# LOK JAGRUTI UNIVERSITY (LJU)
# INSTITUTE OF ENGINEERING AND TECHNOLOGY

**Department of Mechanical Engineering**

**Bachelor of Engineering (B.E.) – Semester – IV**

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| **Course Code:** | **017103403** |
| **Course Name:** | **Thermodynamics 2** |
| **Category of Course:** | Professional Core Course (PCC) |
| **Prerequisite Course:** | Mathematics 1 (017101191), Physics (017101192), Mathematics 3 (017101391), Engineering Mechanics (017102291), Thermodynamics 1 (017103301) |

| Teaching Scheme | | | | |
|---|---|---|---|---|
| Lecture (L) | Tutorial (T) | Practical (P) | Credit | Total Hours |
| 3 | 1 | 2 | 5 | 40 |

| Syllabus | | | | |
|---|---|---|---|---|
| **Unit No.** | **Topic** | **Prerequisite Topic** | **Successive Topic** | **Teaching Hours** |
| 01 | **Properties of Steam** | | | 5 (12.5%) |
| | 1.1 Types of steam and steam formation | --- | --- | |
| | 1.2 Enthalpy, specific volume, internal energy and dryness fraction of steam | Thermal properties (017103301-Unit-1.1) | --- | |
| | 1.3 Use of steam tables and Mollier's chart | Types of steam and steam formation (017103403-Unit-1.1), Finite differences (017101391-Unit-1.1) | --- | |
| | 1.4 Steam calorimeters – Barrel, Separating, Throttling and Combined (Separating and Throttling) calorimeters | Enthalpy, specific volume, internal energy and dryness fraction of steam (017103403-Unit-1.2), Basics of temperature measurement (017101192-Unit-8.1), Barometer (017101192-Unit-7.1) | --- | |
| 02 | **First Law of Thermodynamics** | | | 2 (5%) |
| | 2.1 First law for a closed system undergoing a cycle | Process, path and cycle (017103301-Unit-1.3) | --- | |
| | 2.2 First law for a closed system undergoing change of state | Process, path and cycle (017103301-Unit-1.3) | --- | |
| | 2.3 Energy – a property of the system | Process, path and cycle (017103301-Unit-1.3) | --- | |
| | 2.4 Energy of an Isolated system and PMM1 | --- | --- | |
| | 2.5 First law of thermodynamics for steady state flow process | First law of thermodynamics (017103403-Unit-2.2), First and higher order partial derivatives (017101191-Unit-5.4) | --- | |
| 03 | **First Law Applied to Flow Processes** | | | 4 (10%) |
| | 3.1 Steady flow energy equation applied to nozzle, diffuser | --- | --- | |
| | 3.2 Steady flow energy equation applied to turbine, compressor, pump | --- | --- | |
| | 3.3 Steady flow energy equation applied to boiler, heat exchanger and throttling | --- | --- | |
| | 3.4 Filling and emptying process | First law of thermodynamics for steady state flow process (017103403-Unit-3.1) | --- | |
| 04 | **Second Law of Thermodynamics** | | | 4 (10%) |
| | 4.1 Limitations of first law of thermodynamics | First law of thermodynamics (017103403-Unit-2.1, 2.2) | --- | |
| | 4.2 Cyclic heat engine, energy reservoir | Heat and Work (017103301-Unit-1.2) | --- | |
| | 4.3 Kelvin-Planck and Clausius statements | --- | --- | |
| | 4.4 Refrigerator and Heat Pump | --- | --- | |
| | 4.5 Equivalence of Kelvin-Planck and Clausius statements | --- | --- | |
| 05 | **Limitations and Applications of Second Law of Thermodynamics** | | | 6 (15%) |
| | 5.1 PMM2 | Second law of thermodynamics (017103403-Unit-4.3) | --- | |
| | 5.2 Causes of irreversibility | Friction and its applications (017102291-Unit-7.1) | --- | |
| | 5.3 Carnot theorem and corollary of Carnot theorem | Cyclic heat engine, energy reservoir (017103403-Unit-4.2) | --- | |
| | 5.4 Thermodynamic temperature scale | Cyclic heat engine (017103403-Unit-4.2) | --- | |
| | 5.5 Statement of third law of thermodynamics | --- | --- | |

