MECHANICAL
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PREPARED BY
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Course File

Engineering Thermodynamics (3ME4- 05)

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SYLLABUS

2nd Year - III Semester: B.Tech. (Mechanical Engineering)

3ME4-05 : ENGINEERING THERMODYNAMICS

Credit: 3 **Max. Marks: 150 (IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**Basic Concepts and definitions of Thermodynamics**: System, Surroundings, Property, Energy, Thermodynamic Equilibrium, Process, work and modes of work.	2
	Zeroth and First Law of Thermodynamics: Zeroth of Thermodynamics, Temperature scale, First law of thermodynamics, First law analysis of some elementary processes. Steady and unsteady flow energy equations.	5
2	**Second Law of Thermodynamics:** Heat engine, Heat pump and refrigerator, Second law of thermodynamics, Equivalence of the Kelvin-Plank and Clausius statements. Reversible and Irreversible Processes, Carnot engine, Efficiency of a Carnot engine, Carnot principle, thermodynamic temperature scale, Clausis Inequality.	4
	Entropy: Entropy, Calculation of Entropy change, Principle of entropy increase. Temperature-Entropy diagram, Second law analysis of a control volume.	3
	Availability: Available energy, Loss in available energy, Availability Function, Irreversibility.	3
3	**Thermodynamic Properties of Fluids:** Pure substance, Concept of Phase, Graphical representation of p-v-T data, Properties of steam. Steam tables, Mollier chart	4
	Ideal Gas and Real Gas: Ideal gas, Real gas, Internal energy, enthalpy and specific heats of an ideal gas, equations of state, Dalton's law of partial pressures, Gibbs Dalton law, Thermodynamic properties of gas mixtures.	4
4	**Thermodynamic Relations:** Thermodynamic variables, Independent and dependent variables, Maxwell's thermodynamic relations, Thermodynamic relations involving entropy, Thermodynamic relations involving enthalpy and internal energy, Joule-Thomson coefficient, Clapeyron equation.	4
	Power Cycles: Otto cycle, Diesel cycle, Dual cycle, Brayton cycle and Ericsson cycle.	4
5	**Vapour power cycle:** Rankine cycle, effect of operating conditions on its efficiency, properties of ideal working fluid in vapour power cycle	3
	Reheat cycle, regenerative cycle, bleeding extraction cycle, feed water heating co-generation cycle.	3
	TOTAL	**39**

Course Overview:

Students will learn the basics of Engineering thermodynamics from this 40 hours course. They will be able to know about the laws of thermodynamics, such as first, second & third law and also about their applications. Linear data structures covered under this course are array, stack, queue, double ended queue and linked list. This course provides an introduction to the most powerful engineering principles you will ever learn - Thermodynamics: the science of transferring energy from one place or form to another place or form. We will introduce the tools you need to analyze energy systems from solar panels, to engines, to insulated coffee mugs.

More specifically, we will cover the topics of mass and energy conservation principles; first law analysis of control mass and control volume systems; properties and behaviour of pure substances; and applications to thermodynamic systems operating at steady state conditions.

Course Outcomes:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	Explain the basic principles and applications of the thermodynamics to the various real life systems.
2	Synthesis	Describe fundamental laws of thermodynamics.
3	Design	Apply the concepts such as Entropy, Energy Balance also the calculations of heat, work and other important thermodynamic properties for various ideal gas processes.
4	Design	Estimate performance of various thermodynamic gas power cycles and gas refrigeration cycle and availability in each case.
5	Synthesis	Estimate Pure Substance problem and Analysis of Substance.

