/s. The inlet area of the nozzle is 80 cm². Determine (*a*) the mass flow rate through the nozzle, (*b*) the exit temperature of the air, and (*c*) the exit area of the nozzle. *Answers:* (*a*) 0.5304 kg/s, (*b*) 184.6°C, (*c*) 38.7 cm²

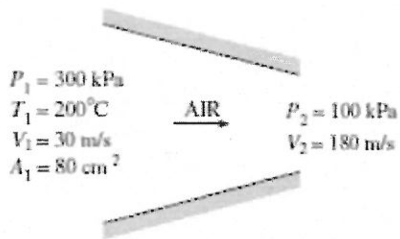


FIGURE P5–30

Problem 12

5–32 Steam at 5 MPa and 400°C enters a nozzle steadily with a velocity of 80 m/s, and it leaves at 2 MPa and 300°C. The inlet area of the nozzle is 50 cm², and heat is being lost at a rate of 120 kJ/s. Determine (*a*) the mass flow rate of the steam, (*b*) the exit velocity of the steam, and (*c*) the exit area of the nozzle.

Problem 13

5–39 Refrigerant-134a at 700 kPa and 120°C enters an adiabatic nozzle steadily with a velocity of 20 m/s and leaves at 400 kPa and 30°C. Determine (*a*) the exit velocity and (*b*) the ratio of the inlet to exit area A_1/A_2.

Problem 14

5–44 Steam enters a nozzle at 400°C and 800 kPa with a velocity of 10 m/s, and leaves at 300°C and 200 kPa while losing heat at a rate of 25 kW. For an inlet area of 800 cm^2, determine the velocity and the volume flow rate of the steam at the nozzle exit. *Answers: 606 m/s, 2.74 m^3/s*

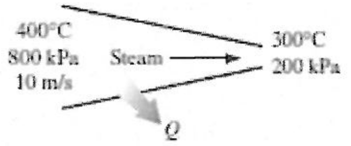


FIGURE P5–44

Problem 15

5–60 Helium is to be compressed from 120 kPa and 310 K to 700 kPa and 430 K. A heat loss of 20 kJ/kg occurs during the compression process. Neglecting kinetic energy changes, determine the power input required for a mass flow rate of 90 kg/min.

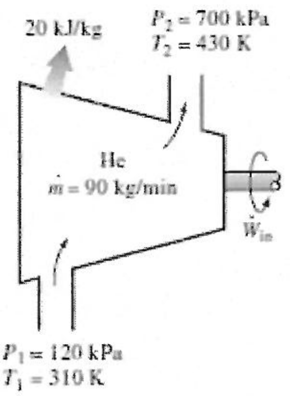


FIGURE P5–60

Problem 16

5–61 Carbon dioxide enters an adiabatic compressor at 100 kPa and 300 K at a rate of 0.5 kg/s and leaves at 600 kPa and 450 K. Neglecting kinetic energy changes, determine (*a*) the volume flow rate of the carbon dioxide at the compressor inlet and (*b*) the power input to the compressor.
Answers: (a) 0.28 m^3/s, (b) 68.8 kW

Availability

Problem 1

Calculate the decrease in available energy when 20kg of water at 90°C mixes with 30kg of water at 30°C, the pressure being taken as constant and the temperature of surroundings being 10°C. Take Cp of water as 4.18 kJ/kg.K

Problem 2

In a parallel flow type heat exchanger, water enters at 50^0C and leaves at 70^0C while oil (specific gravity =0.82 and specific heat 2.6 kJ/kg.K) enters at 240^0C and leaves at 90^0C. If the surrounding temperature is 27^0C determine the loss in availability on the basis of one kg of oil per second.

Problem 3

1 kg of ice at 0^0C is mixed with 10 kg of water at 30^0C. Determine the net increase in the entropy and unavailable energy when the system reaches common temperature. Assume that surrounding temperature is 10^0C. Take specific heat of water as 4.18 kJ/kg.K, specific heat of ice as 2.1 kJ/kg.K and latent heat of fusion as 333.5 kJ/kg.

Problem 4

1 kg of ice at 0^0C is mixed with 12 kg of water at 27^0C. Assuming surrounding temperature as 15^0C. Calculate the net increase in entropy and unavailable energy when the system reaches common temperature. Take specific heat of water as 4.18 kJ/kg.K, specific heat of ice as 2.1 kJ/kg.K and latent heat of fusion as 333.5 kJ/kg.

Problem 5

In a heat exchanger of parallel flow type, water enters at 60^0C and leaves at 80^0C while oil of specific gravity 0.8 enters at 250^0C and leaves at 100^0C. The specific heat of oil is 2.5 kJ/kg.K and surrounding temperature is 300K. Determine the loss in availability on the basis of 1 kg of oil flow per second.

Problem 6

1 kg of ice at -5^0C is mixed with 15 kg of water at 30^0C. Assuming surrounding temperature as 18^0C. Calculate the net increase in entropy and unavailable energy when the system reaches common temperature. Take specific heat of water as 4.18 kJ/kg.K, specific heat of ice as 2.1 kJ/kg.K and latent heat of fusion as 333.5 kJ/kg.

Problem 7

In a heat exchanger of parallel flow type, water enters at 30^0C and leaves at 60^0C while oil of specific gravity 0.8 enters at 235^0C and leaves at 115^0C. The specific heat of oil is 2.6 kJ/kg.K and surrounding temperature is 305K. Determine the loss in availability on the basis of 1 kg of oil flow per second.

Problem 8

Calculate the decrease in available energy when 30kg of water at 85^0C mixes with 25kg of water at 28^0C, the pressure being taken as constant and the temperature of surroundings being 10^0C. Take Cp of water as 4.18 kJ/kg.K

Problem 9

In a parallel flow heat exchanger hot fluid enters at 180^0C and leaves at 120^0C while the cold fluid enters at 55^0C. The specific heats of hot and cold fluids are 1.8 kJ/kg.K and 2.3 kJ/kg.K respectively. The mass flow rate of hot fluid is 2.8 kg/min and that of cold fluid is 3.5 kg/min. Calculate the exit temperature of cold fluid. Calculate the decrease in available energy for ambient temperature of 15^0C and the rate of heat transfer.

Problem 10

8–137 An adiabatic heat exchanger is to cool ethylene glycol (c_p = 2.56 kJ/kg · °C) flowing at a rate of 2 kg/s from 80 to 40°C by water (c_p = 4.18 kJ/kg · °C) that enters at 20°C and leaves at 55°C. Determine (*a*) the rate of heat transfer and (*b*) the rate of exergy destruction in the heat exchanger.

Problem 11

8–136 A well-insulated heat exchanger is to heat water (c_p = 4.18 kJ/kg · °C) from 25°C to 60°C at a rate of 0.4 kg/s. The heating is to be accomplished by geothermal water (c_p = 4.31 kJ/kg · °C) available at 140°C at a mass flow rate of 0.3 kg/s. The inner tube is thin-walled and has a diameter of 0.6 cm. Determine (*a*) the rate of heat transfer and (*b*) the rate of exergy destruction in the heat exchanger.

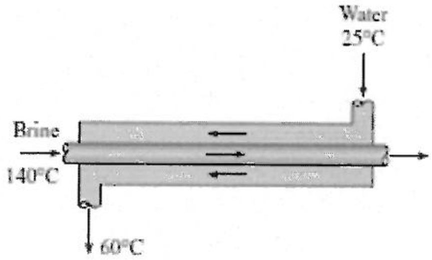


FIGURE P8–136

Problem 12

8–88 Cold water (c_p = 4.18 kJ/kg · °C) leading to a shower enters a well-insulated, thin-walled, double-pipe, counter-flow heat exchanger at 15°C at a rate of 0.25 kg/s and is heated to 45°C by hot water (c_p = 4.19 kJ/kg · °C) that enters at 100°C at a rate of 3 kg/s. Determine (*a*) the rate of heat transfer and (*b*) the rate of exergy destruction in the heat exchanger. Take T_0 = 25°C.

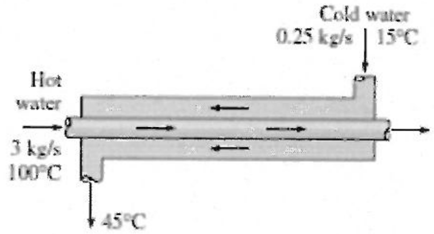


FIGURE P8–88

Problem 13

A heat exchanger is used to cool 2200 kg/hr of oil (c_p=2.5 kJ/kgK), from 100°C to 35°C by the use of water entering at 17°C and leaving at 85°C. Calculate the required quantity of water, the decrease in available energy for ambient temperature of 20°C and the rate of heat transfer.

Problem 14

A home air-conditioning system uses a heat exchanger to cool 0.8 kg/s of air from 45°C to 15°C. The cooling is accomplished by a stream of cooling water that enters the system with 0.5 kg/s flow rate and 8°C temperature. Calculate exit temperature of water, rate of heat transfer and decrease in availability for an ambient temperature of 20°C.

Problem 15

A heat exchanger is used for cooling oil from 200°C to 140°C by using water available at 20°C. The mass flow and specific heat of oil are 10000 kg/hr and 1.9 kJ/kg K and the mass flow and specific heat of water are 3000kg/hr. and 4.187 kJ/kg K. Calculate outlet temperature of water, rate of heat transfer and the decrease in available energy for an ambient temperature of 25°C.

Problem 16

A heat exchanger is used to heat water from 20°C to 80°C using a hot oil at 120°C (c_p=2.5 kJ/kgK). The mass flow rate of water is 1.8 kg/min. Calculate the required quantity of oil, the decrease in available energy for ambient temperature of 25⁰C and the rate of heat transfer.

Entropy

Problem 1

7–124 A well-insulated heat exchanger is to heat water (c_p = 4.18 kJ/kg · °C) from 25 to 60°C at a rate of 0.50 kg/s. The heating is to be accomplished by geothermal water (c_p = 4.31 kJ/kg · °C) available at 140°C at a mass flow rate of 0.75 kg/s. Determine (*a*) the rate of heat transfer and (*b*) the rate of entropy generation in the heat exchanger.

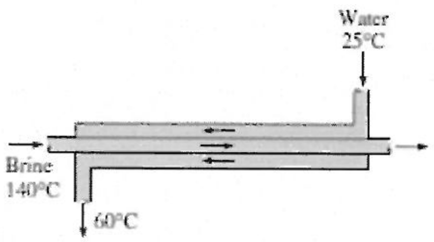


FIGURE P7–124

Problem 2

Air at 20°C and 1·05 bar occupies 0·025 m³. The air is heated at constant volume until the pressure is 4·5 bar, and then cooled at constant pressure back to original temperature. Calculate:

i) The net heat flow from the air

ii) The net entropy change

Problem 3

* $0.04\ m^3$ of nitrogen contained in a cylinder behind a piston is initially at 1.05 bar and 15°C. The gas is compressed isothermally and reversibly until the pressure is 4.8 bar. Calculate:

i) The change of entropy

ii) The heat flow

iii) The work done,

Assume nitrogen to act as a perfect gas. Molecular weight of nitrogen = 28.

Problem 4

* 0.04 kg of carbon dioxide (molecular weight = 44) is compressed from 1 bar, 20°C until the pressure is 9 bar, and the volume is then $0.003\ m^3$. calculate the change of entropy.

Take C_p for CO_2 as 0.88 kJ/kg·K and assume CO_2 to be a perfect gas.

Problem 5

* $1\ m^3$ of air is heated reversibly at constant pressure from 15°C to 300°C, and is then cooled reversibly at constant volume back to the initial temperature. The initial pressure is 1.03 bar. Calculate the net heat flow and overall change of entropy.

Problem 6

Air at 15°C and 1.05 bar occupies $0.02\ m^3$. The air is heated at constant volume until the pressure is 4.2 bar and then cooled at constant pressure back to the original temperature. Calculate the net heat flow to or from the air and the net entropy change.

Problem 7

0.05 kg of carbon dioxide (molecular weight = 44) is compressed from 1 bar, 15^{0}C, until the pressure is 8.3 bar, and the volume is then 0.004m^3. Calculate the change of entropy. Take Cp for carbon dioxide as 0.88 kJ/kg.K and assume carbon dioxide to be a perfect gas.

Problem 8

1.2 m^3 of air is heated reversibly at constant pressure from 300K to 600K, and is then cooled reversibly at constant volume back to initial temperature. If the initial pressure is 1 bar, calculate: the net heat flow and the overall change in entropy. Take Cp for air as 1.005 kJ/kg.K and R = 0.287 kJ/kg.K.

Problem 9

Air at 25^{0}C and 1.05 bar occupies 0.018 m^3. The air is heated at constant volume until the pressure is 4.5 bar and then cooled at constant pressure back to the original temperature. Calculate the net heat flow to or from the air and the net entropy change.

Problem 10

0.85 m^3 of air is heated reversibly at constant pressure from 320K to 580K, and is then cooled reversibly at constant volume back to initial temperature. If the initial pressure is 1.1 bar, calculate: the net heat flow and the overall change in entropy. Take Cp for air as 1.005 kJ/kg.K and R = 0.287 kJ/kg.K.

Theemodynamic's

ISE-2 , Geoup No:→ 3

Q.1 AiE entees a 28·cm diametee pipe steadily at 200 k pa and 20°c with a velocity of 5 m/s AiE is heated as it flows, and leaves the pipe at 180 kpa and 40°c, Deteemine (a) the volume flow eate of aiE at the inlet, (b) the mass flow eate of aiE, and (c) the velocity and volume flow eate at the exit.

Solution :→

AiE, $D = (28)cm = 0.28 m$

$p_{in} = 200 \text{ kpa}$

$T_{in} = 20°c + 273 = 293 K$

$v_{in} = 5 \text{ m/s}$

$p_{out} = 180 \text{ kpa}$, $T_{out} = 40°c + 273 = 313 K$

we need to find $\dot{V}_{in} = ?$ $\dot{V}_{out} = ?$

$\vec{V}_{out} = ?$ $\dot{m} = ?$

$\dot{V}_{in} = \vec{V}_{in} \cdot A = \frac{\pi D^2}{4} \cdot \vec{V}_{in}$

$\dot{V}_{in} = \frac{\pi}{4}(0.28)^2(5) = 0.3079 \text{ m}^3/s$

$\dot{m} = \rho_{in} \cdot \dot{V}_{in}$

by using peefect gas eelation

$PV = RT$

$\frac{P}{\rho} = RT$

$\rho_{in} = \frac{P_{in}}{RT_{in}} = \frac{(200)}{(0.287)(293)} = 2.378 \text{ kg/m}^3$

$\dot{m} = (2.378\ kg/m^3)(0.3079) = 0.7323\ kg/s$

At the outlet

$\dot{m}_{out} = \dot{m}_{in} = 0.7323\ kg/s$

$\dot{m}_{out} = \rho_{out} \vec{V}_{out} \cdot A$

$$\vec{V}_{out} = \frac{\dot{m}_{out}}{\rho_{out} A} = \frac{4\dot{m}}{\pi D^2 \rho_{out}}$$

$$\rho_{out} = \frac{P_{out}}{R T_{out}} = \frac{(180)}{(0.287)(313)} = 2.004\ kg/m^3$$

$$\vec{V}_{out} = \frac{4(0.7323)}{\pi(0.28)^2(2.004)} = 5.934\ m/s$$

$\dot{V}_{out} = \vec{V}_{out} \cdot A = \pi/4\ D^2\ \vec{V}_{out}$

$$\dot{V}_{out} = \frac{\pi}{4}(0.28)^2(5.934) = 0.3654\ m^3/s$$

Entropy

Q. $1m^3$ of air is heated reversibly at constant pressure from 15°C to 300°C, and is then cooled reversibly at constant volume back to the initial temperature, The initial pressure is 1.03 bar. calculate the net heat flow and overall change of entropy.