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| | 5.6 Numerical on applications of second law of thermodynamics | --- | --- | |
| 06 | **Basic Concepts of Entropy** | | | 4 (10%) |
| | 6.1 Clausius theorem | Basic integration (017101191-Unit-3.4), Thermodynamic temperature scale (017103403 Unit-5.4) | --- | |
| | 6.2 Entropy is a property | --- | --- | |
| | 6.3 Inequality of Clausius and its numerical | Basic integration by formulae (017101191-Unit-3.4) | --- | |
| | 6.4 Entropy Principle | --- | --- | |
| 07 | **Applications of Entropy** | | | 4 (10%) |
| | 7.1 Application of entropy principle (Mixing of two fluid, Heat transfer through a finite temperature difference) and its numerical | --- | --- | |
| | 7.2 Maximum work obtainable from Two finite Bodies and its numerical | | --- | |
| | 7.3 Maximum work obtainable from a Finite body and a TER and its numerical | --- | --- | |
| | 7.4 Statement of Second law efficiency | Carnot gas power cycle (017103301-Unit-7.2) and Cyclic heat engine, energy reservoir (017103403-Unit-4.2) | --- | |
| 08 | **Vapor Power Cycles** | | | 3 (7.5%) |
| | 8.1 Carnot vapor cycle | Properties of steam (017103403-Unit-1.1, 1.2) | --- | |
| | 8.2 Rankine cycle | Constant volume process and constant pressure process (017103301-Unit-4.1), Finite differences (017101391-Unit-1.1) | --- | |
| | 8.3 Comparison of Carnot and Rankine cycle | --- | --- | |
| | 8.4 Calculation of cycle efficiencies | --- | --- | |
| | 8.5 Variables affecting efficiency of Rankine cycle (Only Theory) | --- | --- | |
| 09 | **Vapor Compression Refrigeration System** | | | 4 (10%) |
| | 9.1 Definitions of refrigeration, Air conditioning, Refrigerant | --- | --- | |
| | 9.2 Simple Vapor Compression Refrigeration system on P-h & T-s diagram and its numerical | Steady flow energy equation applied to turbine, compressor, pump (017103403-Unit-3.3), Second law of thermodynamics (017103403-Unit-4.2), Finite differences (017101391-Unit-1.1) | --- | |
| | 9.3 Factors affecting the performance of the simple VCR system (Only Theory) | --- | --- | |
| 10 | **Multi Stage Vapor Compression Refrigeration System (Only Theory)** | | | 4 (10%) |
| | 10.1 Two stage compression with water intercooler & liquid sub cooler | Simple Vapor Compression Refrigeration system(017103403-Unit-9.2) | --- | |
| | 10.2 Two stage compression with water intercooler | | --- | |
| | 10.3 Two stage compression with flash chamber | | --- | |
| | 10.4 Two stage compression with liquid subcooler | | --- | |
| | 10.5 Two stage compression with flash chamber, water intercooler and liquid sub cooler | | | |

**Major Components/ Equipment**

| Sr. No. | Component/Equipment |
|---|---|
| 1 | Pipe-in-pipe heat exchanger |
| 2 | Mechanical Heat Pump |
| 3 | Vapor compression refrigeration system |

| Sr No. | Practical Title | Link to Theory Syllabus |
|---|---|---|
| 1 | To determine heat loss from pipe-in-pipe heat exchanger using SFEE. | Unit-3 |
| 2 | To verify First and Second Law with Mechanical Heat Pump. | Unit-4 |
| 3 | To understand different components of VCR system and to determine its COP. | Unit-9 |