Course Outcome Mapping with Program Outcome:

Engineering Thermodynamics Year of study: 2021-22															
Course Outcome	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	1	1	0	0	0	0	1	0	0	2	2	1
CO2	3	1	1	1	1	0	0	0	0	1	0	0	2	1	1
CO3	3	2	3	2	2	0	0	0	0	1	0	1	3	2	2
C04	3	2	3	2	2	0	0	0	0	1	0	1	3	2	2
C05	3	2	3	2	2	0	0	0	0	1	0	1	3	2	2
Average	2.80	1.80	2.40	1.60	1.60	0.00	0.00	0.00	0.00	1.00	0.00	0.60	2.60	1.80	1.60

Course Coverage Module Wise:

Lecture No.	Unit	Topic
1	**1**	Basic Concepts and definitions of Thermodynamics: System, Surroundings, Property, Energy,
2	**1**	Thermodynamic Equilibrium, Process, work and modes of work.
3	**1**	Zeroth of Thermodynamics, Temperature scale
4	**1**	First law of thermodynamics, First law analysis of some elementary processes.
5	**1**	Steady and unsteady flow energy equations.
6	**1**	Numericals
7	**1**	Numericals
8	**1**	Numericals
9	**1**	Numericals
10	**2**	Heat engine, Heat pump and refrigerator, Second law of thermodynamics,
11	**2**	Equivalence of the Kelvin-Plank and Clausius statements
12	**2**	Reversible and Irreversible Processes, Carnot engine

13	**2**	Efficiency of a Carnot engine, Carnot principle, thermodynamic temperature scale, Clausis Inequality
14	**2**	Entropy, Calculation of Entropy change, Principle of entropy increase. T
15	**2**	Temperature-Entropy diagram, Second law analysis of a control volume.
16	**2**	Available energy, Loss in available energy,
17	**2**	Availability Function, Irreversibility
18	**2**	Numericals
19	**2**	Numericals
20	**2**	Numericals
21	**2**	Numericals
22	3	Pure substance, Concept of Phase, Graphical representation of p-v-T data
23	3	Properties of steam. Steam tables, Mollier chart
24	3	Ideal gas, Real gas
25	3	Internal energy, enthalpy and specific heats of an ideal gas,
26	3	equations of state, Dalton's law of partial pressures,
27	3	Gibbs Dalton law, Thermodynamic properties of gas mixtures.
28	3	Numericals
29	3	Numericals
30	3	Numericals
31	4	Thermodynamic variables, Independent and dependent variables,
32	4	Maxwell's thermodynamic relations, Thermodynamic relations involving entropy,
33	4	Thermodynamic relations involving enthalpy and internal

		energy,
34	4	Joule-Thomson coefficient, Clapeyron equation
35	4	: Otto cycle, Diesel cycle, Dual cycle
36	4	Brayton cycle and Ericsson cycle.
37	4	Numerical
38	4	Numerical
39	5	Rankine cycle, effect of operating conditions on its efficiency
40	5	properties of ideal working fluid in vapour power cycle
41	5	Reheat cycle, regenerative cycle, bleeding extraction cycle,, feed water heating co-generation cycle.
42	5	Numerical
43	5	Numerical
44	5	Numerical
45	5	Numerical

TEXT/REFERENCE BOOKS

1. Engineering Thermodynamics, P.k.nag
2. Engineering Thermodynamics By D.S.kumar
3. Thermal Engineering by R.S.Khurmi
4. Thermal Engineering by F.S.Mehta

Course Level Problems (Test Items):

CO.NO.	**Problem description**
1	A. Relate zeroth law with practical everyday life. B. Relate stady flow process with everyday life C. Relate first law with everyday life.
2	A. Relate second law with everyday life B. Attempt numericals on second law of thermodynamicss C. Relate entropy concept with second law.
3	A. Write different phase change properties of water at different pressure. B. Attempt numerical on steam table C. Attempt numeical on moiller chart.

4	A. Derive thermodynamic relation. B. Derive efficency of otto , diesel, dual cycle. C. Attempt numerical on otto,diesel , dual cycle.
5	A. Derive rankine and ideal rankine cycle. B. Derive reheat, regenerative , binary vapor cycle. C. Attempt numerical on reheat, regenerative & binary vapor cycle.

