INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**THERMODYNAMICS**			
Course Code	**R15 - A30306**			
Course Structure	**Lectures**	**Tutorials**	**Practicals**	**Credits**
	4	1	-	4
Course Coordinator	Dr. D. Govardhan, Professor			
Team of Instructors	Dr. D. Govardhan, Professor			

I. Course Overview:

Thermodynamics is the science that deals with the relationship between heat and work and those properties of systems that bear relation to heat and work. General laws of energy transformations concerning all types of systems, mechanical, electrical and chemical may fall within the purview of this science. It is a science based on a number of empirical laws formed by experimentation from which all predictions concerning the physical behavior of the system may be deduced by logical reasoning. The findings have been formalized into certain basic laws, which are known as Zeroth, First, Second and Third laws of thermodynamics. Power cycles and refrigeration cycle based on thermodynamic system is studied.

II. PREREQUISITES:

Level	Credits	Periods	Prerequisites
UG	4	5	Engineering Mathematics, Engineering Physics, Engineering chemistry

III. MARKSDISTRIBUTION

Sessional Marks	University End Exam Marks	Total Marks
There shall be 2 midterm examinations. Each midterm examination consists of one objective paper, one subjective paper and one assignment. The objective paper is for 10 marks and subjective paper is for 10 marks, with duration of 1 hour 20 minutes (20 minutes for objective and 60 minutes for subjective paper). Objective paper is set for 20 bits of – multiple choice questions, fill-in the blanks, 10 marks. Subjective paper contains of 4 full questions (one from each unit) of which, the student has to answer 2 questions, each question carrying 5 marks. First midterm examination shall be conducted for 1-4 units of syllabus and second midterm examination shall be conducted for 5-8 units. 5 marks are allocated for Assignments (as specified by the concerned subject teacher) – first Assignment should be submitted before the conduct of the first mid, and the second Assignment should be submitted before the conduct of the second mid. The total marks secured by the student in each midterm examination are evaluated for 25 marks, and the average of the two midterm examinations shall be taken as the final marks secured by each candidate	75	100

IV EVALUATION SCHEME:

S. No.	Component	Duration	Marks
1	I Mid Examination	1 hour 20 min	20
2	I Assignment lot		05
		Total	**25**
3	II Mid Examination	1 hour 20 min	20
4	II Assignment lot		05
		Total	**25**
5	External Examination	3 hours	75
		GRAND TOTAL	**100**

V. COURSE OBJECTIVES:

I. To get the basic concepts of thermodynamics, temperature measurement, first law and also ability to determine the heat, work in various flow & non-flow processes.

II. To gain the knowledge about second law of thermodynamics and determine the change in entropy, availability in various processes.

III. To get the knowledge various phases of pure substance and calculate its properties using steam tables and Mollier chart to determine properties of perfect gases in various processes.

IV. To develop to learn the concepts of mixture of gases and to calculate the property values during any process.

V. To get the knowledge about the working of different types of cycles and their performance which emphasizes knowledge in IC engines.

VI. COURSE OUTCOMES:

1. Describe knowledge of energy transfer and work done and heat equation in different processes, power cycles and thermodynamic laws.
2. Demonstrate knowledge of ability to identify & apply fundamentals to solve problems like system properties, amount of work transfer and heat during various processes, steam properties at different temperatures and pressures using steam tables.
3. Explore their knowledge & ability to design the thermal related components in various fields of energy transfer equipments.
4. An ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, and safety manufacturability and sustainability related thermal fields like I.C engines, different types of power plants etc.
5. The ability to use modern engineering tools, software and equipment to analyze energy transfer in required applications.
6. A knowledge of impact of engineering solutions on the society and also on contemporary issues related to different types of power cycles.

VII. HOW COURSE OUTCOMES ARE ASSESSED:

Program Outcomes		Level	Proficiency assessed by
PO1	Graduates will demonstrate the ability to use basic knowledge in mathematics, science and engineering and apply them to solve problems specific to mechanical engineering **(Fundamental engineering analysis skills)**.	S	Assignments, Tutorials.
PO2	Graduates will demonstrate the ability to design and conduct experiments, interpret and analyze data, and report results **(Information retrieval skills).**	H	Assignments, Tutorials, Exams.
PO3	Graduates will emonstrate the An ability to design a system, component, process to meet desired needs within appropriate constraints for public	S	Assignments,