Given data,

Solution:→

$v = 1m^3$ | constant pressure $v_2 =$
$T_1 = 15°C = 288K$ | $T_2 = 573K$
$p_1 = 1.03 \times 10^5 \ N/m^2$ | $p_2 = p_1 = 1.03 \times 10^5 \ N/m^2$

constant volume $v_3 = v_2 = 0$
$T_3 = T_1 = 288K$
$p_3 = 0$

At state (1)

$p_1 v_1 = mRT_1$
$1.03 \times 10^5 \times 1 = m \times 287 \times 288$
$m = 1.2461 \ kg$

at state (2)

$p_2 v_2 = mRT_2$
$1.03 \times 10^5 \times v_2 = 1.2461 \times 287 \times 573$
$v_2 = 1.9895 \ m^3$

∴ change in entropy during process 1-2,

$\Delta S_{1-2} = cp . \ln\left(\frac{T_2}{T_1}\right) = 1.005 \times \ln\left(\frac{573}{288}\right)$

$\Delta S = 0.6913 \ kJ/kg.K$

For given mass,

$\Delta s_{1-2} = 0.6913 \times 1.2461 = 0.8614$ kJ/K

$V_2 = V_3 = 1.9895 \, m^3$

change in entropy during process 2-3

$\Delta s_{2-3} = C_v \cdot \ln\left(\frac{T_3}{T_2}\right) = 0.718 \ln\left(\frac{288}{573}\right)$

$\Delta s_{2-3} = -0.493$ kJ/kg.K

For given mass,

$\Delta s_{2-3} = 1.2461 \times -0.493$

$\Delta s_{2-3} = -0.6143$ kJ/K

Net entropy change

$\Delta s_{1-3} = 0.8614 - 0.6143$

$= 0.2471$ kJ

Heat flow during process 1-2 ($\Delta p = 0$)

$Q_{1-2} = m \cdot C_p (T_2 - T_1)$

$= 1.2461 \times 1.005 \times (573 - 288)$

$Q_{1-2} = 356.91$ kJ (Heat-gain)

Heat flow during process 2-3 ($\Delta V = 0$)

$Q_{2-3} = m \cdot C_v \cdot (T_3 - T_2)$

$= 1.2461 \times 0.718 (288 - 573)$

$= -254.99$ kJ (heat rejection)

$\therefore$ Net heat flow,

$Q_{1-3} = 356.91 - 254.99 = 101.92$ kJ

Availibility

Q In an heat exchanger of parallel flow type water enters at 30°C and leaves at 60°C while oil of specific gravity 0.8 enters at 235°C and leaves at 115°C. The specific heat of oil is 2.6 kJ/kg K. and surrounding 350K. Determine the loss in availibility on the basis of 1kg of oil flow per second

→ for water

$T_{w1} = 30°C$ $\quad T_{w2} = 60°C$

$= 30+273$ $\quad = 60+273$

$= 303\,K$ $\quad = 333\,K$

$C_{pw} = 4.18\ kg/kg\,K$ $\quad m_w = ?$

for oil

$T_{o1} = 235°C = 508K$ $\quad T_{o2} = 115° = 388\,K$

$C_{po} = 2.6\ kJ/kg.K$ $\quad m_o = 1\,kg/sec$

$T_{atm} = 350K$

Using energy balance equation

$m_w \cdot C_{pw}(T_{w2} - T_{w1}) = m_o c_{po} (T_{o1} - T_{o2})$

$m_w \; 4.18(333 - 303) = 1 \times 2.6 \times (235 - 388)$

$m_w = + 2.756\ kg/sec$

A.E of water before heat exchanger

$(A.E)_{w1} = 2.756 \times 4.18 \left[(303 - 350) - 350 \ln\left(\frac{303}{350}\right) \right]$

$= 11.520 \times \left[(303 - 350) - 350 \ln\left(\frac{303}{350}\right) \right]$

$= 3.470 \times 11.520$

$= 39.974\ kg/sec$

Page :
Date :

A.E of water after heat exchanger

$(AE)_{2\omega} = 2.756 \times 4.18 \left[(333 - 350) - 350 \ln\left(\frac{333}{350}\right) \right]$

$= 11.520 \times 0.426$

$= 4.907$ kJ/sec

A.E of oil before heat exchange

$(AE)_{01} = 1 \times 2.6 \left[(235 - 350) - 350 \ln\left(\frac{235}{350}\right) \right]$

$= 63$ kJ/sec

A.E of oil After heat exchanger,

$(AE)_{02} = 1 \times 2.6 \left[(388 - 350) - 350 \ln\left(\frac{388}{350}\right) \right]$

$= 5.004$ kJ/sec

Total AE before heat exchanger $= (AE)_{\omega 1} + (AE)_{01} = 39.974 + 63$

$= 75.974$ kJ/sec

Total AE After heat exchanger $= (AE)_{\omega 2} + (AE)_{02} = 4.907 + 5.004$

$= 9.911$

Decrease in A.E $= 75.974 - 9.911$

$= 66.063$ kJ/sec

Camlin

Enroll. No.

K. E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, affiliated to SUK)

End Semester Examination (July 2023)

S.Y. B. Tech. Mechanical Engineering SEM – III / I

QP No.
E369

Engineering Thermodynamics (ME2033) / ME2032)

Day & Date: – Thu., 13/7/2023

Time: – 10.30 to 1.30 pm.

Max Marks: 100

Instructions:

1. All questions are compulsory.
2. Use of non-programmable calculator is allowed.
3. Assume suitable data if necessary
4. Use of steam table allowed

			Marks	CO
Q.1	a)	Explain mechanical, chemical and thermal equilibrium.	**08**	CO1
		OR		
	a)	Develop the steady flow energy equation for heat exchanger applications.		CO1
	b)	A blower handles 1 kg/s of air at 20°C and consumes a power of 15 kW. The inlet and outlet velocities of air are 100 m/s and 150 m/s respectively. Find the exit air temperature, assuming adiabatic conditions. Take C_p of air is 1.005 kJ/kg-K.	07	CO1
Q.2	a)	Show that the efficiency of all reversible heat engines operating between the same temperature levels is the same.	**08**	CO2
		OR		
	a)	Explain Clausius inequality.		CO2
	b)	A 50-kg block of iron casting at 500 K is thrown into a large lake that is at a temperature of 285 K. The iron block eventually reaches thermal equilibrium with the lake water. Assuming an average specific heat of 0.45 kJ/kg·K for the iron, determine (a) the entropy change of the iron block, (b) the entropy change of the lake water, and (c) the entropy generated during this process.	07	CO1
Q.3	a)	Explain in detail available and unavailable energy.	**08**	CO3
		OR		
	a)	Derive the equation for availability (Exergy) of a open system.		CO3
	b)	In a parallel flow type heat exchanger, water enters at 50^{0}C and leaves at 70^{0}C while oil (specific gravity =0.82 and specific heat 2.6 kJ/kg.K) enters at 240^{0}C and leaves at 90^{0}C. If the surrounding	07	CO3

temperature is 27^0C, Calculate the loss in availability based on one kg of oil per second.

Q.4	a)	Explain Daltons law of partial pressure and Amagat's law.	08	CO5
		OR		
	a)	Develop equation for enthalpy of a gas mixture on mass and molar basis using Gibbs-Daltons law.		CO5
	b)	Consider a gas mixture that consists of 5 kg of O_2, 8 kg of N_2 and 12 kg of CH_4. Calculate, a) mass fraction of each component, b) mole fraction of each component, c) the average molar mass and, d) the gas constant of the mixture	07	CO5
Q.5	a)	The steam is produced in the boiler and supplied to the steam turbine at 36 bar and 370°C to generate power in the power plant. Calculate the enthalpy and entropy of the steam at inlet per kg of steam.	08	CO4
	b)	A rigid tank contains 10 kg of water at 90°C. If 8 kg of the water is in the liquid form and the rest is in the vapor form, determine (i) the pressure in the tank and (ii) the volume of the tank.	08	CO4
	c)	Explain PVT surfaces	04	CO4
		OR		
	c)	Explain critical temperature and critical pressure for steam.		CO4
Q.6	a)	Develop the equation for efficiency of the Rankine cycle.	08	CO6
	b)	A steam enters in a turbine at 30 bar and 300^0 C and it expands isentropically up to 0.1 bar pressure in condenser. Determine the cycle efficiency, work ratio and specific steam consumption.	08	CO6
	c)	Write any one method to improve Rankine cycle efficiency	04	CO6
		OR		
	c)	Write limitations of Carnot cycle.		CO6

Enroll. No.

K. E. Society's
Rajarambapu Institute of Technology, Rajaramnagar
(An Autonomous Institute, affiliated to SUK)
End Semester Examination March 2022
S.Y. B. Tech. Mechanical Engineering SEMESTER – III

QP No.
EB2138

Engineering Thermodynamics (ME2033) / Re. Reg - ME2032

Day & Date: Sat. 12/3/2022
Time: – 02:30 to 5:30 pm

Max Marks: 100

Instructions:
1. All questions are compulsory.
2. Use of non-programmable calculator is allowed.
3. Assume suitable data if necessary
4. Use of steam table allowed

			Marks	CO
Q.1	a)	Explain Extensive and Intensive property with suitable examples	08	CO1
		OR		
	a)	Apply steady flow energy equation to develop equation for exit velocity of gas leaving the nozzle.		
	b)	Calculate the power available from a steam turbine with following details: Steam flow rate 1 kg/s Velocity of steam at inlet and exit 100 m/s and 150 m/s Enthalpy of steam at inlet and outlet 2900 kJ/kg and 1600 kJ/kg Change in potential energy is negligible	07	CO1
Q.2	a)	Differentiate between heat pump and refrigerator.	08	CO1
		OR		
	a)	Explain the Clausius theorem		
	b)	1 m^3 of air is heated reversibly at constant pressure from 15^{0}C to 300^{0}C, and is then cooled reversibly at constant volume back to the initial temperature. The initial pressure is 1.03 bar. Calculate the net heat flow and overall change of entropy.	07	CO2
Q.3	a)	Derive the equation for availability (Exergy) of a finite body at temperature T.	08	CO3
		OR		
	a)	Derive the equation for availability (Exergy) of a steady flow process.		
	b)	Calculate the decrease in exergy when 25 kg of water at 95^{0}C mix with 35 kg of water at 35°C, the pressure being taken as constant and the temperature of the corresponding being 15°C. Cp of water is 4.2 kJ/kgK.	07	CO3

Q.4 a) State Gibbs-Dalton law and derive equation for internal energy of a gas mixture on mass and molar basis. 08 CO5

OR

a) Explain the following

1. Mole fraction
2. Dalton's law
3. Mass Fraction
4. Amagat's law

b) Consider a gas mixture that consists of 5 kg of O_2, 8 kg of N_2 and 12 kg of CH_4. Calculate, a) mass fraction of each component, b) mole fraction of each component, c) the average molar mass and, d) the gas constant of the mixture 07 CO5

Q.5 a) Calculate the missing properties of steam in the following table for water: 08 CO4

S. N.	T, ^{0}C	P, bar	h, kJ/kg	x	s, kJ/kg.K	Type of steam
1.		80	2700			
2.	400	90				
3.		0.4		0.8		
4.	40			0.9		

b) The steam is produced in the boiler and supplied to the steam turbine at 31 bar and 420°C to generate power in the power plant. Calculate the enthalpy and entropy of the steam at inlet per kg of steam. 08 CO4

c) Draw P-v and T-v diagram for water and label it. 04 CO4

OR

c) Write van der Waals equation of state and meaning of terms in it.

Q.6 a) Develop the equation for efficiency of the Rankine cycle. 08 CO6

b) A simple Rankine cycle works between pressure 18 and 0.8 bar, the initial condition of steam being dry saturated. Calculate: i) The cycle efficiency ii) Work ratio ii) Specific steam consumption. 08 CO6

c) State process of Otto cycle and draw PV diagram 04 CO6

OR

c) Draw Carnot vapour cycle on P-V, T-S diagrams.

Engg. Thermodynamics

Q.P. No
RE 2636

Re Exam – Oct 2022

Model Answer sheet.

Q.1.

a) i) Explanation with definition, fig. of each term & Example each

01 Mark * 8 = (08) Marks

ii) Definition — (01)
fig. Example — (01)
of each term

* 04 term = (08) Marks

OR

(a) limitation of 1st law

04 limitation (04) Marks

Clausius statement — (02 M)
Explanation with fig — (02 M)

Q.1.(b) Given,

$m_1 = 4.2$ kg/s, $h_1 = 313.93$ kJ/kg, $h_2 = 2676$ kJ/kg, $h_3 = 429$ kJ/kg — (4M)

Now by applying mass balance principle — (2M)

$m_1 + m_2 = m_3$

by applying energy balance principle.

$m_1 h_1 + m_2 h_2 = m_3 h_3$ — (2M)

$4.2 \times 313.93 + m_2 \times 2676 = (4.2 + m_2)\, 419$

$m_2 = 0.196$ kg/s — (2M)

The steam supplied is 0.196 kg/s for heating.

Q.2 (a) PMM (I) & (II) difference

08 difference point * (01)M each = 08 Marks

OR

(a) Clausius Inequality

Statement — (02M)

figure — (02M)

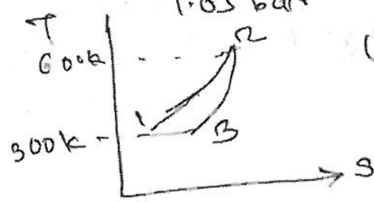
Proof of equation — (04M)

(08M)

(b) $V_1 = 1.5 m^3$, $P_1 = P_2$, $T_1 = 25+273 K = 298 K$

$T_2 = 330+273 = 603 K$

$P_1 = 1.05 bar$, $C_p = 1.005 kJ/kgK$, $R = 0.287 kJ/kgK$.



(i) mass of air $= \frac{P_1 V_1}{R T_1} = \frac{1.05 \times 10^5 \times 1.5}{0.287 \times 1000 \times 298}$

$= 1.8415$ kg — (2M)

$Q = Q_{12} + Q_{23}$

$= mC_p(T_2 - T_1) + mC_v(T_3 - T_2)$

$= m(T_2 - T_1)(C_p - C_v) = m \times (T_2 - T_1) \times R$

$= 1.84 \times (603 - 298) \times 0.287 = 161.19$ kJ

— (2M)

Entropy change during process 1.2.

$S_2 - S_1 = 1.84 \times 1.005 \times \ln\left(\frac{603}{298}\right)$

$= 1.30$ kJ/K.