Assessment Methodology:

1. Practical exam in lab where they have to prepare practical model related to thermodynamic laws .(Once in a week)
2. Assignments one from each unit.
3. Midterm subjective paper where they have to attempt numericals.
4. Final paper at the end of the semester subjective.

Teaching and Learning resources unit-wise:

Unit-1

Basic Concept of thermodynamics

Video Tutorials: https://www.youtube.com/watch?v=CWKMCXc1qWk

Theory conchttps:https://www.edibon.com/en/thermodynamics-thermotechnics/fundamentals-and-basic-concepts-of-thermodynamics

Sample Quiz: https://www.mechanicaltutorial.com/thermodynamics-objective-type-questions-and-answers

Unit-2

A. Heat engine , Heat pump & refrigerator(Second law of thermodynamics)

Video Tutorials: https://www.youtube.com/watch?v=Z1crLo7KyH8

Theory concepts: https://www.livescience.com/50941-second-law-thermodynamics.html

Sample Quiz: https://www.mechanicaltutorial.com/thermodynamics-objective-type-questions-and-answers

B. Clausius inequality & 3rd law of thermdynamics

Video Tutorials: https://www.youtube.com/watch?v=c5v1b5pCL40

Theory concept:- https://itp.uni-frankfurt.de/~gros/Vorlesungen/TD/4_Entropy_second_law.pdf

Sample Quiz: https://www.mechanicaltutorial.com/thermodynamics-objective-type-questions-and-answers

Unit-3

A. Pure substance, Concept of Phase, Graphical representation of p-v-T data

Video Tutorials: https://www.youtube.com/watch?v=D28Mg5u3cW8

Theory concepts:https://www.ohio.edu/mechanical/thermo/Intro/Chapt.1_6/Chapter2a.html

Sample Quiz: https://www.mechanicaltutorial.com/thermodynamics-objective-type-questions-and-answers

B. Steam table & moiller chart

Video Tutorials:https://www.youtube.com/watch?v=jtsLoBKc5hE

Theory concepts:http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2410

Sample Quiz:https://www.mechanicaltutorial.com/thermodynamics-objective-type-questions-and-answers

Unit-4

A. Thermodynamic relation, Thermodynamic variables, Independent and dependent variables,

Video Tutorials: https://www.youtube.com/watch?v=wlzVbnCovO0

Theory concepts: https://www.cpp.edu/~tknguyen/che302/Notes/chap8-1.pdf

Sample Quiz: https://www.mechanicaltutorial.com/thermodynamics-objective-type-questions-and-answers

B. Gas power cycles

Video Tutorials: https://www.youtube.com/watch?v=U6sKICs5XtY&list=PLvGeDdLVzd1kqvbp0fdQjv8fMwB620S_O

Theory concepts: http://www.nitjsr.ac.in/course_assignment/ME4255_2.pdf

Sample Quiz: https://www.mechanicaltutorial.com/thermodynamics-objective-type-questions-and-answers

Unit-5

A. Vapour power cycle

Video Tutorials:
https://www.youtube.com/watch?v=lucNT3kGjKY&list=PLvGeDdLVzd1kVAEtLsL6sb0bQyUOH0PpC

Theory concepts: http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2430

Sample Quiz: https://www.mechanicaltutorial.com/thermodynamics-objective-type-questions-and-answers

B. Binary vapor cycle & cogeneration power plant

Video Tutorials: https://www.youtube.com/watch?v=PWqyKT8TOQA

Theory concepts: https://www.learnthermo.com/T1-tutorial/ch09/lesson-C/pg10.php

Sample Quiz: https://www.mechanicaltutorial.com/thermodynamics-objective-type-questions-and-answers

Previous Year Question Papers:

3E1208

Roll No. ________

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3E1208

B.Tech. III Sem. (Main) Examination, April/May - 2022

Automobile Engineering

3AE4-05 Engineering Thermodynamics

AE, ME

Time : 3 Hours

Maximum Marks : 70

Instructions to Candidates:

Attempt all ten questions From Part A, All five Questions from Part B and three questions out of five questions from Part C.