	Health, safety, cultural, societal and environmental onsiderations.**(Creative skills).**		Tutorials, Exams
PO4	Graduates will demonstrate the ability to function as a coherent unit in multidisciplinary design teams, and deliver results through collaborative research **(Teamwork).**	S	--
PO5	Graduates will demonstrate the ability to identify, formulate and solve aeronautical engineering problems of a complex kind**(Engineering problem solving skills).**	H	Assignments, Exams
PO6	Graduates will demonstrate an understanding of their professional and ethical responsibilities, and use technology for the benefit of mankind **(Professional integrity).**	S	--
PO7	Graduates will be able to communicate effectively in both verbal and written forms **(Speaking / Writing skills).**	S	--
PO8	Graduates will have the confidence to apply engineering solutions in Global and societal contexts **(Engineering impact assessment skills).**	H	Assignments, Exams.
PO9	Graduates should be capable of self-education and clearly understand the value of life-long learning **(Continuing education awareness).**	S	---
PO10	Graduates will develop an open mind and have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues **(Social awareness).**	S	--
PO11	Graduates will be familiar with applying software methods and modern computer tools to analyze aeronautical engineering problems **(Software hardware interface).**	S	--
PO12	Graduates will have the ability to recognize the importance of professional development by pursing post graduate studies or face competitive examinations that offer challenging and rewarding carees in Aeronautical Engineering **(Successful career and immediate employment).**	S	--

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Level	Proficiency assessed by
PSO:1	**Professional skills:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	H	Lectures, Assignments
PSO:2	**Problem solving skills:** imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles	S	Tutorials
PSO:3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	S	Seminars and Projects
PSO:4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats		

N - None **S - Supportive** **H - Highly Related**

VIII. SYLLABUS:

UNIT I

Introduction – Basic Concepts : System, Control Volume, Surrounding, Boundaries, Universe, Types of Systems, Macrosopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, State, Property, Process, Exact &Inexat Differentials, Cycle – Reversibility – Quasi Static Process, Irreversible Process, Causes of Irreversibility – Energy in State and in Transition, Types, Displacement & Other forms of Work, Heat, Point and Path Functions, Zeroth Law of Thermodynamics – Concept of Temperature – Principles of Thermometry – Reference Points – Constant Volume gas Thermometer – Scales of Temperature, Ideal Gas Scale – Joule's Experiments – First Law of Thermodynamics – Corollaries – First Law applied to a Process – applied to a flow system – Steady Flow Energy Equation

UNIT II

Limitation of the First Law – Thermal Reservoir, Heat Engine, Heat Pump, Parameters of performance, Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence/Corollaries, PMM of Second Kind, Carnot's principle, Carnot cycle and its specialties, Thermodynamic scale of Temperature, Clausius Inequality, Entropy, Principle of Entropy Potentials, Gibbs and Helmholtz Functions, Maxwell Relations – Elementary Treatment of the Third Law of Thermodynamics

UNIT III

Perfect Gas Laws – Equation of State, specific and Universal Gas Constants – various Non – Flow Processes, properties, end states, Heat and Work Transfer, changes in Internal Energy –Throttling and Free Expansion Processes – Flow processes. Deviations from perfect Gas Model – Vander Waals Equation of State – Compressibility charts – variable specific Heats – Gas Tables – Phase Transformations – Triple point at critical state properties during change of phase, Dryness Fraction – Clausius – Clapeyron Equation Property tables – Mollier charts – Various Thermodynamic processes and energy Transfer – Steam Calorimetry

UNIT IV

Mixtures of perfect Gases – Mole Fraction, Mass friction Gravimetric and volumetric Analysis – Dalton's Law of partial pressure, Avogadro's Law of additive volumes – Mole fraction, Volume fraction and partial pressure, Equivalent Gas constant and Molecular Internal Energy, Enthalpy, specific Heats and Entropy of Mixture of perfect Gases and Vapour, Atmospheric air – Psychrometric Properties – Dry bulb Temperature, Wet Bulb Temperature, Dew Point Temperature, Thermodynamic Wet Bulb Temperature, Specific Humidity, Relative Humidity, Saturated Air, Vapour Pressure, Degree of Saturation – Adiabatic Saturation, Carrier's Equation – Psychrometric Charts

UNIT V

Thermodynamic Cycles : Power Cycles: Otto, Diesel, Dual Combustion cycles, Sterling cycle, Atkinsion Cycle, Ericsson Cycle, Lenoir Cycle – Description and representation on P – V and T – S diagrams, Thermal Efficiency, Mean Effective Pressure on Air Standard Basis – Comparison of Cycles

Refrigeration Cycles: Bell-Coleman Cycle – Vapour Compression Cycle – Performance Evaluation

Text Books:

1. Engineering Thermodynamics / PK Nag / TMH, 5th Edition
2. Engineering Thermodynamics / E Rathkrishnan / PHI 2nd Edition / 2013

Reference Books:

1. Engineering Thermodynamics / DP Mishra / Cengage Learning / Second impression 2012
2. Thermodynamics – An Engineering Apprach – YunusCengel& Michael Boles / TMH
3. Thermodynamics – J.P.Holman / McGrawHill
4. Engeneering Thermodynamics – Jones & Dugan
5. Engineering Thermodynamics / P.Chattopadhayay /Oxford Higher Education / Revised First Edition
6. Thermodynamics & Heat Engines – Yadav – Central Book Depot, Allahabad

VIII. Course Plan:

The course plan is meant as a guideline. There may probably be changes.