Entropy change during process 2-3

$S_3 - S_2 = mC_v \ln\left(\frac{T_3}{T_2}\right) = 1.84 \times 0.718 \times \ln\left(\frac{298}{603}\right)$

$= -0.9311$ — (2M)

∴ overall change in entropy

$= (S_2 - S_1) + (S_3 - S_2)$

$= 1.30 - (-0.9311)$

$= 2.2311$ kJ/K — (2M)

Q.3 (a) Exergy destruction in HT process

Figure (02M)

Explanation – (04M)

Final equation – (02M)

OR

(a) Exergy of closed system

Figure (02) M

Explanation – (04M)

Final equation – (02M)

(b) Given:

$T_1 = 235°C = 508\,K$, $T_2 = 115°C = 388\,K$

$T_0 = 305\,K$

Initial availability =

$\psi_1 = (h_1 - h_0) - T_0(S_1 - S_0)$

$= C_p(T_1 - T_0) - T_0 C_p \ln\left(\frac{T_1}{T_0}\right)$

$= 2.6\,(508 - 305) - 305 \times 2.6 \times \ln\left(\frac{508}{305}\right)$

$= 123.23\ kJ/kg$ —— (3M)

$\psi_2 = C_p(T_2 - T_0) - T_0 C_p \ln\left(\frac{T_2}{T_1}\right)$

$= 2.6\,(388 - 305) - 305 \times 2.6 \times \ln\left(\frac{388}{305}\right)$

$= 24.93\ kJ/kg$ —— (2M)

Hence loss in availability of oil is

$= \psi_1 - \psi_2$

$= 123.23 - 24.93$

$= 98.3\ kJ/kg$ —— (2M)

Q.4 (a) Definition of term - (01M)
Explanation - (01M) * 04 term = (08M)
of each term

OR

(a) Statement of law - (02M)
Explanation with fig - (02M) * 02 terms = (08M)

(b) Given.
Composition on mole basis.
65% O_2, & 35% CH_4
Hence,
molar mass

$M_m = \Sigma y_i M_i$
$= 0.65 \times 32 + 0.35 \times 16$
$= 26.4$ kg/kmol — (1M)

Now Gas constant

$R_m = \frac{R_u}{M_m} = \frac{8.314}{26.4} = 0.3149$ kJ/kgK — (2M)

Same for
65% O_2 and 35% N_2

$M_m = 0.65 \times 32 + 0.35 \times 28$
$= 30.6$ kg/kmol — (2M)

and
$R_m = \frac{R_u}{M_m} = \frac{8.314}{30.6} = 0.2716$ kJ/kgK — (2M)

Q.5 (a) Detail Calculation of missing terms each of [0.5 Marks]

T	P	h	x	s	Type of steam
(1) 362.17	90	3000		6.1058	Superheat
(2) 400	90	3118.8		6.2876	Superheat
(3) 85.95	0.6	2424	0.9	6.892	Wet
(4) 50	0.1235	1877	0.7	5.863	Wet

(b) Given

$P = 30.5$ bar

$T = 330°C$

$h = 3067.2$ kJ/kg — (2M)

$s = 6.6580$ kJ/kgK — (2M)

(c) Draw figure (01 M)

Nature of line (01M)

× 02 terms = (04 M)

OR

(c) Mollier diagram

fig – (01M)

lines – (02M)

Explanation – (01M)

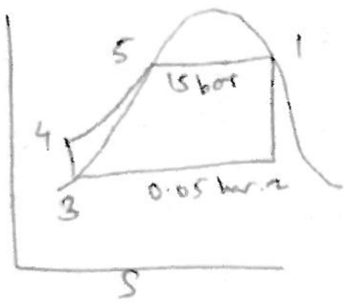
Q. 6 (a) list of methods - (02M) — 03 methods

improvement fig of each method - (01) M * 03 methods = (06M)

Explanation of each methods - (01) M

= 08 M

(b)



at 15 bar $h_1 = 2791$ kJ/kg

$S_1 = 6.4430$

at 0.06 bar $h_2 =$

consider 1-2 isentropic process

hence

$S_1 = S_2$

∴ from this $h_2 = 1963.7$

$W_t = h_1 - h_2 = 2791 - 1963.7 = 827.3$ kJ/kg

Pump work $= V_f(P_1 - P_2) = 0.01053 \times (15 - 0.05) = 15.74$ kJ/kg

Now $W_p = h_4 - h_3$

$15.74 = h_4 - 137.75$ ∴ $h_4 = 153.49$ kJ/kg — (1M)

(i) Now, cycle Analysis, cycle efficiency $= \frac{W_{net}}{Q_{in}} = \frac{827.3 - 15.74}{(2791 - 153.49)}$

$= 0.3076 \times 100$

$= 30.76\%$ — (2M)

(ii) Work ratio $= \frac{W_{net}}{W_{turbine}} = \frac{811.56}{827.3} = 0.98$ — (2M)

(iii) Specific steam consumption $= \frac{3600}{W_{net}} = \frac{3600}{811.56} = 4.435$ kg/kWh.

— (2M)

(c) PV, TS dia - (02M)

Efficiency eqn developed - (02M) } - (04M)

OR

PV, TS dia - (02M)

Explanation or steps of developed final eqn (02M) } — 04M

Date:22-11-2022

NOTICE

For S. Y. B. Tech Mechanical

All S. Y. B. Tech Mechanical students are hereby informed that an industrial visit for the course Engineering Thermodynamics is arranged at Rajarambapu Sugar Factory, Wategaon (Unit=02) as per following details:

Location: **Rajarambapu Sahakari Sakhar Karkhana Ltd**

Wategaon Unit No: 02

Visit Schedule:-

Day &Date	**Division**	**Time (Batch of Students)**
Friday, 25th Oct. 2022	B	9.30 AM Onwards
	A	02.00 PM Onwards

Kindly Note:

1. For SY Mech Div A classes will be conducted as per time table upto 12.10 pm and then visit will start.

2. For S Y Mech Div B after visit classes will be conducted from 3.10 pm onwards as per timetable.

3. All student should come in dress code for visit

4. Shoes are compulsory.

Course coordinator

Head,

Mech Engg. Dept.

ETH -Course end survey 2022-23

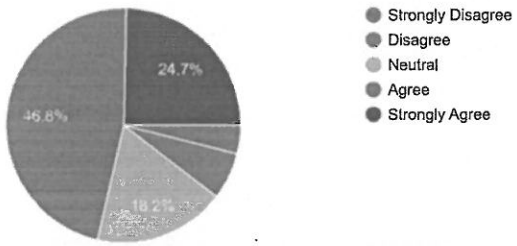
77 responses

Publish analytics

Can you Apply thermodynamics principles to mechanical engineering applications?

Copy

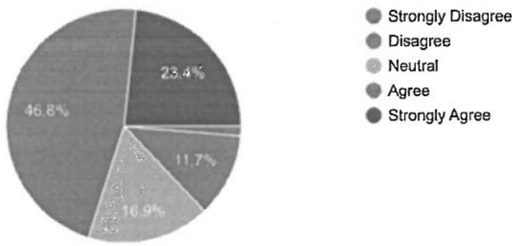
77 responses



Can you Describe entropy, change in entropy and increase of entropy principle?

Copy

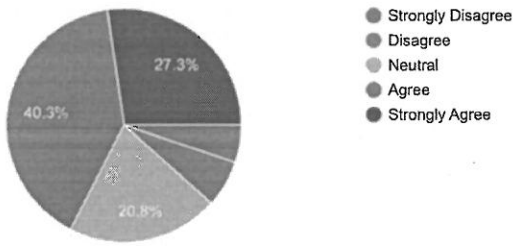
77 responses



Are you able to Differentiate between available and unavailable energy with examples?

Copy

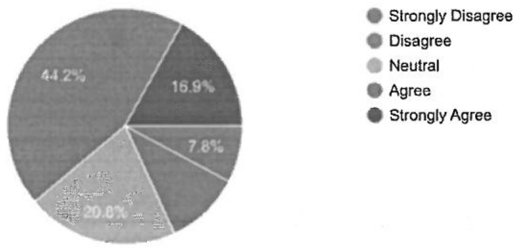
77 responses



Can you Recognize the properties of pure substances and use thermodynamic property tables, charts?

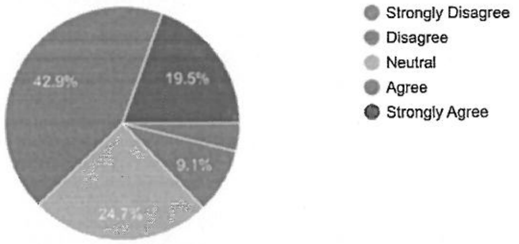
Copy

77 responses



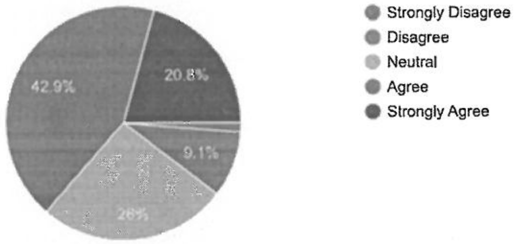
Are you able to Apply mathematical fundamental to study the properties of steam gas and gas mixtures?

77 responses



Can you Explain the air and vapor power cycles and calculate cycle performance?

77 responses



Course End Survey -ETH 21-22

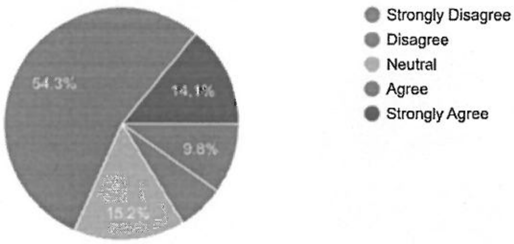
92 responses

Publish analytics

Are you able to apply thermodynamics principles to mechanical engineering applications ?

Copy

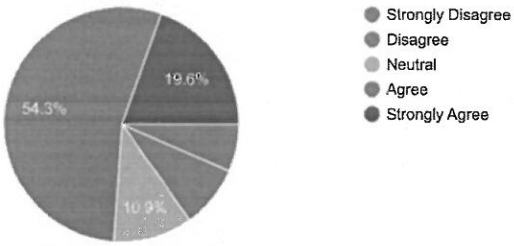
92 responses



Can you describe entropy, change in entropy and increase of entropy principle ?

Copy

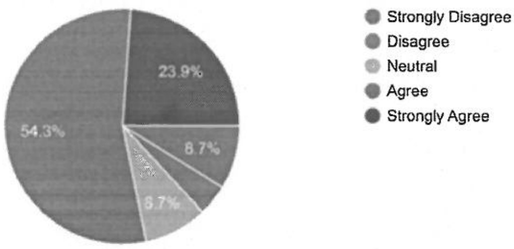
92 responses



Are you able to differentiate between available and unavailable energy with examples ?

Copy

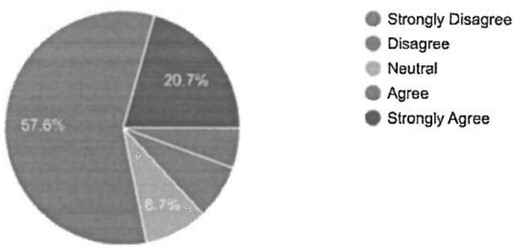
92 responses



Can you recognize the properties of pure substances and use thermodynamic property tables, charts ?

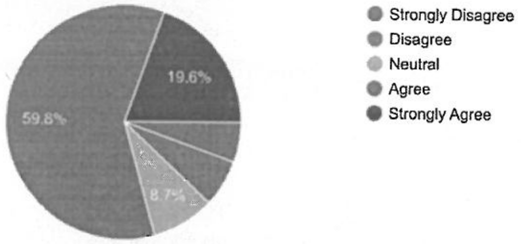
Copy

92 responses



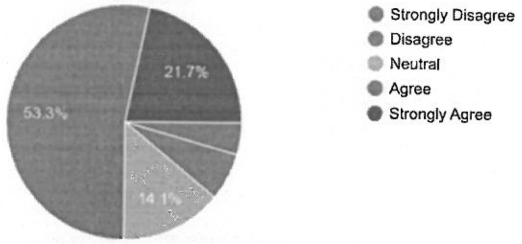
Are you able to apply mathematical fundamental to study the properties of steam gas and gas mixtures ?

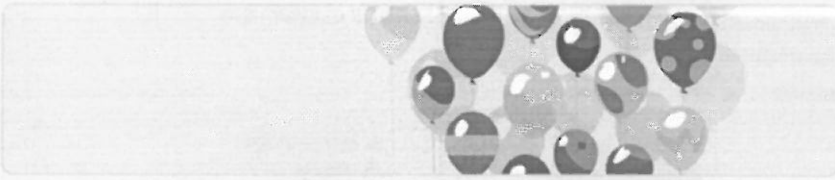
92 responses



Can you explain the air and vapor power cycles and calculate cycle performance ?

92 responses





Course End Survey -ETH 20-21

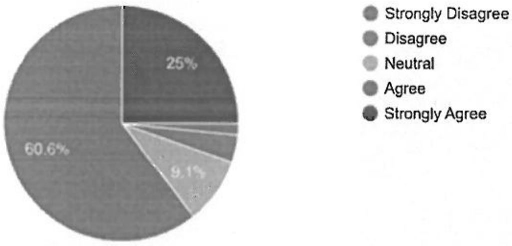
132 responses

Publish analytics

Apply thermodynamics principles to mechanical engineering applications?

Copy

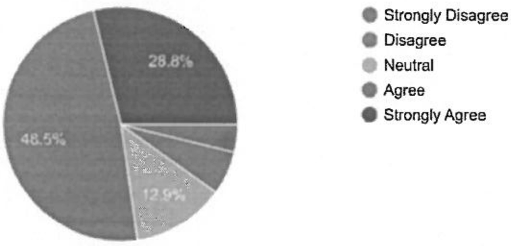
132 responses



Describe entropy, change in entropy and increase of entropy principle?

Copy

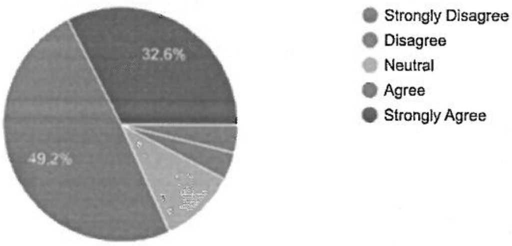
132 responses



Differentiate between available and unavailable energy with examples?

Copy

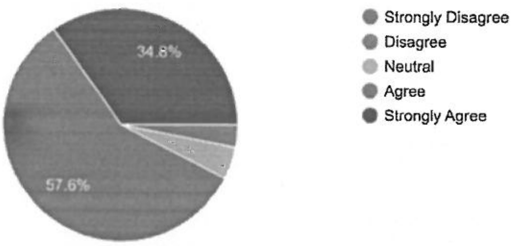
132 responses



Recognize the properties of pure substances and use thermodynamic property tables, charts?

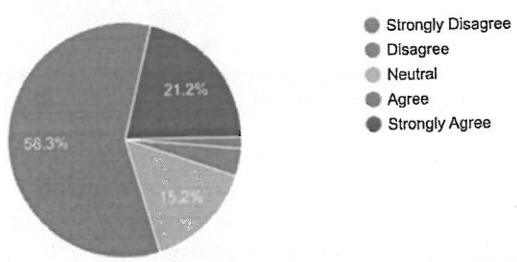
Copy

132 responses



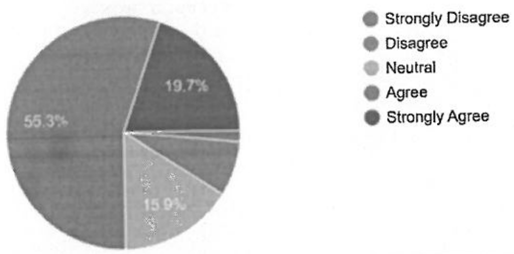
Apply mathematical fundamental to study the properties of steam gas and gas mixtures?

132 responses



Explain the air and vapor power cycles and calculate cycle performance.?

132 responses

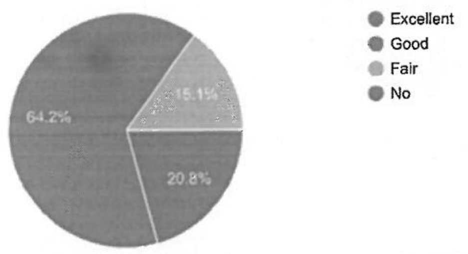


Engg. Thermodynamics (ME2032)_Course End Survey_Sem I_2019-20

53 responses

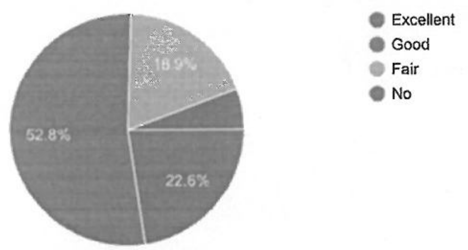
Are you able to apply thermodynamics principles to mechanical engineering applications

53 responses



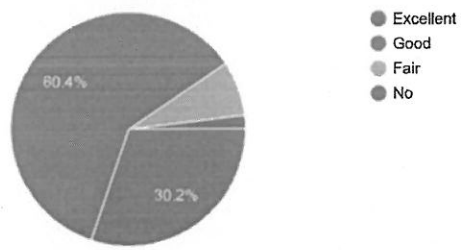
Can you describe entropy, change in entropy and increase of entropy principle

53 responses



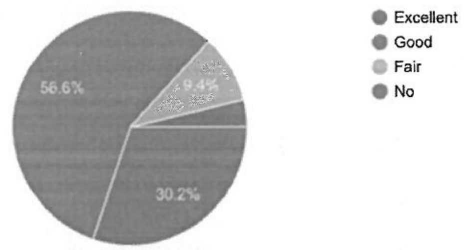
Are you able to differentiate between available and unavailable energy with examples

53 responses



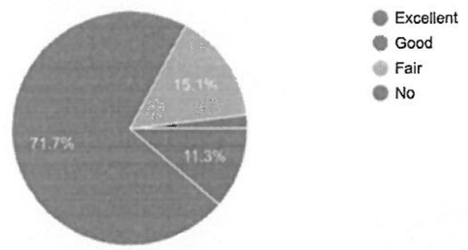
Can you recognize the properties of pure substances and use thermodynamic property tables, charts

53 responses



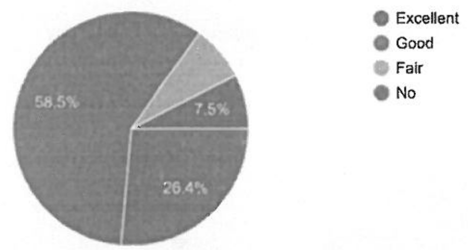
Are you able to apply mathematical fundamental to study the properties of steam gas and gas mixtures

53 responses



Can you explain the air and vapor power cycles and calculate cycle performance

53 responses



Basic Concepts of Thermodynamics

Every science has its own unique vocabulary associated with it. Precise definition of basic concepts forms a sound foundation for development of a science and prevents possible misunderstandings. Careful study of these concepts is essential for a good understanding of topics in thermodynamics.