Schematic diagram must be shown wherever necessary. Any data missing may suitably be assumed and states clearly. Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination (As mentioned in form No. 205).

PART - A (Word limit 25) **(10×2=20)**

1. What is thermodynamic equilibrium? **(2)**
2. What is triple point of a substance? **(2)**
3. Explain clausius statement? **(2)**
4. Explain the principle of entropy increase? **(2)**
5. What is a pure substance? **(2)**
6. Explain Gibbs Dalton law. **(2)**
7. In Otto, Diesel and dual cycle, with same operating conditions which cycle has the maximum thermal efficiency? **(2)**
8. What are the thermodynamic variables? **(2)**
9. What are the properties of Ideal working fluid in vapour power cycle? **(2)**
10. What do you mean by Regeneration in a cycle. **(2)**

PART - B (Word limit 100) **(5×4=20)**

1. 0.3 Kg of nitrogen gas of 100 kpa and 40°C is contained in a cylinder. The piston is moved compressing or Nitrogen until 1 MPa. at this point the temperature is 160°C. The work done during the process is 30 KJ. Calculate the heat transfer from the Nitrogen.

   To the surroundings take C_v = 0.75 KJ/kg K. for Nitrogen. **(4)**

3. Explain the concept of Entropy and Irreversibility and prove

$ds \geq \frac{\delta Q}{T}$ **(4)**

3. A vessel of $0.03 m^3$ capacity contains gas at 3.5 Bar pressure and 35°C temperature. Determine the mass of the gas in the vessel. If the pressure of this gas is increased to 10.5 Bar while the volume remain constant, What will be the temperature of the Gas? For the gas take R = 290 J/kg K **(4)**

4. A) Prove that the equation for enthalphy is given by: all nomenclature have usual meaning.

$$dh = C_p dT + \left\{ v - T\left(\frac{\partial v}{\partial T}\right)_p \right\} dP$$ **(2)**

B) Prove that thermal efficiency of an Otto cycle is given by: $\left\{ \eta = 1 - \frac{1}{r^{\gamma-1}} \right\}$.

Where all nomenclature have usual meaning. **(2)**

5. A) Explain vapour power cycle with a neat Diagram. **(2)**

B) What are the various effect of operating conditions on the efficiency of vapour power cycle? **(2)**

PART - C (Any three) (3×10=30)

1. A) The specific heat capacity of the system during a certain process is given by:

$C_n = (0.4 + 0.004T)\, KJ/kg\ ^\circ C$

If the mass of the gas is 6 kg and its temperature changes from 25°C to 125°C find: https://www.rtuonline.com

i) Heat transferred

ii) Mean specific heat of gas. **(5)**

B) Comment whether the following quantities can be called as properties or not.

i) $\int Pdv$ ii) $\int vdP$ iii) $\int Pdv + vdP$ **(5)**

2. Air at 20°C and 1.05 bar occupies $0.025 m^3$, 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) Net heat flow from the air.

ii) Net entropy change. Sketch the process on T-S diagram. **(10)**

3. Write short notes on

   A) P-V-T Surface

   B) Dryness fraction

   C) Super heated Steam

   D) Latent heat. **(10)**

4. For a perfect gas obeying $Pv=RT$ show that C_v and C_p are independent of pressure. **(10)**

5. A turbine is supplied with steam at a pressure of 32 *Bar and a temperature of* 410°C. The steam then expands isentropically to a pressure of *0.08 Bar*. Find the dryness fraction at the end of expansion and thermal efficiency of the cycle.