**Proposed Theory + Practical Evaluation Scheme by Academicians**
**(% Weightage Category Wise and it's Marks Distribution)**

| L : | 3 | T: | 1 | P: | 2 |
|---|---|---|---|---|---|

**Note : In Theory Group, Total 4 Test (T1+T2+T3+T4) will be conducted for each subject.**
**Each Test will be of 25 Marks.**
**Each Test Syllabus Weightage: Range should be 20% - 30%**

| Group (Theory or Practical) | Group (Theory or Practical) Credit | Total Subject Credit | Category | % Weightage | Marks Weightage |
|---|---|---|---|---|---|
| Theory | 4 | 5 | MCQ | 34% | 43 |
| Theory | | | Theory Descriptive | 0% | 0 |
| Theory | | | Formulas and Derivation | 12% | 15 |
| Theory | | | Numerical | 34% | 42 |
| **Expected Theory %** | **80%** | | **Calculated Theory %** | 80% | 100 |
| Practical | 1 | | Individual Project | 10% | 50 |
| Practical | | | Group Project | 0% | 0 |
| Practical | | | Internal Practical Evaluation (IPE) | 10% | 50 |
| Practical | | | Viva | 0% | 0 |
| Practical | | | Seminar | 0% | 0 |
| **Expected Practical %** | **20%** | | **Calculated Practical %** | 20% | 100 |
| **Overall %** | **100%** | | | 100% | 200 |

## Course Outcome

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| | *Upon completion of the course students will be able to* |
| 1 | Evaluate steam properties using steam table and apply concepts of first law of thermodynamics. |
| 2 | Understand second law of thermodynamics with its application and limitations. |
| 3 | Apply concepts of entropy analysis for mixing of fluids, finite bodies and Thermal energy reservoir. |
| 4 | Analyze vapor power cycle and vapor compression refrigeration system in real world. |

## Suggested Reference Books

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|---|---|
| 1 | Engineering Thermodynamics by P.K. Nag, McGraw-Hill Education |
| 2 | Fundamentals of Thermodynamics by Borgnakke and Sonntag, 7th Ed. Wiley India (P) Ltd. |
| 3 | Thermodynamics – An Engineering Approach by Yunus Cengel and Boles, McGraw-Hill Education |
| 4 | Engineering Thermodynamics by Gordon Rogers and Yon Mayhew, Pearson Education Ltd |
| 5 | Engineering Thermodynamics by Krieth, CRC Press |
| 6 | Engineering Thermodynamics by Jones and Dugan, PHI Learning Pvt. Ltd |
| 7 | MATLAB for Mechanical Engineers by Rao V Dukkipati, New age science Ltd.,2009 |

## List of Open Source Software/Learning website

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|---|---|
| 1 | http://nptel.ac.in |
| 2 | www.coursera.org |

## Practical Project

| Sr. No. | Project List | Linked with Unit |
|---|---|---|
| **1** | Evaluate the power output from turbine for given conditions of steam with steam table data. Do Parametric analysis and plots for different variables. | Unit-3 |
| **2** | Do velocity analysis of nozzle for given conditions of steam with steam table. | Unit-3 |
| **3** | Heat transfer analysis of Heat Exchanger for given conditions of steam with steam table. | Unit-3 |
| **4** | Develop mathematical model for heat pump and refrigerator system to find the COP of the user given inputs.<br>• What changes you will suggest in the system if customer wants predefined COP value? Generate the plots to justify your analysis. | Unit-4 |
| **5** | Evaluate the entropy of system, surrounding and universe for any real-life problem.<br>• Use any loop for user defined input<br>Parametric analysis and plots for different variables | Unit-6 |
| **6** | Develop mathematical model to find maximum work obtainable from Two finite Bodies. What will be the effect on maximum work with change in source and sink temperature? Justify your result with different types of plots. | Unit-7 |
| **7** | Develop mathematical model to find maximum work obtainable from finite body and TER. What will be the effect on maximum work with change in source and sink temperature? Justify your result with different types of plots. | Unit-7 |
| **8** | User should be able to find efficiency of Rankine cycle from your model. Do parametric analysis to see the effect of change in different system variables on the performance of the cycle. | Unit-8 |
| **9** | Develop a model to analyze the effect of conditions (Dry, Superheated) of refrigerant at the inlet of compressor on COP of the system. Do Parametric analysis and plots for different variables. | Unit-9 |
| **10** | Develop a program to find the effect of condenser pressure on COP of the system. Do Parametric analysis and plots for different variables. | Unit-9 |
| **11** | Evaluate the effect of subcooling on COP of the system. Do Parametric analysis and plots for different variables. | Unit-9 |
| **12** | Evaluate the effect of evaporator pressure on COP of the system. Do Parametric analysis and plots for different variables. | Unit-9 |