Thermodynamics and Energy

Thermodynamics can be defined as the study of energy, energy transformations and its relation to matter. The analysis of thermal systems is achieved through the application of the governing conservation equations, namely *Conservation of Mass*, *Conservation of Energy* (1st law of thermodynamics), the 2nd law of thermodynamics and the property relations. Energy can be viewed as the ability to cause changes.

<u>First law of thermodynamics:</u> one of the most fundamental laws of nature is the conservation of energy principle. It simply states that during an interaction, energy can change from one form to another but the total amount of energy remains constant.

<u>Second law of thermodynamics:</u> energy has quality as well as quantity, and actual processes occur in the direction of decreasing quality of energy.

Whenever there is an interaction between energy and matter, thermodynamics is involved. Some examples include heating and air-conditioning systems, refrigerators, water heaters, etc.

Example 1: Unit Conversion

The heat dissipation rate density of an electronic device is reported as 10.72 mW/mm^2 by the manufacturer. Convert this to W/m^2.

$$10.72\frac{mW}{mm^2}\times\left(\frac{1000mm}{1m}\right)^2\times\frac{1W}{1000mW}=10720\frac{W}{m^2}$$

Closed and Open Systems

A *system* is defined as a quantity of matter or a region in space chosen for study. The mass or region outside the system is called the *surroundings*.

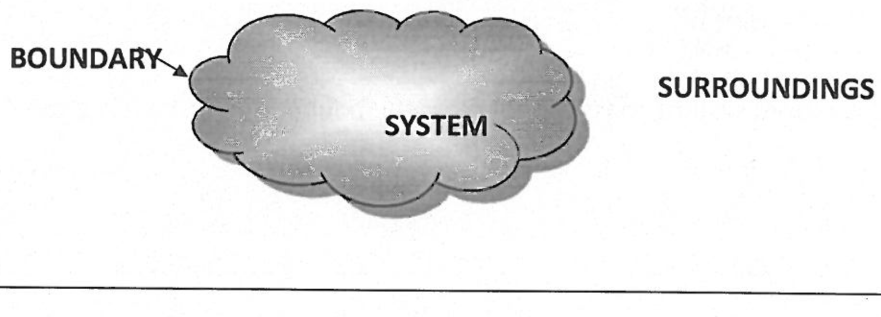


Fig. 1: System, surroundings, and boundary

Boundary: the real or imaginary surface that separates the system from its surroundings. The boundaries of a system can be fixed or movable. Mathematically, the boundary has zero thickness, no mass, and no volume.

Closed system or control mass: consists of a fixed amount of mass, and no mass can cross its boundary. But, energy in the form of heat or work, can cross the boundary, and the volume of a closed system does not have to be fixed.

Open system or control volume: is a properly selected region in space. It usually encloses a device that involves mass flow such as a compressor. Both mass and energy can cross the boundary of a control volume.

Important note: some thermodynamics relations that are applicable to closed and open systems are different. Thus, it is extremely important to recognize the type of system we have before start analyzing it.

Isolated system: A closed system that does not communicate with the surroundings by any means.

Rigid system: A closed system that communicates with the surroundings by heat only.

Adiabatic system: A closed or open system that does not exchange energy with the surroundings by heat.

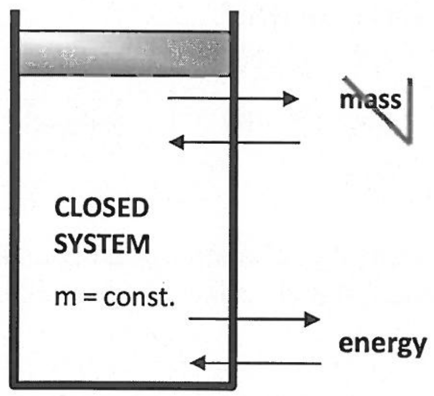


Fig. 2: Closed system, mass cannot cross the boundaries, but energy can.

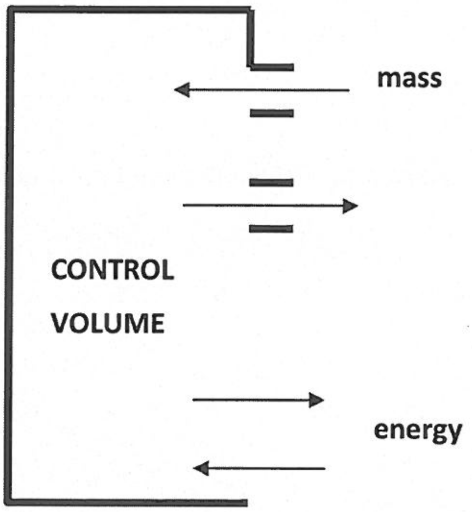


Fig. 3: Control volume, both mass and energy can cross the boundaries.

Energy

In thermodynamics, we deal with change of the total energy only. Thus, the total energy of a system can be assigned a value of zero at some reference point. Total energy of a system has two groups: *macroscopic* and *microscopic*.

Macroscopic forms of energy: forms of energy that a system posses as a whole with respect to some outside reference frame, such as kinetic and potential energy. The macroscopic energy of a system is related to motion and the influence of some external effects such as gravity, magnetism, electricity, and surface tension.

- Kinetic energy: energy that a system posses as a result of its relative motion relative to some reference frame, KE

$$KE = \frac{mV^2}{2} \qquad (kJ)$$

where V is the velocity of the system in (m/s).

- Potential energy: is the energy that a system posses as a result of its elevation in a gravitational field, PE

$$PE = mgz \qquad (kJ)$$

where g is the gravitational acceleration and z is the elevation of the center of gravity of the system relative to some arbitrary reference plane.

Microscopic forms of energy: are those related to molecular structure of a system. They are independent of outside reference frames. The sum of microscopic energy is called the *internal energy, U.*

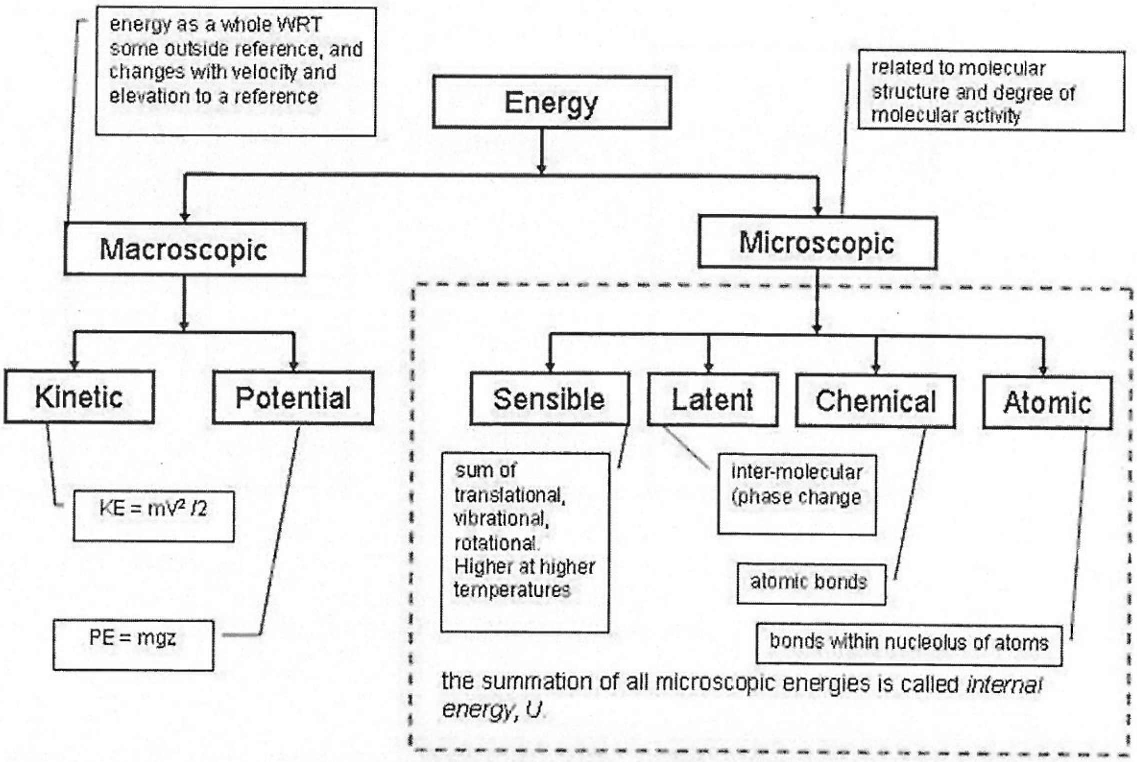
The total energy of a system consists of the kinetic, potential, and internal energies:

$$E = U + KE + PE = U + \frac{mV^2}{2} + mgz \qquad (kJ)$$

where the contributions of magnetic, electric, nuclear energy are neglected. Internal energy is related to the molecular structure and the degree of molecular activity and it may be viewed as the sum of the kinetic and potential energies of molecules.

- The sum of translational, vibrational, and rotational energies of molecules is the kinetic energy of molecules, and it is also called the *sensible energy.* At higher temperatures, system will have higher sensible energy.
- Internal energy associated with the phase of a system is called *latent heat*. The intermolecular forces are strongest in solids and weakest in gases.
- The internal energy associated with the atomic bonds in a molecule is called *chemical* or *bond energy*. The tremendous amount of energy associated with the bonds within the nucleolus of atom itself is called *atomic energy*.

Energy interactions with a closed system can occur via *heat transfer* and *work*.



$$E = U + KE + PE \qquad (kJ)$$

Fig. 1-4: Forms of energy.

Properties of a System

Any characteristic of a system is called a *property*. In classical thermodynamics, the substance is assumed to be a *continuum*, homogenous matter with no microscopic holes. This assumption holds as long as the volumes, and length scales are large with respect to the intermolecular spacing.

Intensive properties: are those that are independent of the size (mass) of a system, such as temperature, pressure, and density. They are not additive.

Extensive properties: values that are dependant on size of the system such as mass, volume, and total energy U. They are additive.

- Generally, uppercase letters are used to denote extensive properties (except mass m), and lower case letters are used for intensive properties (except pressure P, temperature T).
- Extensive properties per unit mass are called specific properties, e.g. specific volume (v=V/m).

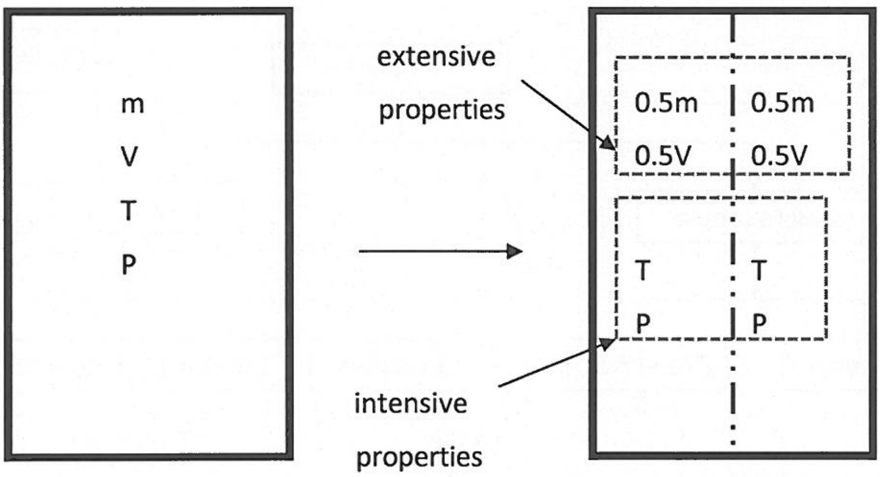


Fig. 1-5: Intensive and extensive properties of a system.

State and Equilibrium

At a given *state*, all the properties of a system have fixed values. Thus, if the value of even one property changes, the state will change to different one.

In an equilibrium state, there are no unbalanced potentials (or driving forces) within the system. A system in equilibrium experiences no changes when it is isolated from its surroundings.

- Thermal equilibrium: when the temperature is the same throughout the entire system.

L2

- Mechanical equilibrium: when there is no change in pressure at any point of the system. However, the pressure may vary within the system due to gravitational effects.
- Phase equilibrium: in a two phase system, when the mass of each phase reaches an equilibrium level.
- Chemical equilibrium: when the chemical composition of a system does not change with time, i.e., no chemical reactions occur.

Processes and Cycles

Any change a system undergoes from one equilibrium state to another is called a *process,* and the series of states through which a system passes during a process is called a *path.*

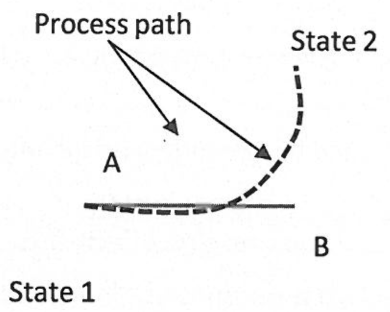


Fig. 6: To specify a process, initial and final states and path must be specified.

Quasi-equilibrium process: can be viewed as a sufficiently slow process that allows the system to adjust itself internally and remains infinitesimally close to an equilibrium state at all times. Quasi-equilibrium process is an idealized process and is not a true representation of the actual process. We model actual processes with quasi-equilibrium ones. Moreover, they serve as standards to which actual processes can be compared.

Process diagrams are used to visualize processes. Note that the process path indicates a series of equilibrium states, and we are not able to specify the states for a non-quasi-equilibrium process.

Prefix *iso-* is used to designate a process for which a particular property is constant.

- Isothermal: is a process during which the temperature remains constant
- Isobaric: is a process during which the pressure remains constant
- Isometric: is process during which the specific volume remains constant.

A system is said to have undergone a *cycle* if it returns to its initial state at the end of the process.

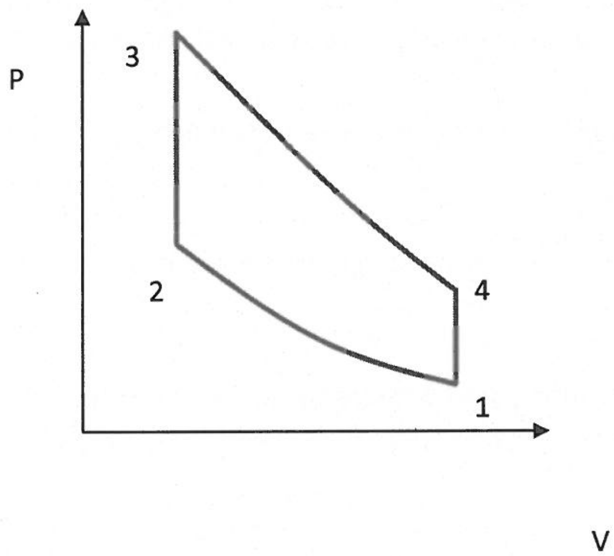


Fig. 1-7: A four-process cycle in a P-V diagram.