   If the steam is reheated at 5.5 Bar to a temperature of 395°C and then expanded isentropically to a pressure of 0.08 Bar, What will be the dryness fraction and thermal efficiency of the cycle? **(10)**

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3E1633

B. Tech. (Sem. III) (Main/Back) Examination, December - 2017
Mechanical Engg.
3ME3A Engg. Thermodynamics

Time : 3 Hours **Maximum Marks : 80**
Min. Passing Marks : 26

*Attempt any **five questions**, selecting **one question** from **each unit**. All Questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used / calculated must be stated clearly.*

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. Nil 2. Nil

UNIT - I

1 (a) (i) What is property ? Distinguish between different types of properties. **4**

(ii) What is thermodynamic equilibrium ? **4**

(b) A 0.5 m^3 vessel is fitted with air at atmospheric pressure. The air is churned by a paddle wheel attached to a shaft 0.1 m in dia., rotating at a speed of 1800 rpm. A force of 5N acts on the rim of the shaft. What would be the pressure in the vessel after 10 second of operation ? **8**

OR

1 (a) Apply first law to the following processes of a closed system using ideal gas as the working substance :

(i) Constant volume

(ii) Constant pressure

(iii) Constant temperature

(iv) Reversible adiabatic. 8

(b) Five kilogram of air initially at 25°C and atmospheric pressure (101.325 kPa) is heated in a rigid container by adding 10 kJ of heat. Calculate the change in internal energy of the system and the final temperature attained. 8

UNIT - II

2 (a) (i) Explain the working principle of a Carnot engine. 4

(ii) What is perpetual motion machine of the second kind ? 4

(b) A Carnot refrigerator operates between temperature limits of 7°C in the evaporator and 35°C in the condenser. It is now desired to keep a medicine which requires a steady temperature of −5°C, in the refrigerator. By what percent should the compressor capacity be increased keeping the same refrigerating effect and the same condenser temperature ? 8

OR

2 One kg of nitrogen expands from 200 kPa and 400°C to 100 kPa and 300°C. Calculate the entropy change along different paths and prove that entropy is a point function. 16

UNIT - III

3 (a) (i) What is triple point ? Explain with reference to P-T, P-V and T-V planes.

(ii) What is pure substance ? Explain in detail. 4

(b) Derive the relations for the entropy change of an ideal gas in terms of T-P, T-V, P-V. 4

8

OR

3 A vessel with a volume of 0.1 m^3 contains an ideal gas at 100°C, 600 kPa. It expands isentropically to a final pressure of 150 kPa. Evaluate the work done. Assume C_v = 0.7202 kJ/kgK and C_p = 1.0044 kJ/kgK.

16

UNIT - IV

4 (a) Explain with P-V and T-S diagram - Otto cycle, Diesel cycle, Dual cycle and Brayton cycle. 8

(b) Derive an expression for the air standard efficiency of a diesel cycle. 8

OR

4 The velocity of sound C in a medium is given by $C = \sqrt{\left(\frac{\partial p}{\partial \rho}\right)_s}$. Find an expression for the velocity of sound in terms of such quantities as p, u, T, R and k for

(a) an ideal gas and

(b) an incompressible liquid.

16

UNIT - V

5 (a) What factors render the Carnot cycle an impractical cycle ? 8

(b) What is cogeneration ? Explain the working principle of a practical cogeneration plant. 8

OR

5 A steam power plant operates on the Rankine cycle with superheated steam entering the turbine at 4 MPa and 300°C. The steam is condensed in a condenser at 20 kPa. Determine the thermal efficiency of the cycle assuming ideal conditions. 16

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3E1633

B. Tech. III Sem. (Main / Back) Exam., Feb. 2015

Mechanical Engineering

3ME3A Engineering Thermodynamics

Common to 3PI3A and 3AE3A

Time: 3 Hours **Maximum Marks: 80**

Min. Passing Marks:

Main: 26

Back: 24

Instructions to Candidates:

Attempt any ***five questions,*** *selecting* ***one question*** *from* ***each unit.*** *All questions carry* ***equal*** *marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly.*

Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination.

