THERMAL ENGINEERING-I

Subject code: ME502PC
Regulations: R16-JNTUH
Class: III Year B. Tech MECH I Sem

Department of Mechanical Engineering
BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY
Ibrahimpatnam - 501 510, Hyderabad

THERMAL ENGINEERING-I (ME502PC)

COURSE PLANNER

COURSE OBJECTIVES AND RELEVANCE:

At the end of the course the student will be in a position to,

1. Get the basics of I.C Engine.
2. Get the idea about the combustion in IC Engines.
3. Learn about the different types of compressor and their applications.
4. Learn about the different types of Refrigeration and Air Conditioning Systems and their applications

I. COURSE PURPOSE:

Applied thermodynamics is basically focused on application of thermodynamic principles for real world applications. More specifically this course is focused on application of thermodynamic principles or laws to Internal Combustion Engines, compressors and refrigeration. The main purpose of implementing this course in curriculum is to learn about working of I.C Engines, compressors and refrigerators and their applications.

II. COURSE OBJECTIVES

S. No.	Course Objectives
The objectives of the course are:	
I.	To apply the laws of thermodynamics to Analyze the air standard cycles
II.	To Evaluate the performance of IC Engine and its systems
III.	To understand and minimize the power required in compressors
IV.	Understand the working principles of Refrigeration systems and air conditioning systems
V.	To evaluate the performance of R&AC systems

III. COURSE OUTCOMES

S. No.	Course Outcomes (CO)	Bloom's Taxonomy Level
At the end of the course, student should be able to:		
CO1	Evaluate the performance of IC Engines and compressors under the given operating conditions	Knowledge, Understand &Apply (Level 1,Level2,Level 3)

CO2	Apply the laws of thermodynamics to evaluate the performance of Refrigeration and Air Conditioning systems	Understand(Level2)
CO3	Understand the functionality of major components of IC Engines and effects of operating conditions on their performance	Understand(Level2)

IV. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (PO)		Level	Proficiency assessed by
PO1	**Engineering knowledge**: Graduates will demonstrate the ability to use basic knowledge in mathematics, science and engineering and apply them to solve problems specific	2	Assignments
PO2	**Problem analysis**: Graduates will demonstrate the ability to design and conduct experiments, interpret and analyze data, and report results.	2	Assignments
PO3	**Design/development of solutions**: Graduates will demonstrate the ability to design any mechanical system or thermal that meets desired specifications and	2	Assignments
PO4	**Conduct investigations of complex problems**: Graduates will demonstrate the ability to identify, formulate and solve mechanical engineering problems of a complex	2	Assignments
PO5	**Modern tool usage**: Graduates will be familiar with applying software methods and modern computer tools to analyze mechanical engineering problems.	1	-
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent	3	-
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge	2	-
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the	3	-
PO9	**Individual and team work**: Graduates will demonstrate the ability to function as a coherent unit in multidisciplinary design teams, and deliver results through	2	Projects
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design	2	Seminars

Program Outcomes (PO)		Level	Proficiency assessed by
PO11	**Project management and finance**: Graduate will be able to design a system to meet desired needs within environmental, economic, political, ethical health and safety, manufacturability and management knowledge and	1	Projects
PO12	**Life-long learning**: Graduates should be capable of self-education and clearly understand the value of life-long	3	Exams& conferences

1: Slight (Low) **2: Moderate (Medium)** **3: Substantial (High)** **- : None**

V. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes (PSO)		Level	Proficiency assessed by
PSO1	**Foundation of mathematical concepts:** To use mathematical methodologies to crack problem using suitable mathematical analysis, data structure and suitable algorithm.	2	Assignments
PSO2	**Foundation of Mechanical System:** The ability to interpret the fundamental concepts and methodology of Mechanical systems. Students can understand the functionality of different machine,	2	Assignments
PSO3	**Layout of plant:** The ability to grasp the knowledge of plant layout and material handling along with the systematic allocation of all the facilities.	2	Group work