The state of a system is described by its properties. The state of a *simple compressible system* is completely specified by two *independent*, intensive properties.

A system is called <u>simple compressible system</u> in the absence of electrical, magnetic, gravitational, motion, and surface tension effects (external force fields).

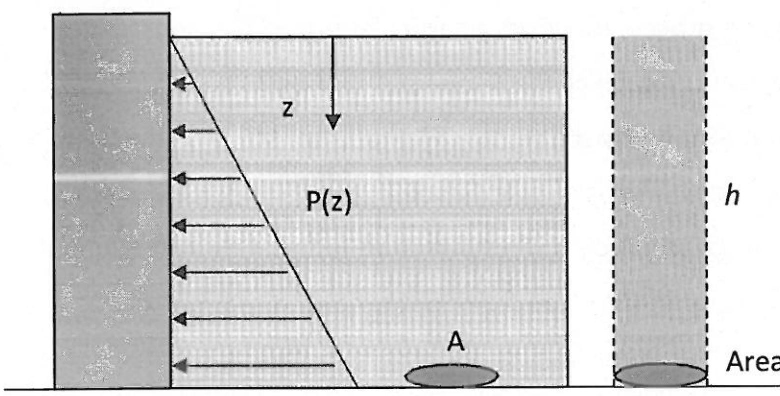
<u>Independent properties</u>: two properties are independent if one property can be varied while the other one is held constant.

Pressure

Pressure is the force exerted by a fluid per unit area.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \qquad \frac{N}{m^2} \equiv Pa$$

In fluids, gases and liquids, we speak of *pressure*; in solids this is *stress*. For a fluid at rest, the pressure at a given point is the same in all directions.



$$P = \frac{\text{Weight of liquid}}{\text{Area}}$$

$$P = \frac{mg}{A} = \frac{\rho A h g}{A}$$

$$P = \rho g h$$

Fig. 8: Pressure of a fluid at rest increases with depth (due to added weight), but constant in horizontal planes.

The actual pressure at a given position is called the *absolute pressure*, and it is measured relative to absolute vacuum.

gauge pressure = absolute pressure - atmospheric pressure

$$P_{gauge} = P_{abs} - \quad P >$$
$$P_{atm} P_{vac} = \quad P_{atm} P <$$
$$P_{atm} - P_{abs} \quad P_{atm}$$

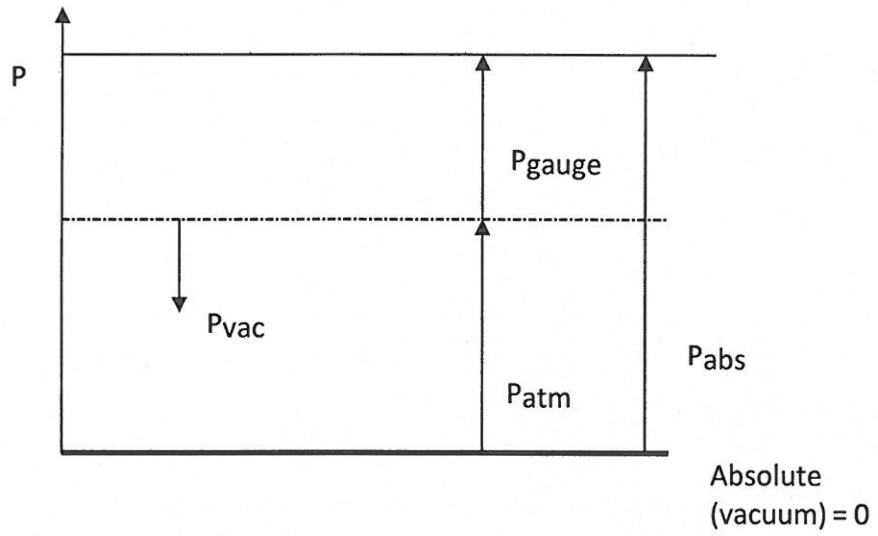


Fig. 9: Absolute, gauge, and vacuum pressures.

In thermodynamics calculations, always use absolute pressure. Most pressure measuring devices are calibrated to read zero in the atmosphere (they measure P_{gauge} or P_{vac}). Be aware of what you are reading!

A device that measures pressure using a column of liquid is called a *Manometer.* The cross sectional area of the tube is not important. The manometer measures the gauge pressure.

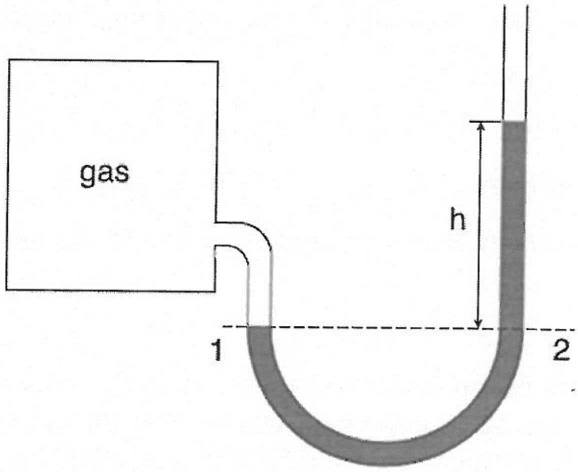


Fig. 10: Basic manometer, $P_2=P_1$.

$$P_1 = P_{atm} + \rho g h \qquad (kPa)$$

Bourdon Tube is a device that measures pressure using mechanical deformation. *Pressure Transducers* are devices that use piezoelectrics to measure pressure.

- very accurate and robust
- can measure from 10^{-6} to 10^{5} atm
- can measure P_{gauge} or P_{abs}

Barometer is a device that measures atmospheric pressure. It is a manometer with a near vacuum on one end

Example 2: Pressure

The piston of a cylinder-piston device has a mass of 60 kg and a cross-sectional area of 0.04 m^2, as shown in Fig. 12. The depth of the liquid in the cylinder is 1.8 m and has a density of 1558 kg/m^3. The local atmospheric pressure is 0.97 bar, and the gravitational acceleration is 9.8 m/s^2. Determine the pressure at the bottom of the cylinder.

Solution: the pressure at the bottom of the cylinder can be found from the summation of the forces due to atmospheric pressure, piston weight, and the weight of the liquid in the cylinder.

$$W_{bottom} = P_{atm} A + W_{liquid} + W_{Piston}$$

$$P_{bottom} = P_{atm} + \frac{mg}{A} + \rho g h$$

L3

=

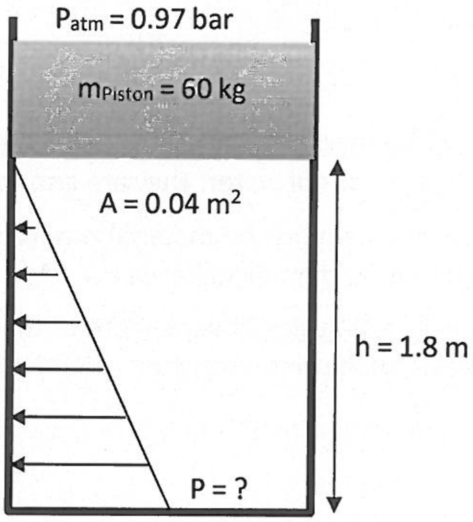


Fig. 12: Sketch for example 2.

Temperature

Temperature is a pointer for the direction of energy transfer as heat.

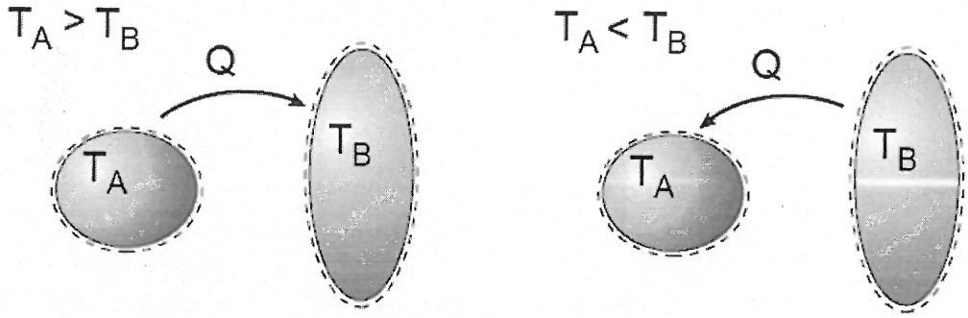


Fig. 13: Heat transfer occurs in the direction of higher-to-lower-temperature.

When the temperatures of two bodies are the same, *thermal equilibrium* is reached. The equality of temperature is the only requirement for thermal equilibrium.

The 0th law of thermodynamics: states that if two bodies are in thermal equilibrium with a third body, they are also in thermal equilibrium with each other.

The 0th law makes a thermometer possible.

In accordance with the 0th law, any system that possesses an equation of state that relates temperature T to other accurately measurable properties can be used as a thermometer e.g. an ideal gas obeys the equation of state:

$$T = \frac{PV}{mR}$$

Experimentally obtained Temperature Scales: the *Celsius* and *Fahrenheit* scales, are based on the melting and boiling points of water. They are also called two-point scales.

Conventional thermometry depends on material properties e.g. mercury expands with temperature in a repeatable and predictable way

Thermodynamic Temperature Scales (independent of the material), the Kelvin and Rankine scales, are determined using a constant volume gas thermometer.

CHAPTER 1
INTRODUCTION AND BASIC CONCEPTS

Objectives

- 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.
- Review the metric SI and the English unit systems.
- Explain the basic concepts of thermodynamics such as system, state, state postulate, equilibrium, process, and cycle.
- Review concepts of temperature, temperature scales, pressure, and absolute and gage pressure.
- Introduce an intuitive systematic problem-solving technique.

2

THERMODYNAMICS AND ENERGY

- **Thermodynamics:** The science of *energy*.
- **Energy:** The ability to cause changes.
- The name *thermodynamics* stems from the Greek words *therme* (heat) and *dynamis* (power).
- **Conservation of energy principle:** During an interaction, energy can change from one form to another but the total amount of energy remains constant.
- Energy cannot be created or destroyed.
- **The first law of thermodynamics:** An expression of the conservation of energy principle.
- The first law asserts that *energy* is a thermodynamic property.

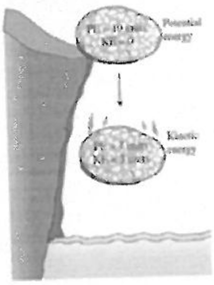


FIGURE 1–1
Energy cannot be created or destroyed; it can only change forms (the first law).

- **The second law of thermodynamics:** It asserts that energy has *quality* as well as *quantity*, and actual processes occur in the direction of decreasing quality of energy.
- **Classical thermodynamics:** A macroscopic approach to the study of thermodynamics that does not require a knowledge of the behavior of individual particles.
- It provides a direct and easy way to the solution of engineering problems and it is used in this text.
- **Statistical thermodynamics:** A microscopic approach, based on the average behavior of large groups of individual particles.
- It is used in this text only in the supporting role.

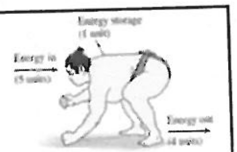


FIGURE 1–2
Conservation of energy principle for the human body.

FIGURE 1–3
Heat flows in the direction of decreasing temperature.

Application Areas of Thermodynamics

FIGURE 1–4
The design of many engineering systems, such as this solar hot water system, involves thermodynamics.

Refrigerator

Boats

Aircraft and spacecraft

Power plants

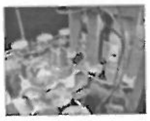
All activities in nature involve some interaction between energy and matter; thus, it is hard to imagine an area that does not relate to thermodynamics in some manner.

5

Human body

Cars

Wind turbines



Food processing

A piping network in an industrial facility.

6

IMPORTANCE OF DIMENSIONS AND UNITS

- Any physical quantity can be characterized by **dimensions.**
- The magnitudes assigned to the dimensions are called **units.**
- Some basic dimensions such as mass *m*, length *L*, time *t*, and temperature *T* are selected as **primary or fundamental dimensions,** while others such as velocity *V*, energy *E*, and volume *V* are expressed in terms of the primary dimensions and are called **secondary dimensions,** or **derived dimensions.**
- **Metric SI system:** A simple and logical system based on a decimal relationship between the various units.
- **English system:** It has no apparent systematic numerical base, and various units in this system are related to each other rather arbitrarily.

7

TABLE 1–1
The seven fundamental (or primary) dimensions and their units in SI

Dimension	Unit
Length	meter (m)
Mass	kilogram (kg)
Time	second (s)
Temperature	kelvin (K)
Electric current	ampere (A)
Amount of light	candela (cd)
Amount of matter	mole (mol)

TABLE 1–2
Standard prefixes in SI units

Multiple	Prefix
10^{24}	yotta, Y
10^{21}	zetta, Z
10^{18}	exa, E
10^{15}	peta, P
10^{12}	tera, T
10^{9}	giga, G
10^{6}	mega, M
10^{3}	kilo, k
10^{2}	hecto, h
10^{1}	deka, da
10^{-1}	deci, d
10^{-2}	centi, c
10^{-3}	milli, m
10^{-6}	micro, μ
10^{-9}	nano, n
10^{-12}	pico, p
10^{-15}	femto, f
10^{-18}	atto, a
10^{-21}	zepto, z
10^{-24}	yocto, y

8

Some SI and English Units

1 lbm = 0.45359 kg

1 ft = 0.3048 m

Force = (Mass) (Acceleration)

$$F = ma$$

$$1\ \text{N} = 1\ \text{kg}\cdot\text{m/s}^2$$

$$1\ \text{lbf} = 32.174\ \text{lbm}\cdot\text{ft/s}^2$$

Work = Force × Distance
1 J = 1 N·m
1 cal = 4.1868 J
1 Btu = 1.0551 kJ

FIGURE 1–6
The SI unit prefixes are used in all branches of engineering.

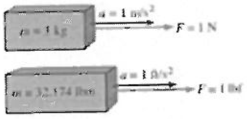


FIGURE 1–7
The definition of the force units.

9

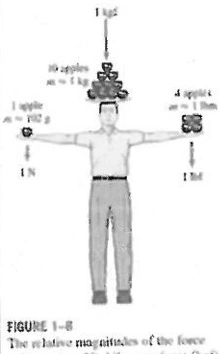


FIGURE 1–8
The relative magnitudes of the force units newton (N), kilogram-force (kgf), and pound-force (lbf).

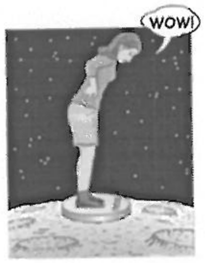


FIGURE 1–9
A body weighing 150 lbf on earth will weigh only 25 lbf on the moon.

$W = mg$ (N)

W weight
m mass
g gravitational acceleration

10

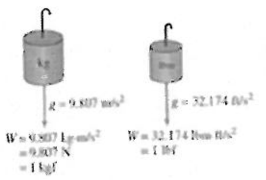


FIGURE 1–10
The weight of a unit mass at sea level.

Specific weight γ: The weight of a unit volume of a substance.

$$\gamma = \rho g$$

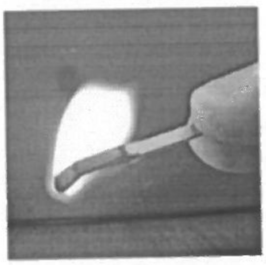


FIGURE 1–11
A typical match yields about one Btu (or one kJ) of energy if completely burned.

