Ahmedabad University

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| Course | ENR208 Engineering Thermodynamics | Semester | Monsoon Semester 2024 |
| Faculty Name(s) | Sunil Kale | Contact | sunil.kale@ahduni.edu.in |
| School | SEAS | Credits | 2 |
| GER Category: | Not Applicable | Teaching Pedagogy Enable:NO | P/NP Course: Can not be taken as P/NP |

Schedule

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| Section 1 | 12:00 pm to 01:00 pm | Wed | 30-09-24 to 26-11-24 |
| | 01:00 pm to 02:00 pm | Wed | 30-09-24 to 26-11-24 |
| | 01:00 pm to 02:00 pm | Mon | 30-09-24 to 26-11-24 |
| | 01:00 pm to 02:00 pm | Fri | 30-09-24 to 26-11-24 |

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| Prerequisite | Not Applicable |
| Antirequisite | Not Applicable |
| Corequisite | Not Applicable |

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| Course Description | This course builds up on the concepts of continuum and balance laws taught in continuum mechanics course, with classical thermodynamics treatment of the First and Second laws, irreversibility and availability, and behaviour of a pure substance and equations of state (and online data). Both control mass and control volume approaches will be considered. Applications of these concepts in energy conversion, particularly power and refrigeration cycles, will be discussed. Energy sources and their uses, and societal and environmental impacts will be discussed. |
| Course Objectives | The educational objectives of the course are to:<br>CEO1 Understand the laws of thermodynamics from a classical thermodynamics approach, and their implications;<br>CEO2 Understand the thermodynamic behaviour of a pure substance;<br>CEO3 Learn about equations of state and property relations;<br>CEO4 Learn to interpret property data and its use in problem solving;<br>CEO5 Learn about thermodynamic processes in devices, and cycles; and<br>CEO6 Learn about the connection between thermodynamics and environmental impacts, especially climate change. |
| Learning Outcomes | After completing this course, a student should be able to,<br>• CO1 Formulate thermodynamic problems for device processes;<br>• CO2 Obtain thermodynamic property data for problem solving;<br>• CO3 Ascertain whether processes and cycles are realizable;<br>• CO4 Perform analysis of thermodynamic equipment processes;<br>• CO5 Perform analysis of thermodynamic cycles;<br>• CO6 Design systems based on thermodynamic analysis; and<br>• CO7 Calculate carbon footprint of energy conversion technologies. |
| Pedagogy | The instruction will be lecture based. Some assignments will be team-based, design type using online property data. |
| Expectation From Students | |

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| Assessment/Evaluation | • Mid-Semester Examination:<br>  ◦ Written - 25%<br>• End Semester Examination:<br>  ◦ Written - 30%<br>• Other Components:<br>  ◦ Quiz - 25%<br>  ◦ Assignment - 20% |
| Attendance Policy | As per Ahmedabad University Policy. |
| Project / Assignment Details | assignment: Weekly assessment of the students learning will be done through the assignment basis the questions relevant to real-world problems.<br><br>Quiz: Planned and surprised quizzes will be taken to check the learning of the student to solve a problem of interest. |
| Course Material | Other Book<br>• Notes by S R Kale.,<br>• Online thermodynamic property calculators,<br><br>Text Book(s)<br>• Fundamentals of Thermodynamics, C. Borgnakke and R. E. Sonntag,, 9 Edition, John Wiley, Year: 2020.,<br><br>Reference Book<br>• Fundamentals of Engineering Thermodynamics, M. J. Moran, H. E. Shapiro, D. D. Boettner, M. B. Bailey,, 9 Edition, Wiley, Year: 2018,<br>• Fuel Cell fundamentals, R O'Hayre, S-W Cha, W G COlella, F B Prinz,, 3 Edition, Wiley, Year: 2016, |
| Additional Information | |