Lecture No.	Course Learning outcomes	Topics to be covered	Reference
1-2	**Explain** basic concept of thermodynamics	**UNIT– I –Basic concepts in Thermodynamics**	T1.1
3	**Define** system	Surrounding, Boundaries, Universe, Types of Systems, properties	T1.1
4	**Discuss** concepts	Concept of Continuum, Thermodynamic Equilibrium, Process, Cycle – Reversibility Quasi – static	T1.1
5-6	**Discuss** concept energy transfer by heat	Energy transfer by heat	T1.1
7-8	**Discuss** the first law of thermodynamics, Reversible & Irreversible processes	Work transfer,pdV-work,path and point function	T1.1
9-10	**Define** perfect gases, internal energy and enthalpy	Concept of quality of Temperature – Principles of Thermometry – Reference Points – Const. Volume gas	T2.2
10-11	**Discuss** Specific heats, adiabatic reversible process,	First law for a closed system,PMM-1	T2.2
11-12	**Derive** relations for thermally & calorically perfect gas	applied to a flow system – Steady Flow and Energy Equation	T2.2
		Unit II	T1.2
13-14	**Discuss** Energy reservoirs	Energy reservoirs, Kelvin-Planck and Clausius Statements	T1.4
15-16	**Explain** irreversability	Refrigerator and heat pump,causes of irreversibility	T1.2
17-20	**Derive** carnots relations	Carnot's principle, Carnot cycle and its specialties	T1.3
21-22	**Explain** principle of entropy	Entropy, Principle of Entropy Increase – Energy Equation	T1.3
23-24	**Explain** availability	Availability and Irreversibility	T1.3
		UNIT– III	T1.17
24-27	**Discuss** p-v and T-s diagrams	Pure Substances, p-V-T- surfaces, T-S and h-s diagrams	T1.17
28-31	**Explain** Mollier charts	Mollier charts VariousThermodynamic processes and energyTransfer	T1.17
32-35	**Explain** gas constants	Universal gas constants	T2.4
36-39	**Derive** vander Waals equation	Deviations from perfect Gas Model – Vander Waals Equation of State	T2.4
		Unit - IV:	T2.17
40-43	**Discuss** equation of gas laws	Avogadro's law, equation of state of gas	T2.17
44-45	**Discuss** equation of state	Ideal gas, equation of state	T2.17
46-49	**Discuss** laws of corresponding states	Laws of corresponding states	T2.17
50-53	**Define** Daltons law	Dalton's law of partial pressure	T2.17
54-58	**Discuss** and **Explain** Enthalpy	Enthalpy and specific heats of gas mixtures	T2.17
		Unit -V:	
59-60	**Discuss** various cycles	Air standard cycles ,otto cycle	T2.20
61-62	**Discuss** Diesel cycle	Diesel cycle	T2.22
63-64	**Discuss** dual cycle	Dual cycle	T2.29

65	**Compare** the cycles	Comparison of cycles .	T2.33
66	**Discuss** Brayton cycle.	Brayton cycle	T2.36
67	**Discuss** bell coleman cycle	Bell coleman cycle	T2.39

IX. MAPPING COURSE OBJECTIVES LEADING TO ACHIEVEMENT OF THE PROGRAM OUTCOMES.

Course Objectives	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
I	H	H	S	N	H	N	N	S	N	N	H	S	N	S	N	N
II	H	H	S	N	H	N	N	N	H	N	N	N	H	S	N	N
III	H	H	S	N	N	N	N	S	H	N	N	S	H	S	N	N
IV	H	H	S	S	H	N	N	N	N	N	N	S	H	S	N	N
V	H	H	S	N	H	N	N	N	N	N	N	N	N	S	N	N

S – Supportive **H - Highly Related**

X. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Objectives	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
1	H	H	S	S	H	N	S	N	N	N	N	N	N	S	N	N
2	H	H	S	N	N	S	N	S	N	N	N	S	H	S	N	N
3	H	H	S	N	H	N	S	N	H	N	N	S	H	S	N	N
4	H	H	S	N	H	N	N	S	N	N	H	S	H	S	N	N
5	H	H	S	S	H	N	S	N	H	N	H	N	N	S	N	N
6	H	H	S	N	H	N	N	S	H	N	N	S	H	N	N	N

S – Supportive **H - Highly Related**

Prepared By: Dr. D Govardhan, Professor

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