1: Slight (Low) **2: Moderate (Medium)** **3: Substantial (High)** **- : None**

PRE REQUISITES:

1) Knowledge of principles of thermodynamics

VI. JNTUH SYLLABUS

UNIT – I

I.C. Engines: Classification - Working principles of Four & Two stroke engine, SI & CI engines, Valve and Port Timing Diagrams, Air – Standard, air-fuel and actual cycles - Engine systems – Carburetor and Fuel Injection Systems for SI engines, Fuel injection systems for CI engines, Ignition, Cooling and Lubrication system, Fuel properties and Combustion Stoichiometry

UNIT – II

Normal Combustion and abnormal combustion in SI engines – Importance of flame speed and effect of engine variables – Abnormal combustion, pre-ignition and knocking in SI Engines – Fuel requirements and fuel rating, anti knock additives – combustion chamber – requirements, types of SI engines. Four stages of combustion in CI engines – Delay period and its importance –

Effect of engine variables – Diesel Knock– Need for air movement, suction, compression and combustion induced turbulence in Diesel engine – open and divided combustion chambers and fuel injection– Diesel fuel requirements and fuel rating

UNIT III

Testing and Performance: Parameters of performance - measurement of cylinder pressure, fuel consumption, air intake, exhaust gas composition, Brake power – Determination of frictional losses and indicated power – Performance test – Heat balance sheet and chart Classification of compressors – Fans, blowers and compressors – positive displacement and dynamic types – reciprocating and rotary types.

UNIT – IV

Rotary Compressor (Positive displacement type): Roots Blower, vane sealed compressor, Lysholm compressor – mechanical details and principle of working – efficiency considerations.

Dynamic Compressors: Centrifugal compressors: Mechanical details and principle of operation – velocity and pressure variation. Energy transfer-impeller blade shape-losses, slip factor, power input factor, pressure coefficient and adiabatic coefficient – velocity diagrams – power.

Axial Flow Compressors: Mechanical details and principle of operation – velocity triangles and energy transfer per stage degree of reaction, work done factor - isentropic efficiency-pressure rise calculations – Polytropic efficiency

UNIT –V

Refrigeration: Mechanical Refrigeration and types – units of refrigeration – Air Refrigeration system, details and principle of operation – applications of air refrigeration, Vapour compression refrigeration systems – calculation of COP – effect of superheating and sub cooling, desired properties of refrigerants and common refrigerants- Vapour absorption system – mechanical details – working principle, Use of p-h charts for calculations

Air-Conditioning: Concepts of Psychrometry – Properties of moist air – Usage of Psychrometric Chart – Calculation of moist air properties. Types of air – conditioning systems – Requirements - schematic layout of a typical plant.

TEXTBOOKS:

1. I.C.Engines / V.Ganesan / TMH
2. Thermal Engineering / R K Rajput / Lakshmi publications
3. Refrigeration and Air-conditioning by R.S.Khumi.

REFERENCES:

4. Thermal Engineering / P.K.Nag / 3 rd edition
5. IC Engines – Mathur & Sharma – Dhanpath Rai & Sons
6. Refrigeration and Air-conditioning by R.S.Khumi
7. Engineering fundamentals of IC Engines – Pulkrabek / Pearson / PHI
8. Thermal Engineering / Rudramoorthy – TMH
9. Thermodynamics & Heat Engines / B.Yadav / Central Book Depot., Allahabad
10. I.C Engines / Heywood / McGraw-Hill

WEBSITES:

1. http://nptel.ac.in/courses/112105123/1
2. http://nptel.kmeacollege.ac.in/courses.php?disciplineId=112
3. http://nptel.ac.in/course.php