11

Dimensional homogeneity

All equations must be dimensionally **homogeneous.**

Unity Conversion Ratios

All nonprimary units (secondary units) can be formed by combinations of primary units.
Force units, for example, can be expressed as

$$\text{N} = \text{kg}\,\frac{\text{m}}{\text{s}^2} \quad \text{and} \quad \text{lbf} = 32.174\ \text{lbm}\,\frac{\text{ft}}{\text{s}^2}$$

They can also be expressed more conveniently as unity conversion ratios as

$$\frac{\text{N}}{\text{kg}\cdot\text{m/s}^2} = 1 \quad \text{and} \quad \frac{\text{lbf}}{32.174\ \text{lbm}\cdot\text{ft/s}^2} = 1$$

Unity conversion ratios are identically equal to 1 and are unitless, and thus such ratios (or their inverses) can be inserted conveniently into any calculation to properly convert units.

12

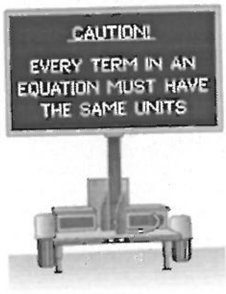


FIGURE 1–14
Always check the units in your calculations.

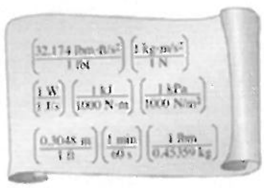


FIGURE 1–15
Every unity conversion ratio (as well as its inverse) is exactly equal to one. Shown here are a few commonly used unity conversion ratios.

13

FIGURE 1–16
A mass of 1 lbm weighs 1 lbf on earth.

$$W = mg = (453.6\ \text{g})(9.81\ \text{m/s}^2)\left(\frac{1\ \text{N}}{1\ \text{kg·m/s}^2}\right)\left(\frac{1\ \text{kg}}{1000\ \text{g}}\right) = 4.49\ \text{N}$$

FIGURE 1–17
A quirk in the metric system of units.

SYSTEMS AND CONTROL VOLUMES

- **System:** A quantity of matter or a region in space chosen for study.
- **Surroundings:** The mass or region outside the system
- **Boundary:** The real or imaginary surface that separates the system from its surroundings.
- The boundary of a system can be *fixed* or *movable.*
- Systems may be considered to be *closed* or *open.*
- **Closed system (Control mass):** A fixed amount of mass, and no mass can cross its boundary

15

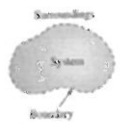


FIGURE 1–18
System, surroundings, and boundary.

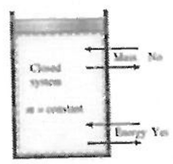


FIGURE 1–19
Mass cannot cross the boundaries of a closed system, but energy can.

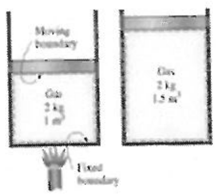


FIGURE 1–20
A closed system with a moving boundary.

16

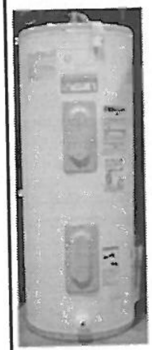
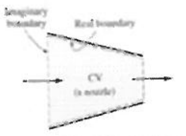


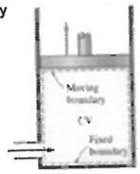
FIGURE 1–22
An open system (a control volume) with one inlet and one exit.

- ***Open system (control volume)***: A properly selected region in space.
- It usually encloses a device that involves mass flow such as a compressor, turbine, or nozzle.
- Both mass and energy can cross the boundary of a control volume.
- **Control surface**: The boundaries of a control volume. It can be real or imaginary.

A control volume can involve fixed, moving, real, and imaginary boundaries.



(a) A control volume (CV) with real and imaginary boundaries.



(b) A control volume (CV) with fixed and moving boundaries as well as real and imaginary boundaries.

PROPERTIES OF A SYSTEM

- **Property:** Any characteristic of a system.
- Some familiar properties are pressure P, temperature T, volume V, and mass m.
- Properties are considered to be either *intensive* or *extensive*.
- **Intensive properties:** Those that are independent of the mass of a system, such as temperature, pressure, and density.
- **Extensive properties:** Those whose values depend on the size—or extent—of the system.
- **Specific properties:** Extensive properties per unit mass.

$(v = V/m) \qquad (e = E/m)$

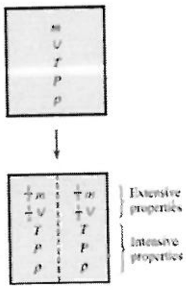


FIGURE 1–23
Criterion to differentiate intensive and extensive properties.

Continuum

- Matter is made up of atoms that are widely spaced in the gas phase. Yet it is very convenient to disregard the atomic nature of a substance and view it as a continuous, homogeneous matter with no holes, that is, a **continuum**.
- The continuum idealization allows us to treat properties as point functions and to assume the properties vary continually in space with no jump discontinuities.
- This idealization is valid as long as the size of the system we deal with is large relative to the space between the molecules.
- This is the case in practically all problems.
- In this text we will limit our consideration to substances that can be modeled as a continuum.

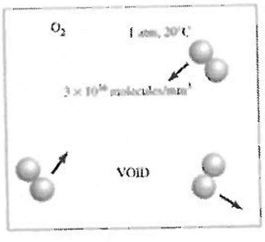


FIGURE 1–24
Despite the relatively large gaps between molecules, a gas can usually be treated as a continuum because of the very large number of molecules even in an extremely small volume.

19

DENSITY AND SPECIFIC GRAVITY

Density

$$\rho = \frac{m}{V} \qquad (\mathrm{kg/m^3})$$

Specific volume

$$v = \frac{V}{m} = \frac{1}{\rho}$$

Specific gravity: The ratio of the density of a substance to the density of some standard substance at a specified temperature (usually water at 4°C).

$$SG = \frac{\rho}{\rho_{H_2O}}$$

Specific weight: The weight of a unit volume of a substance.

$$\gamma_s = \rho g \qquad (\mathrm{N/m^3})$$

Density is mass per unit volume; specific volume is volume per unit mass.

TABLE 1–3
Specific gravities of some substances at 0°C

Substance	SG
Water	1.0
Blood	1.05
Seawater	1.025
Gasoline	0.7
Ethyl alcohol	0.79
Mercury	13.6
Wood	0.3–0.9
Gold	19.2
Bones	1.7–2.0
Ice	0.92
Air (at 1 atm)	0.0013

STATE AND EQUILIBRIUM

- Thermodynamics deals with *equilibrium* states.
- **Equilibrium:** A state of balance.
- In an equilibrium state there are no unbalanced potentials (or driving forces) within the system.
- **Thermal equilibrium:** If the temperature is the same throughout the entire system.
- **Mechanical equilibrium:** If there is no change in pressure at any point of the system with time.
- **Phase equilibrium:** If a system involves two phases and when the mass of each phase reaches an equilibrium level and stays there.
- **Chemical equilibrium:** If the chemical composition of a system does not change with time, that is, no chemical reactions occur.

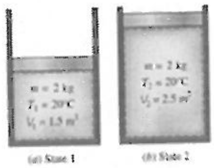


FIGURE 1–26
A system at two different states.

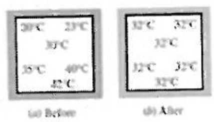


FIGURE 1–27
A closed system reaching thermal equilibrium.

The State Postulate

- The number of properties required to fix the state of a system is given by the **state postulate**:
  - ✓ *The state of a simple compressible system is completely specified by two independent, intensive properties.*
- **Simple compressible system:** If a system involves no electrical, magnetic, gravitational, motion, and surface tension effects.

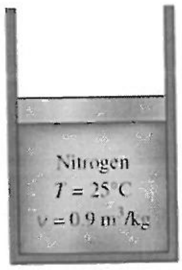


FIGURE 1–28
The state of nitrogen is fixed by two independent, intensive properties.

PROCESSES AND CYCLES

Process: Any change that a system undergoes from one equilibrium state to another.

Path: The series of states through which a system passes during a process.

To describe a process completely, one should specify the initial and final states, as well as the path it follows, and the interactions with the surroundings.

Quasistatic or quasi-equilibrium process: When a process proceeds in such a manner that the system remains infinitesimally close to an equilibrium state at all times.

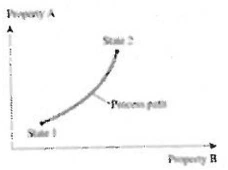


FIGURE 1–29
A process between states 1 and 2 and the process path.

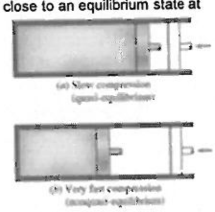


FIGURE 1–30
Quasi-equilibrium and nonquasi-equilibrium compression processes.

- Process diagrams plotted by employing thermodynamic properties as coordinates are very useful in visualizing the processes.
- Some common properties that are used as coordinates are temperature *T*, pressure *P*, and volume *V* (or specific volume *v*).
- The prefix *iso-* is often used to designate a process for which a particularproperty remains constant.
- **Isothermal process:** A process during which the temperature *T* remains constant.
- **Isobaric process:** A process during which the pressure *P* remains constant.
- **Isochoric (or isometric) process:** A process during which the specific volume *v* remains constant.
- **Cycle:** A process during which the initial and final states are identical.

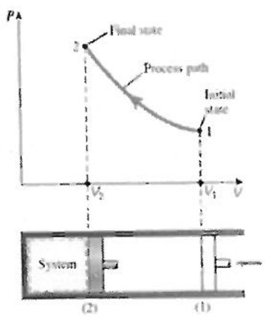


FIGURE 1–31
The *P-V* diagram of a compression process.

24

The Steady-Flow Process

- The term *steady* implies *no change with time*. The opposite of steady is *unsteady*, or *transient*.
- A large number of engineering devices operate for long periods of time under the same conditions, and they are classified as *steady-flow devices*.
- **Steady-flow process**: A process during which a fluid flows through a control volume steadily.
- Steady-flow conditions can be closely approximated by devices that are intended for continuous operation such as turbines, pumps, boilers, condensers, and heat exchangers or power plants or refrigeration systems.

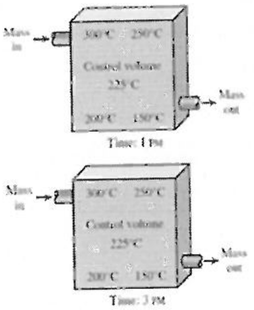


FIGURE 1–32
During a steady-flow process, fluid properties within the control volume may change with position but not with time.

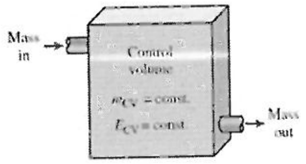


FIGURE 1–33
Under steady-flow conditions, the mass and energy contents of a control volume remain constant.

26

TEMPERATURE AND THE ZEROTH LAW OF THERMODYNAMICS

- **The zeroth law of thermodynamics:** If two bodies are in thermal equilibrium with a third body, they are also in thermal equilibrium with each other.
- By replacing the third body with a thermometer, the zeroth law can be restated as *two bodies are in thermal equilibrium if both have the same temperature reading even if they are not in contact.*

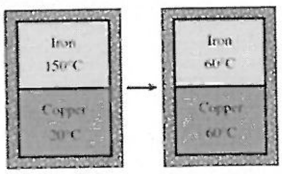


FIGURE 1–34
Two bodies reaching thermal equilibrium after being brought into contact in an isolated enclosure.

27

Temperature Scales

- All temperature scales are based on some easily reproducible states such as the freezing and boiling points of water: the *ice point* and the *steam point.*
- **Ice point:** A mixture of ice and water that is in equilibrium with air saturated with vapor at 1 atm pressure (0°C or 32°F).
- **Steam point:** A mixture of liquid water and water vapor (with no air) in equilibrium at 1 atm pressure (100°C or 212°F).
- **Celsius scale:** in SI unit system
- **Fahrenheit scale:** in English unit system
- **Thermodynamic temperature scale:** A temperature scale that is independent of the properties of any substance.
- **Kelvin scale** (SI) **Rankine scale** (E)
- A temperature scale nearly identical to the Kelvin scale is the **ideal-gas temperature scale.** The temperatures on this scale are measured using a constant-volume gas thermometer.

28

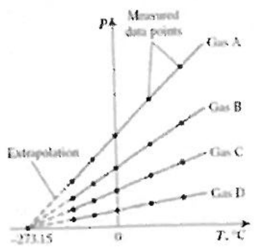


FIGURE 1–35
P versus *T* plots of the experimental data obtained from a constant-volume gas thermometer using four different gases at different (but low) pressures.

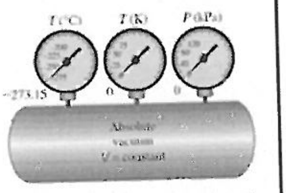
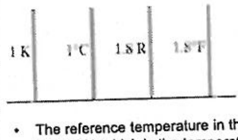


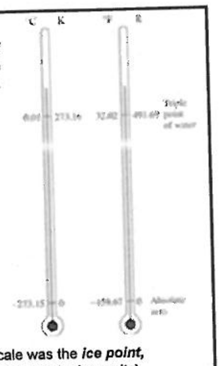
FIGURE 1–36
A constant-volume gas thermometer would read −273.15°C at absolute zero pressure.

29

$$T(\text{K}) = T(^\circ\text{C}) + 273.15$$
$$T(\text{R}) = T(^\circ\text{F}) + 459.67$$
$$T(\text{R}) = 1.8T(\text{K})$$
$$T(^\circ\text{F}) = 1.8T(^\circ\text{C}) + 32$$
$$\Delta T(\text{K}) = \Delta T(^\circ\text{C})$$
$$\Delta T(\text{R}) = \Delta T(^\circ\text{F})$$



Comparison of magnitudes of various temperature units.



Comparison of temperature scales.

- The reference temperature in the original Kelvin scale was the ***ice point***, 273.15 K, which is the temperature at which water freezes (or ice melts).
- The reference point was changed to a much more precisely reproducible point, the ***triple point*** of water (the state at which all three phases of water coexist in equilibrium), which is assigned the value 273.16 K.

30

The International Temperature Scale of 1990 (ITS-90)

The *International Temperature Scale of 1990* supersedes the International Practical Temperature Scale of 1968 (IPTS-68), 1948 (ITPS-48), and 1927 (ITS-27).

The ITS-90 is similar to its predecessors except that it is more refined with updated values of fixed temperatures, has an extended range, and conforms more closely to the thermodynamic temperature scale.

On this scale, the unit of thermodynamic temperature *T* is again the kelvin (K), defined as the fraction 1/273.16 of the thermodynamic temperature of the triple point of water, which is sole defining fixed point of both the ITS-90 and the Kelvin scale and is the most important thermometric fixed point used in the calibration of thermometers to ITS-90. The unit of Celsius temperature is the degree Celsius (°C).

The ice point remains the same at 0°C (273.15 K) in both ITS-90 and ITPS-68, but the steam point is 99.975°C in ITS-90 whereas it was 100.000°C in IPTS-68.

The change is due to precise measurements made by gas thermometry by paying particular attention to the effect of sorption (the impurities in a gas absorbed by the walls of the bulb at the reference temperature being desorbed at higher temperatures, causing the measured gas pressure to increase).

31

PRESSURE

Pressure: A normal force exerted by a fluid per unit area

$$1 \text{ Pa} = 1 \text{ N/m}^2$$

$$1 \text{ bar} = 10^5 \text{ Pa} = 0.1 \text{ MPa} = 100 \text{ kPa}$$
$$1 \text{ atm} = 101{,}325 \text{ Pa} = 101.325 \text{ kPa} = 1.01325 \text{ bars}$$
$$1 \text{ kgf/cm}^2 = 9.807 \text{ N/cm}^2 = 9.807 \times 10^4 \text{ N/m}^2 = 9.807 \times 10^4 \text{ Pa}$$
$$= 0.9807 \text{ bar}$$
$$= 0.9679 \text{ atm}$$

Some basic pressure gages.

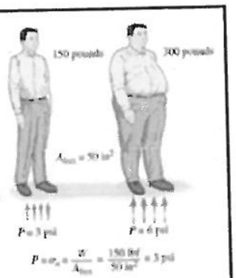


FIGURE 1–39
The normal stress (or "pressure") on the feet of a chubby person is much greater than on the feet of a slim person.