# Session Plan

| NO. | TOPIC TITLE | TOPIC & SUBTOPIC DETAILS | READINGS,CASES,ETC. | ACTIVITIES | IMPORTANT DATES |
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| 1 | Revision of Concepts and Definitions | System, system boundary, surroundings. Definition of work, and heat. Types of work. Modes of heat (transfer). Mass and energy transfer across system boundary. Open, closed, isolated systems. | Borgnakke & Sonntag Ch-1 | Revision of some parts of course Continuum Mechanics. Problem solving-based discussions. | |
| 2 | Thermodynamic concepts | State. Change of state. Process. Cycle. Equilibrium, quasi-equilibrium. Steady, unsteady, quasi-steady states. Reversible and irreversible processes. Reversible heat transfer. Extensive, intensive properties.Pressure – absolute and gauge. Temperature. | Borgnakke & Sonntag Ch-1, 2 | Revision of some parts of course Continuum Mechanics. Pressure, temperature – related to Sensors, Instrumentation and Experimentation. Problem solving-based discussions. Borgnakke & Sonntag Ch-1, 2 | |
| 3 | Laws of Thermodynamics | Zeroth law, 1st and 2nd law statements for closed and open systems. | Borgnakke & Sonntag Ch-5, 6, 7 and 8 | Continuation from course Continuum Mechanics. | |
| 4 | Laws of Thermodynamics | Clausius inequality. | Borgnakke & Sonntag Ch-5, 6, 7 and 8 | Lecture + discussion | |
| 5 | Laws of Thermodynamics | Carnot cycle. | Borgnakke & Sonntag Ch-5, 6, 7 and 8 | Lecture + discussion + examples | |
| 6 | Laws of Thermodynamics | Internal energy. Enthalpy. | Borgnakke & Sonntag Ch-5, 6, 7 and 8 | Lecture + discussion | |
| 7 | Laws of Thermodynamics | 3rd law and its implications. | Borgnakke & Sonntag Ch-5, 6, 7 and 8 | Lecture + discussion + examples | |
| 8 | Exergy and Availability | Gibbs energy. Exergy. Availability. Irreversibility. Heat and work of process and reaction. | Borgnakke & Sonntag Ch- 9 and 10 | Lecture + discussion + examples | |

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| 9 | Properties of a pure substance | Phases. Behaviour of a pure substance. Saturated states, Critical state and triple point | Borgnakke & Sonntag Ch-3, 7 | Lecture | |
| 10 | Properties of a pure substance | Equilibrium states of mixtures of 2 or 3 phases. Ideal gas behaviour. | Borgnakke & Sonntag Ch-3, 7 | Lecture | |
| 11 | Properties of a pure substance | Compressibility factor. Equations of state. | Borgnakke & Sonntag Ch-3, 7 | Lecture + discussion | |
| 12 | Properties of a pure substance | Property relations. Property data – interpretation and use of tables and online data. | Borgnakke & Sonntag Ch-3, 7 | Lecture + discussion + examples | |
| 13 | Energy conversion devices | Types of devices, and their ideal and actual processes. | Borgnakke & Sonntag Ch-11 | Lecture | |
| 14 | Energy conversion devices | Performance characterization. | Borgnakke & Sonntag Ch-12 | Lecture+dicussion+examples | |
| 15 | Energy conversion devices | Work producing devices – turbines for power and propulsion. | Borgnakke & Sonntag Ch-13 | Lecture+dicussion+examples | |
| 16 | Energy conversion devices | Work consuming devices – compressors, fans, blowers, pumps. | Borgnakke & Sonntag Ch-14 | Lecture+dicussion+examples | |
| 17 | Power and refrigeration cycles | Vapour power cycles – Rankine cycle and its variants. | Borgnakke & Sonntag Ch-12 | Lecture + dicussion | |
| 18 | Power and refrigeration cycles | Sterling cycle. Gas power cycles - Otto, Diesel, Brayton | Borgnakke & Sonntag Ch-12 | Lecture + dicussion | |
| 19 | Power and refrigeration cycles | Gas power cycles – Otto, Diesel, Brayton. Vapour compression refrigeration cycles. | Borgnakke & Sonntag Ch-12 | Lecture + dicussion | |
| 20 | Power and refrigeration cycles | Vapour absorption cycles. Combined cycle power plants. Applications. | Borgnakke & Sonntag Ch-12 | Lecture + dicussion+examples | |

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| 21 | Future energy technologies | Fuel cells – basic thermodynamics | O'Hayre et al. Ch-2 | Lecture | |
| 22 | Future energy technologies | Electrolysers – basic thermodynamics | O'Hayre et al. Ch-2 | Lecture | |
| 23 | Future energy technologies | Hydrogen storage – basic thermodynamics | O'Hayre et al. Ch-2 | Lecture | |
| 24 | Environmental and Sustainability in Energy | Energy sources. Fossil fuels – coal, oil and natural gas. Carbon footprint, energy sources, | Various sources. | Lecture | |
| 25 | Environmental and Sustainability in Energy | Environmental implications of power generation, transportation, air-conditioning, data centres, etc. | Various sources. | Lecture + dicussion + examples | |
| 26 | Environmental and Sustainability in Energy | Low carbon technologies and extent of quantified impacts. | | Lecture + dicussion | |
| 27 | Mid-semester exam | Mid-semester exam | Mid-semester exam | Mid-semester exam | |
| 28 | Revision and reflection | Revision and reflection | Revision and reflection | Revision and reflection | |
| 29 | End-semester examination | End-semester examination | End-semester examination | End-semester examination | |
| 30 | End-semester examination | End-semester examination | End-semester examination | End-semester examination | |