VII. LESSON PLAN- COURSE SCHEDULE (WEEK-WISE):

Lecture No.	Week No.	TOPIC	COURSE LEARNING OUTCOMES	Reference
		UNIT - 1		
1.	1	I.C. engines , Four & Two stroke engine	Understanding IC Engines	Book No. 1, 2, 4, 5
2.		SI & CI engines	Understanding the Concept of SI &CI Engines	
3.		Valve and Port Timing Diagrams	Evaluating valve and port timing functions	
4.		Fuel Injection System for SI engines	Understanding Fuel Injection System	
5.	2	Fuel Injection System for CI engines	Understanding Fuel Injection System	
6.		Ignition System	Understanding about Ignition	
7.		Cooling and Lubrication system	Understanding about Lubrication	
8.		Fuel properties and Combustion Stoichiometry	Understanding the concepts of Stoichiometry	
		UNIT – 2		
9.	3	Combustion in SI and CI Engines : Normal Combustion in SI engines	Understanding the Concept of SI &CI Engines	Book No. 1, 2, 4, 5
10.		Abnormal combustion in SI engines	Basic knowledge of SI engines	
11.		Importance of flame speed and effect of engine variables Abnormal combustion	Understanding about combustion	
12.		Pre-ignition and knocking in SI engines	Basic knowledge of pre-ignition	
		Mock Test - I		
13.	4	Fuel requirements and fuel rating-anti knock additives	Basic knowledge of antiknocking additives	
14.		Combustion chamber – requirements - types of	Understandin	

		S.I. engines.	g the function of Combustion chamber	
15.		Four stages of combustion in CI engines – Delay period and its importance	Basic Knowledge of four stages of combustion in CI engines	
16.		Effect of engine variables – Diesel Knock	Understandin g the Engine variables	
		Tutorial / Bridge Class # 1		
17.	5	Need for air movement, suction, compression and combustion induced turbulence in Diesel engines	Understandin g the need for air movement,su ction,compre ssion and combustion	
18.		Open and divided combustion chambers	Basic knowledge of combustion chambers	
19.		Fuel injection	Understandin g the fuel injection	
20.		Fuel requirements and fuel rating.	Basic knowledge of Fuel requirements	
		Tutorial / Bridge Class # 2		
		UNIT – 3		
21.	6	Testing and Performance of Engines	Basic knowledge of Performance of Engines	Book No. 1, 2, 4, 5
22.		Measurement of cylinder pressure,	Evaluation of cylinder pressure	
23.		Measurement of air intake,	Evaluation of air intake	
24.		Measurement fuel consumption	Evaluation fuel	

			consumption	
		Tutorial / Bridge Class # 3		
25.	7	Measurement of exhaust gas composition	Evaluation of exhaust gas composition	
26.		Brake power ,Performance test	Understanidng the Knowledge of Brake power	
27.		Heat balance sheet and chart	Understanidng Heat balance sheet	
28.		Problems on Performance test	Numericals	
		Tutorial / Bridge Class # 4		
29.	8	Problems on Performance test	Numericals	
30.		Problems on Heat balance sheet	Numericals	
31.		Problems on Heat balance sheet	Numericals	
32.		Revision		
		Tutorial / Bridge Class # 5		
		I Mid Examinations		
33.	9	Classification of Compressors – Fans, blowers and compressors	Basic knowledge of Compressors	Book No. 1, 2, 4, 5
34.		Positive displacement and dynamic types	Understanidng Positive displacement compressors	
35.		Reciprocating types.	Understandin g the knowledge of reciprocating type of Engines	
36.		Rotary types	Understandin g the knowledge of Rotary type of Engines	
		Tutorial / Bridge Class # 6		
		UNIT – 4		
37.	10	Roots Blower–mechanical details and principle of working	Understandin g the knowledge of Roots blower	