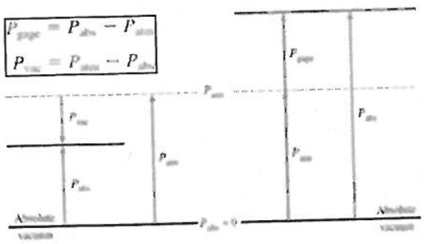
32

- **Absolute pressure:** The actual pressure at a given position. It is measured relative to absolute vacuum (i.e., absolute zero pressure).
- **Gage pressure:** The difference between the absolute pressure and the local atmospheric pressure. Most pressure-measuring devices are calibrated to read zero in the atmosphere, and so they indicate gage pressure.
- **Vacuum pressures:** Pressures below atmospheric pressure.

Throughout this text, the pressure *P* will denote ***absolute pressure*** unless specified otherwise.

$$P_{gage} = P_{abs} - P_{atm}$$

$$P_{vac} = P_{atm} - P_{abs}$$



Variation of Pressure with Depth

$$\Delta P = P_2 - P_1 = \rho g \, \Delta z = \gamma_s \, \Delta z$$

$$P = P_{atm} + \rho g h \quad \text{or} \quad P_{gage} = \rho g h$$

When the variation of density with elevation is known

$$\Delta P = P_2 - P_1 = -\int_1^2 \rho g \, dz$$

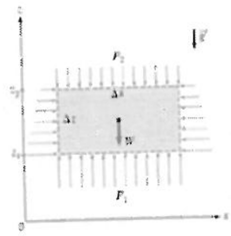


FIGURE 1–43
Free-body diagram of a rectangular fluid element in equilibrium.

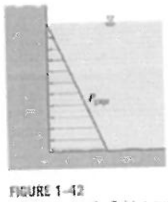


FIGURE 1–42
The pressure of a fluid at rest increases with depth (as a result of added weight).

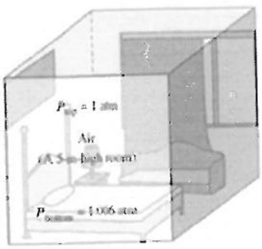


FIGURE 1–44
In a room filled with a gas, the variation of pressure with height is negligible.

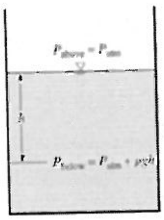


FIGURE 1–45
Pressure in a liquid at rest increases linearly with distance from the free surface.

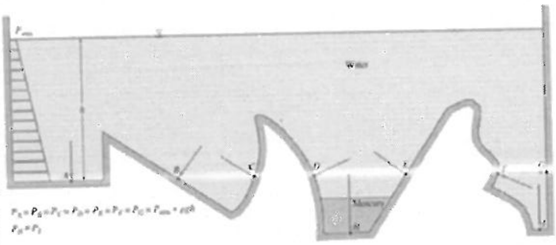


FIGURE 1–46
Under hydrostatic conditions, the pressure is the same at all points on a horizontal plane in a given fluid regardless of geometry, provided that the points are interconnected by the same fluid.

Pascal's law: The pressure applied to a confined fluid increases the pressure throughout by the same amount.

$P_1 = P_2 \rightarrow \frac{F_1}{A_1} = \frac{F_2}{A_2} \rightarrow \frac{F_2}{F_1} = \frac{A_2}{A_1}$

The area ratio A_2/A_1 is called the *ideal mechanical advantage* of the hydraulic lift.

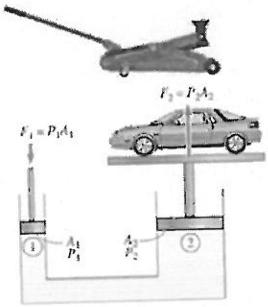


FIGURE 1–47
Lifting of a large weight by a small force by the application of Pascal's law. A common example is a hydraulic jack.

PRESSURE MEASUREMENT DEVICES

The Barometer

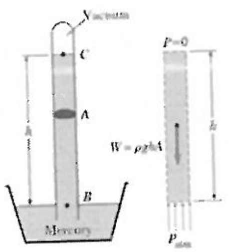


FIGURE 1–48
The basic barometer.

$P_{atm} = \rho g h$

- Atmospheric pressure is measured by a device called a **barometer**; thus, the atmospheric pressure is often referred to as the ***barometric pressure***.
- A frequently used pressure unit is the *standard atmosphere*, which is defined as the pressure produced by a column of mercury 760 mm in height at 0°C (ρ_{Hg} = 13,595 kg/m^3) under standard gravitational acceleration (g = 9.807 m/s^2).

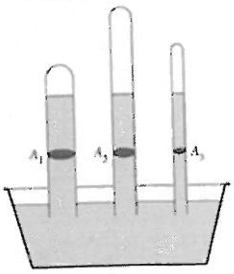


FIGURE 1–49
The length or the cross-sectional area of the tube has no effect on the height of the fluid column of a barometer, provided that the tube diameter is large enough to avoid surface tension (capillary) effects.

FIGURE 1–50
At high altitudes, a car engine generates less power and a person gets less oxygen because of the lower density of air.

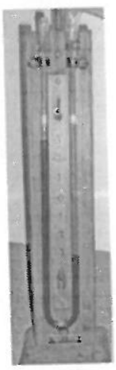
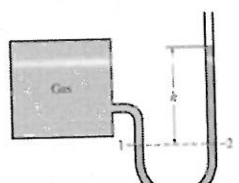


FIGURE 1–54
A simple U-tube manometer, with high pressure applied to the right side.

The Manometer

It is commonly used to measure small and moderate pressure differences. A manometer contains one or more fluids such as mercury, water, alcohol, or oil.



$P_2 = P_{atm} + \rho g h$

FIGURE 1–55
The basic manometer.

L24

PROPERTIES OF GASES AND GAS MIXTURES

Dr Sharad D. Patil
Associate Professor,
Department of Mechanical Engineering,
Rajarambapu Institute of Technology

COURSE OUTCOMES

- Explain different laws associated with gas and gas mixtures
- Define the quantities used to describe the composition of a mixture, such as mass fraction, mole fraction and a volume fraction.
- Derive state, Vander Waal's, Clausius Clapeyron equation

INTRODUCTION

Gases have a number of properties that are very different from liquids and solids:

1) Gases are compressible
2) Gases exert a pressure
3) Gas pressure depends on the amount of confined gas
4) Gases fill their container
5) Gases mix freely with each other
6) Gas pressure increases with temperature

- The properties of a gas mixture obviously depend on the properties of the individual gases (called components or constituents) as well as on the amount of each gas in the mixture

Gas Laws

Boyle's Law :

$$P_1V_1 = P_2V_2 \quad (\text{when } T_1 = T_2)$$

Charles' Law :

$$V_1/T_1 = V_2/T_2 \quad (\text{when } P_1 = P_2)$$

Gay - Lussac's Law :

$$P_1/T_1 = P_2/T_2 \quad (\text{when } V_1 = V_2)$$

- The three gas laws are often used in a single equation called the combined gas law

$$\frac{PV}{T} = \text{constant} \quad \text{or} \quad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \quad (\text{fixed amount})$$

- When using this equation the temperature must always be in kelvins

Example: What will be the final pressure of a sample of oxygen with a volume of 850 m³ at 6.55 bar and 25.0°C if it is heated to 80.0°C and given a final volume of 1066 m³?

ANALYSIS: Use the combined gas law with temperature in kelvins.

SOLUTION:

$$P_2 = P_1 \times \frac{V_1}{V_2} \times \frac{T_2}{T_1}$$

$$= 6.55 \times \frac{850\ \text{m}^3}{1066\ \text{m}^3} \times \frac{(80.0 + 273.2)\text{K}}{(25.0 + 273.2)\text{K}}$$

$$= 6.19\ \text{bar}$$

- **The law of combining volume states:**
  - When gases react at the same temperature and pressure, their combining volumes are in ratios of simple, whole numbers
  - Example:

hydrogen + chlorine → hydrogen chloride

1 volume   1 volume   2 volumes

- Amedeo Avogadro studied this and devised **Avogadro's principle:**
  - When measured at the same temperature and pressure, equals volumes of gases contain equal number of moles

---

- A corollary to Avogadro's principle is:
  - The volume of a gas is directly proportional to its number of moles, *n*

$$V \propto n \quad \text{(at constant } T \text{ and } P\text{)}$$

- Thus, the volume of one mole of any gas at standard temperature and pressure (STP) or 0°C and 1 atm is 22.4 L (a constant for all ideal gases)
- This is called the standard molar volume of a gas

- The combined gas law can be generalized to include changes in the number of moles of sample
- **The ideal gas law is**

n = number of moles

$$n = \frac{m}{M}$$

$$M = molecularweight$$

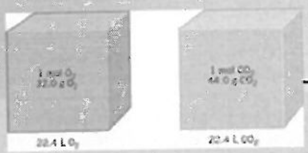
$$m = mass$$

$$PV = \frac{mRT}{M}$$

$$PV = mR_gT$$

- The molecular mass is obtained by taking the *ratio* of mass to moles, which could be determined using the ideal gas law
- Gas densities (*d*), a ratio of gas mass to volume, can be calculated by taking the ratio of the molar mass to molar volume
  - Example: The molar mass of oxygen is 32.0 g/mol. What is the density of oxygen at STP?

$$d_{O_2} = \frac{32.0 \text{ g/mol}}{22.4 \text{ L/mol}} = 1.42 \text{ g L}^{-1}$$



One mole of each gas occupies 22.4 at STP. Carbon dioxide is more dense than oxygen due to molar mass differences.

- We now need to consider mixtures of gases
- One useful way to describe a composition of a mixture is in terms of its *mole fractions*
- The **mole fraction** is the ratio of the number of moles of a given component to the total moles of all components

---

- For a mixture of *A*, *B*,... substances, the mole fraction of substance *i* (y_i) is

$$y_i = \frac{n_A}{n_A + n_B + ... + n_Z}, \quad n_i = \text{moles of } i$$

- This provides a convenient way to 'partition' the total pressure of a mixture of gases

Dalton's law of partial pressures:

It states: the total pressure of a mixture of gases is the sum of their individual partial pressures

Mole fraction

It is the ratio of the number of moles of a given component to the total moles of all components

- For a system of only gases, mole fractions and partial pressure partition the total pressure in the same fashion

$$P_{Total} = P_A + P_B + \dots$$
$$= P_{Total}y_A + P_{Total}y_B + \dots$$
$$1 = y_A + y_B + \dots$$

- Gases are often collected over water in the laboratory
- These (collected) gases are saturated with water

- The space above any liquid contains some of the liquid's vapor
- The pressure this vapor exerts is called the **vapor pressure**

As the gas bubbles through the water, water vapor gets into the gas so the total pressure inside the bottle includes the partial pressure of the water vapor

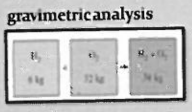
L 25

COMPOSITION OF A GAS MIXTURE

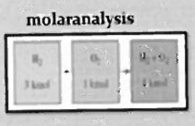
To determine the properties of a mixture, we need to know the *composition* of the mixture as well as the properties of the individual components.

There are two ways to describe the composition of a mixture: either by specifying the number of moles of each component, called **molar analysis,** or by specifying the mass of each component, called **gravimetric analysis.**

gravimetricanalysis



molaranalysis



MASS AND MOLE FRACTIONS

Mole fraction (molar analysis)

It is the ratio of the number of moles of a given component to the total moles of all components

$$y_i = \frac{n_A}{n_A + n_B + \dots + n_Z}, \quad n_i = \text{moles of } i$$

Mass fraction (Gravimetric analysis)

It is the ratio of the mass of the component to the mass of the mixture

$$m_f = \frac{m_A}{m_m},$$

Mass of substance (m)

It is expressed in terms of the mole number (n) and molar mass(M)

$$m = n \times M$$

Universal Gas constant (Ru) = **8.314 kJ/kg mol K**

Gas constant (R)

$$R = \frac{R_u}{M}$$

Molar mass of mixture can be expressed as:

$$M_m = \frac{m_m}{n_m} = \frac{\sum m_i}{n_m} = \frac{\sum n_i \times m_i}{n_m}$$

P-V-T BEHAVIOR OF GAS MIXTURES

- An ideal gas is defined as a gas whose molecules are spaced far apart so that the behavior of a molecule is not influenced by the presence of other molecules—a situation encountered at low densities.
- We also mentioned that real gases approximate this behavior closely when they are at a low pressure or high temperature relative to their critical-point values
- .

IDEAL AND REAL GASES

Ideal gas

The *P-v-T* behavior of an ideal gas is expressed by the simple relation

*(P*V=R*T)*

which is called the *ideal- gas equation of state*.

Real Gas

The P-v-T behavior of real gases is expressed by more complex equations of state or by (*P*V=Z*R*T*)

where Z is the compressibility actor

- When two or more ideal gases are mixed, the behavior of a molecule normally is not influenced by the presence of other similar or dissimilar molecules and therefore a nonreacting mixture of ideal gases also behaves as an ideal gas.
- When a gas mixture consists of real (nonideal) gases, however, the prediction of the *P-v-T* behavior of the mixture becomes rather involved.

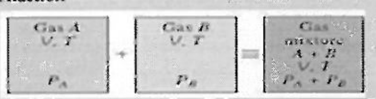
MIXTURES LAWS

- The prediction of the P-v-T behavior of gas mixtures is usually based on two models:

Dalton's law of additive pressures:

The pressure of a gas mixture is equal to the sum of the pressures each gas would exert if it existed alone at the mixture temperature and volume $P_{Total} = P_A + P_B + \ldots$

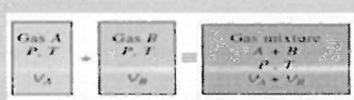
- $P_m = \sum_{i=1}^{k} P_i(T_m, V_m)$ P_i =componentpressure
- Note: thatequ exact for ideal gases, approximate for real gases
- $\frac{P_i}{P_m}$ = pressure fraction



- **Amagat's law of additive volumes:**

The volume of a gas mixture is equal to the sum of the volumes each gas would occupy if it existed alone at the mixture temperature and pressure

- $V_m = \sum_{i=1}^{k} V_i(T_m, P_m)$ V_i = componentvolume
- Note: thatequ exact for ideal gases, approximate for real gases
- $\frac{V_i}{V_m}$ = volume fraction



[illegible] a gas mixture that consists of 3 kg of O_2, 5 kg of [illegible] and 12 kg of [illegible] Determine (a) the mass fraction of each component, (b) the mole fraction of each component, and (c) the average molar mass and gas constant of the mixture.

Example

$$m = n \times M$$

$$n = \frac{m}{M}$$

$$m_{Total} = m_A + m_B + \ldots$$

$$n = \frac{mo2}{Mo2} = \frac{3}{32} = 0.094 kmol$$

$$m_{Total} = 3+5+12$$

$$n_{total} = 1.023 kmol$$

$$m_{fo2} = \frac{m_{O2}}{m_m} = \frac{3}{20} = 0.15$$

$$y_{O2} = \frac{n_{O2}}{n_{total}} = \frac{0.094}{1.023} = 0.092$$

L 26

IDEAL-GAS MIXTURES

- For ideal gases, *Pi and Vi can be related to mole fraction(y)* *by using the ideal-gas relation* for both the components and the gas mixture:

- *Dalton's law:* $\frac{P_i(T_m, V_m)}{P_m} = \frac{n_i R_u T_m / V_m}{n_m R_u T_m / V_m} = \frac{n_i}{n_m} = y_i$

- *Amagat's law:* $\frac{V_i(T_m, P_m)}{V_m} = \frac{n_i R_u T_m / P_m}{n_m R_u T_m / P_m} = \frac{n_i}{n_m} = y_i$

- Therefore, $\frac{P_i}{P_m} = \frac{V_i}{V_m} = \frac{n_i}{n_m} = y_i$

- And the quantity $P_i = y_i * P_m$ is called partial pressure
- The quantity $V_i = y_i * V_m$ is called partial volume

L 27

REAL-GAS MIXTURES

- Dalton's law of additive pressures and Amagat's law of additive volumes can also be used for real gases, often with reasonable accuracy but the component pressures or component volumes should be evaluated from relations that take into account the deviation of each component from ideal-gas behavior
- 1-Use ideal gas equation with compressibility factor (Z)

$$P * V = Z * N * R * T$$

- compressibility factor of mixture(Z_m) can expressed in terms of compressibility factor of the individual gas(Z_i) by applying

COMPRESSIBILITY FACTOR:

3.1

- At higher pressure and low temperatures, the intermolecular forces are significant due to which behavior of real gas deviates from that of ideal gas behavior. This deviation is significant at states near the saturation region and the critical point.
- Owing to this, ideal-gas equation of state is modified to fit real gas behavior by introducing a correction factor called as **compressibility factor**

$$\text{Compressibility factor } Z = \frac{pv}{RT} \text{ or } Z = \frac{V_{actual}}{V_{ideal}}$$

Where V ideal = RT/P

For an ideal gas, Z=1 and for a real gas, Z=f(p,T) which can be greater or less than 1. More the difference between Z of a real gas and 1, the deviation of gas is more from ideal gas behavior.