1. Steam Table ___________ 2. Mollier chart ___________

UNIT – I

Q. 1 (a) What is the zeroth law of thermodynamics. Consider a system whose temperature is 18°C. Express this temperature in R, K, and °F [8]

(b) The main water line into a tall building has a pressure of 600kPa at 5m below ground level. A pump brings the pressure up so the water can be delivered at 200 kPa at the top floor 150m above ground level. Assume a flow rate of 10kg/s liquid water at 10°C and neglect any difference in kinetic energy and internal energy u. Find the pump work. [8]

OR

Q. 1 (a) Explain intensive and extensive properties. Classify the following properties as intensive or extensive:

Mass, Energy, Temperature, Volume, Sp. Volume, density. [8]

(b) A nozzle receives 0.1kg/s of steam at 1 MPa and 400°C with negligible kinetic energy. The exit is at 500 kPa and 350°C, and the flow is adiabatic. Find the nozzle exit velocity and the exit area. [8]

UNIT – II

Q. 2 (a) Explain carnot cycle on T-S and P-V diagram. Give the reason, why carnot cycle is practically not possible? [8]

(b) The interior lighting of refrigerator is provided by Incandescent lamps whose switches are actuated by the opening of the refrigerator door. Consider a refrigerator whose 40-W light bulb remain on continuously as a result of the mal function of the switch. If the refrigerator has a coefficient of performance of 1.3 and cost of the electricity is Rs 8 per kwh, determine the increase in the energy consumption of the refrigerator and its cost per year if the switch is not fixed. [8]

OR

Q. 2 (a) An inventor claims to have developed a refrigerator that maintains the refrigerated space at -3°C while operating in a room where the temperature is 22°C and that has a coefficient of performance of 13.5. Is this claim reasonable? [8]

(b) A heat source of 800k loses 2000kJ of heat to sink at (i) 500k and (ii) 750k. Determine which heat transfer process is more irreversible. [8]

UNIT-III

Q. 3 (a) Derive Maxwell relation and explain their importance in thermodynamics. [12]

(b) Write Clapeyron equation, what is its importance in thermodynamics. [4]

OR

Q. 3 (a) What is Joule-Thomson coefficient, define it? What is it's significance? [8]

(b) What is compressibility factor? What is the role of generalized compressibility chart in thermodynamics? [8]

UNIT-IV

Q. 4 (a) Write the assumption utilized in the analysis of air standard gas power cycles. [4]

(b) An ideal Otto cycle has a compression ratio of 8. At the beginning of the compression process, air is at 100kPa and 17°C, and 800kJ/kg of heat is transferred to air during the constant volume heat-addition process. Determine

(i) The maximum temperature and pressure that occur during the cycle

(ii) The net work output

(iii) Thermal efficiency

(iv) The mean effective pressure for the cycle. [12]

OR

Q. 4 (a) Explain stirling cycle using T-S and P-V diagram. [6]

(b) A gas turbine power plant operating on an ideal Brayton cycle has a pressure ratio of 8. The gas temperature is 300k at the compressor inlet and 1300k at the turbine inlet. Utilizing the air standard assumptions, determine:

(i) The gas temperature at the exit of the compressor and the turbine

(ii) Work ratio

(iii) The thermal efficiency [10]

UNIT-V

Q. 5 (a) In a Rankine cycle, steam leaves the boiler and enters the turbine at 4 MPa and 400°C. The condenser pressure is 10kPa. Determine the cycle efficiency. [10]

(b) Explain the effect of pressure and temperature of the efficiency of the Rankine cycle. [6]

OR

Q. 5 (a) Explain the Reheat cycle and it's advantages. Draw T-S and schematic diagram for reheat cycle, [6]

(b) Consider a reheat cycle utilizing steam. Steam leaves the boiler and enters the turbine at 4 MPa, 400°C. After expansion in the turbine to 400 kPa, the steam is reheated to 400°C and then expanded in the low pressure turbine to 10kpa Determine the cycle efficiency. [10]