COMPRESSIBILITY FACTOR:

32

- It is well known fact that at high pressure or low temperature behavior of real gas deviates from that of ideal gas behavior.
- The term **high pressure** or **low temperature** differs from substance to substance. For example, -100ºC is a low temperature for most of the substances but not for air. Air (consisting mainly nitrogen) behaves closely as an ideal-gas this temperature and atmospheric pressure. This is because nitrogen is well above its critical temperature (-147ºC) and away from the saturation region.
- At this temperature and pressure, most substances exists in a solid phase. Hence, pressure or temperature of a substance is called high or low by relating it to its critical temperature or pressure.

POLL

- **Compressibility factor Z depends upon**
  - pressure of gas
  - temperature of gas
  - molecular interactions
  - mixture volume

REDUCED PROPERTIESAND LAW OF CORRESPONDING STATES:

34

- At normalized pressures and temperatures with respect to its critical pressure and temperature, all gases behave very much same.

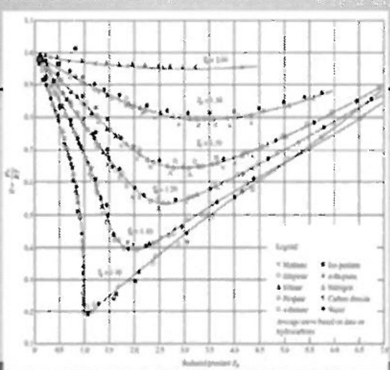
$$P_r = \frac{P}{P_{cr}} \text{ and } T_r = \frac{T}{T_{cr}}$$

Where Pr and Tr are reduced pressure and reduced temperature respectively.

- At the same reduced pressure and temperature, the compressibility factor for all gases is approximately same. This is called the **law of corresponding states**

COMPRESSIBILITY CHART:

35



COMPRESSIBILITY CHART:

36

Observations

-
-
- The deviation of a gas from ideal-gas behavior is greatest in the vicinity of the critical point.

When P and v or T and v are given instead of P and T, the compressibility chart can be used to determine the third property, involving tedious trial and error. Hence, one more property called **pseudo reduced specific volume** is defined

$$v_r = \frac{v_{actual}}{\frac{RT_{cr}}{P_{cr}}}$$

OTHER EQUATION OF STATE:

37

- Ideal-gas equation of state cannot be applied over a wide range, though it is very simple.
- Hence, it is vital to have equation of state that can accurately predict P-v-T behavior of substances accurately over a wide range with no limitations.
- These equations are complicated but gives accurate results over a wide range as compared to ideal-gas equation of state.
  - -van der Waals Equation of State
  - -Beattie-Bridgeman Equation of State
  - -Benedict, Webb-Rubin Equation of State
  - -Virial Equation of State
  - -Redlich-Kwong Equation of State

VAN DER WAALS EQUATION OF STATE:

38

- [illegible]

$$\left(P + \frac{a}{v^2}\right)(v - b) = RT$$

- Van der Waals equation of state considers two effects which were not considered in ideal-gas equation of state. The term a/v^2 accounts for intermolecular forces of attraction and b accounts for volume occupied by the gas molecules.
- The constants a and b are given by:

$$a = \frac{27R^2T_{cr}^2}{64P_{cr}} \text{ and } b = \frac{RT_{cr}}{8P_{cr}}$$

L28

GIBBS-DALTON LAW:

40

- [illegible] Dalton's law of partial pressures to calculate extensive properties of an ideal-gas mixture which is known as Gibbs-Dalton law.
- According to the Gibbs-Dalton law, the internal energy, enthalpy and specific heat of a gas mixture is equal to the sum of internal energies, enthalpies and specific heats of an individual components respectively each at mixture volume and mixture temperature

$$U_m = U_1 + U_2 + U_3 + \cdots + U_k$$
$$H_m = H_1 + H_2 + H_3 + \cdots + H_k$$
$$m_m C_v = m_1 Cv_1 + m_2 Cv_2 + m_3 Cv_3 + \cdots + m_k Cv_k$$

INTERNAL ENERGY OF A GAS MIXTURE:

41

- According to the Gibbs-Dalton law: [illegible]

SPECIFIC HEAT OF A GAS MIXTURE:

42

- According to the Gibbs-Dalton law: [illegible]

POLL

$$P_m = \sum_{i=1}^{k} P_i(T_m, V_m) \Rightarrow \frac{Z_m * n_m * R * T_m}{V_m} = \sum_{i=1}^{k} \frac{Z_i * n_i * R * T_m}{V_m} \Rightarrow Z_m = \sum_{i=1}^{k} \frac{Z_i * n_i}{n_m} \Rightarrow Z_m = \sum_{i=1}^{k} y_i * Z_i$$

- The compressibility-factor approach, in general, gives more accurate results when the Z_i *are evaluated by using Amagat's law instead of* Dalton's law. This is because Amagat's law involves the use of mixture pressure *Pm, which accounts for the influence of intermolecular forces* between the molecules of different gases. *Therefore,*
- Dalton's law is more appropriate for gas mixtures at low pressures.
- Amagat's law is more appropriate at high pressures

Kay's rule:

Another approach for predicting the P-v-T behavior of a gas mixture is to treat the gas mixture as a pseudopure substance. involves the use of a *pseudocritical pressure (Pcr)m and pseudocritical temperature (Tcr)m* for the mixture, defined in terms of the critical pressures and temperatures of the mixture components as:

$$P'_{cr,m} = \sum_{i=1}^{k} y_i P_{cr,i} \qquad T'_{cr,m} = \sum_{i=1}^{k} y_i * T_{cr,i}$$

$$P_{cr,i} : T_{cr,i}$$

- Van der Waals Equation of State :

Van der Waals intended to improve the ideal-gas equation of state by including two of the effects not considered in the deal-gas model: the *intermolecular attraction forces and the volume occupied by the molecules themselves*. The term *a/v2 accounts for the intermolecular forces, and b accounts* for the volume occupied by the gas molecules

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

$$a = \frac{27 R^2 T_{cr}^2}{64 P_{cr}} \quad \text{and} \quad b = \frac{R T_{cr}}{8 P_{cr}}$$

- The constants *a and b can be determined for any substance from the critical point* data alone

---

Beattie-Bridgeman Equation of State:

The Beattie- Bridgeman equation is known to be reasonably accurate for densities up to about 0.8ρcr, where ρcr is the density of the substance at the critical point.

$$P = \frac{R_u T}{\bar{V}^2}\left(1 - \frac{c}{\bar{V} T^3}\right)(\bar{V} + B) - \frac{A}{\bar{V}^2}$$

$$A = A_0\left(1 - \frac{a}{\bar{V}}\right) \qquad B = B_0\left(1 - \frac{b}{\bar{V}}\right)$$

- The constants appearing in the above equation are given in Table for various substances.

TABLE 3-4

Constants that appear in the Beattie-Bridgeman and the Benedict-Webb-Rubin equations of state

(a) When P is in kPa, $\bar{v}$ is in m^3/kmol, T is in K, and R_u = 8.314 kPa · m^3/kmol · K, the five constants in the Beattie-Bridgeman equation are as follows:

Gas	A_0	a	B_0	b	c
Air	131.8441	0.01931	0.04611	−0.001101	4.34×10^4
Argon, Ar	130.7802	0.02328	0.03931	0.0	5.99×10^4
Carbon dioxide, CO_2	507.2836	0.07132	0.10476	0.07235	6.60×10^5
Helium, He	2.1886	0.05984	0.01400	0.0	40
Hydrogen, H_2	20.0117	−0.00506	0.02096	−0.04359	504
Nitrogen, N_2	136.2315	0.02617	0.05046	−0.00691	4.20×10^4
Oxygen, O_2	151.0857	0.02562	0.04624	0.004208	4.80×10^4

Source: Gordon J. Van Wylen and Richard E. Sonntag, *Fundamentals of Classical Thermodynamics*, English/SI Version, 3rd ed. (New York: John Wiley & Sons, 1986), p. 46, table 3.3.

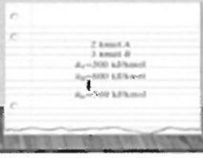
(b) When P is in kPa, $\bar{v}$ is in m^3/kmol, T is in K, and R_u = 8.314 kPa · m^3/kmol · K, the eight constants in the Benedict-Webb-Rubin equation are as follows:

Gas	a	A_0	b	B_0	c	C_0	α	γ
n-Butane, C_4H_{10}	190.68	1021.6	0.039998	0.12436	3.205×10^7	1.006×10^8	1.101×10^{-3}	0.0340
Carbon dioxide, CO_2	13.86	277.30	0.007210	0.04991	1.511×10^6	1.404×10^7	8.470×10^{-5}	0.00539
Carbon monoxide, CO	3.71	135.87	0.002632	0.05454	1.054×10^5	8.673×10^5	1.350×10^{-4}	0.0060
Methane, CH_4	5.00	187.91	0.003380	0.04260	2.578×10^5	2.286×10^6	1.244×10^{-4}	0.0060
Nitrogen, N_2	2.54	106.73	0.002328	0.04074	7.379×10^4	8.164×10^5	1.272×10^{-4}	0.0053

Source: Kenneth Wark, *Thermodynamics*, 4th ed. (New York: McGraw-Hill, 1983), p. 815, table A-21M. Originally published in H. W. Cooper and J. C. Goldfrank, *Hydrocarbon Processing* 46, no. 12 (1967), p. 141.

PROPERTIES OF GAS MIXTURES IDEAL AND REAL GASES

- The extensive properties of a mixture are determined by adding the properties of the components
- The intensive properties of a mixture are determined by adding weighted average
- The relations given below are exact for ideal-gas mixtures, and approximate for real-gas mixtures
- they are also applicable to nonreacting liquid and solid solutions especially when they form an "ideal solution.



- The total internal energy, enthalpy, and entropy of a gas mixture can be expressed, respectively as

- $U_m = \sum_{i=1}^{k} U_i = \sum_{i=1}^{k} m_i u_i = \sum_{i=1}^{k} N_i \bar{u}_i$ (KJ)
- $H_m = \sum_{i=1}^{k} H_i = \sum_{i=1}^{k} m_i h_i = \sum_{i=1}^{k} N_i \bar{h}_i$ (KJ)
- $S_m = \sum_{i=0}^{k} S_i = \sum_{i=1}^{k} m_i s_i = \sum_{i=1}^{k} N_i \bar{s}_i$ (KJ/K)

- The changes in internal energy, enthalpy, and entropy of a gas mixture during a process can be expressed,

- $\Delta U_m = \sum_{i=1}^{k} \Delta U_i = \sum_{i=1}^{k} m_i \Delta u_i = \sum_{i=1}^{k} n_i \Delta \bar{u}_i$ (KJ)
- $\Delta H_m = \sum_{i=1}^{k} \Delta H_i = \sum_{i=1}^{k} m_i \Delta h_i = \sum_{i=1}^{k} n_i \Delta \bar{h}_i$ (KJ)
- $\Delta S_m = \sum_{i=1}^{k} \Delta S_i = \sum_{i=1}^{k} m_i \Delta s_i = \sum_{i=1}^{k} n_i \Delta \bar{s}_i$ (KJ/K)

- The internal energy, enthalpy, and entropy of a mixture *per unit mass or per unit mole of the mixture can be determined by dividing the equations* above by the mass or the mole number of the mixture

- $u_m = \sum_{i=1}^{k} mf_i u_i$ (KJ/Kg) and $\bar{u}_m = \sum_{i=1}^{k} y_i \bar{u}_i$ (KJ/Kmol)
- $h_m = \sum_{i=1}^{k} mf_i h_i$ (KJ/kg) and $\bar{h}_m = \sum_{i=1}^{k} y_i \bar{h}_i$ (KJ/Kmol)
- $s_m = \sum_{i=1}^{k} mf_i s_i$ (KJ/kg . K) and $\bar{s}_m = \sum_{i=1}^{k} y_i \bar{s}_i$ (KJ/kmol . K)

- the specific heats of a gas mixture can be expressed as:

- $c_{v,m} = \sum_{i=1}^{k} mf_i c_{v,i}$ (KJ/kg . K) and $\bar{c}_{v,m} = \sum_{i=1}^{k} y_i \bar{c}_{v,i}$ (KJ/Kmol.K)
- $c_{p,m} = \sum_{i=1}^{k} mf_i c_{p,i}$ (Kj/kg . K) and $\bar{c}_{p,m} = \sum_{i=1}^{k} y_i \bar{c}_{p,i}$ (KJ/kmol.k)

IDEAL-GAS MIXTURES

- All gases that comprise a mixture at a high temperature and low pressure relative to the critical-point values of individual gases can be treated as ideal gases
- Gibbs-Dalton law :the properties of a gas are not influenced by the presence of other gases, and each gas component in the mixture behaves as ideal gas if it exists alone at the mixture temperature *Tm and mixture* volume *Vm*.
- the *h, u, cv, and cp of* an ideal gas depend on temperature only and are independent of the pressure or the volume of the ideal-gas mixture.
- Evaluation of *u or h of the components of an ideal-gas mixture during* a process is relatively easy since it requires only a knowledge of the initial and final temperatures
- evaluating the *s of the components since the entropy of an ideal gas depends on the pressure* or volume of the component as well as on its temperature

- The entropy change of individual gases in an ideal-gas mixture during a process can be determined from

$$\Delta s_i = s^\circ_{i,2} - s^\circ_{i,1} - R_i \ln \frac{P_{i,2}}{P_{i,1}} \cong c_{p,i} \ln \frac{T_{i,2}}{T_{i,1}} - R_i \ln \frac{P_{i,2}}{P_{i,1}}$$

$$\Delta \bar{s}_i = \bar{s}^\circ_{i,2} - \bar{s}^\circ_{i,1} - R_u \ln \frac{P_{i,2}}{P_{i,1}} \cong \bar{c}_{p,i} \ln \frac{T_{i,2}}{T_{i,1}} - R_u \ln \frac{P_{i,2}}{P_{i,1}}$$

- Note: $P_{i,2} = y_{i,2} P_{m,2}$ $P_{i,1} = y_{i,1} P_{m,1}$

REAL-GAS MIXTURES

- When the components of a gas mixture do not behave as ideal gases, the analysis becomes more complex
- the properties of real (nonideal) gases such as *u, h, cv , and cp depend on the pressure (or specific volume)* as well as on the temperature
- The diffrence between ideal gas and real gas is the influence of the molecules of different gases on each other

- Consider the following *T ds relation for a gas mixture*

$$dh_m = T_m ds_m + V_m dP_m$$

$$d\left(\sum mf_i h_i\right) = T_m d\left(\sum mf_i s_i\right) + \left(\sum mf_i v_i\right) dP_m$$

$$\sum mf_i \left(dh_i - T_m ds_i - v_i dp_m\right) = 0$$

$$dh_i = T_m ds_i + v_i dp_m$$

Thanks For Your Patience And Attention...