38.		Mechanical details, principle working of Vane sealed compressor	Understanding the Knowledge of Vane sealed compressors	Book No. 1, 2, 4, 5
39.		Mechanical details, principle working of Lysholm compressor	Understanding the knowledge of Lysholm compressor	
40.		Efficiency considerations.		
		Tutorial / Bridge Class # 7		
41.	11	Mechanical details, principle working of Centrifugal compressors:	Understanding the working of Centrifugal compressors:	
42.		Velocity and Pressure variation, Energy transfer of impeller blade shape	Understanding the knowledge of Energy transfer of impeller blade shape	
43.		Losses, slip factor, power input factor, Pressure coefficient	Understanding about Losses,	
44.		Adiabatic coefficient, Velocity diagrams – power.	Basic knowledge of Velocity diagrams	
		Tutorial / Bridge Class # 8		
45.	12	Mechanical details and principle of operation Compressors	Understanding the principle of operation Compressors	
46.		Velocity triangles and energy transfer per stage degree of reaction	Understanding the Velocity triangles	
47.		Work done factor - isentropic efficiency	Understanding the Workdone factor	

48.		Pressure rise calculations –Polytrophic efficiency.	Numericals	
		Tutorial / Bridge Class # 9		
		UNIT – 5		
49.		Mechanical Refrigeration and types - Units of refrigeration	Basic knowledge of Mechanical Refrigeration	
50.		Air Refrigeration system, details and principle of operation	Understanding the principle of Air Refrigeration system	
51.	13	Applications of Air refrigeration	Understanding about the applications of Air refrigeration	
52.		Mechanical details of Vapour compression refrigeration system	Understanding about Vapour compression refrigeration system	Book No. 3
		Mock Test - II		
53.		Calculation of COP	Numericals	
54.		Problems on Vapour Compression refrigeration system	Numericals	
55.	14	Effect of super heating and sub cooling	Understanding about super heating and sub cooling	
56.		desired properties of refrigerants and common refrigerants	Understanding about desired properties of refrigerants	
		Tutorial / Bridge Class # 10		
57.	15	Mechanical details of Vapour Absorption System.	Understanding about Vapour Absorption	

			System.	
58.		Working principles of Vapour Absorption System.	Understanding the Working principles of Vapour Absorption System.	
59.		Use of p-h charts for calculations.	Numericals	
60.		Problems on Vapour Absorption System.	Numericals	
		Tutorial / Bridge Class # 11		
61.	16	Revision		
62.		Revision		
63.		Revision		
64.		Revision		
		Tutorial / Bridge Class # 12		
		II Mid Examinations		

VIII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcomes	Program Outcomes (PO)												Program Specific Outcomes (PSO)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	3	1	3	2	2	1	3	2	2	1
CO2	3	3	2	2	1	3	1	3	2	2	1	3	2	2	1
CO3	1	1	2	2	1	3	3	3	2	2	2	3	1	2	2

1: Slight(Low) 2: Moderate(Medium) 3: Substantial (High) - : None

IX. QUESTION BANK: (JNTUH)

Short Answer Questions:

Q. No	Questions	Blooms Taxonomy Level	Course Outcome

Unit-I			
1	What is valve timing diagram why the inlet valve is opened before TDC and closed after BDC?	Knowledge	1
2	What is fluid friction in an engine?	Knowledge	1
3	What is an internal combustion engine?	Knowledge	1
4	What are the products formed during combustion process	Understand	2
5	What is scavenging?	Understand	2
6	What is meant by compression ratio?	Understand	2
7	What do you mean by SFC?	Apply	3
8	Define mean effective pressure	Understand	2
9	Define firing order	Understand	2
Unit-II			
1	What is the normal combustion and abnormal combustion in SI engine?	Understand	2
2	What is called flame front and flame velocity?	Knowledge	1
3	What is knocking in both SI and CI engines?	Knowledge	1
4	What decides severity of knocking in both SI and CI Engines?	Knowledge	2
5	What is pre ignition and optimum ignition timing?	Knowledge	1
6	What are anti-knock agents? Main difference between working of antiknock agent in SI and CI Engines?	Knowledge	1
7	What is a combustion chamber? What are the different combustion zones in combustion chamber	Understand	2
8	What is mixture strength? How it influences the combustion?	Knowledge	1
9	What is ignition delay period?Define suction induced swirl and combustion induced swirl?	Understand	2
UNIT-III			
1	Define mean effective pressure. How is it related to in power of an I.C. engine?	Knowledge	1
2	What is meant by single acting compressor?	understand	2
3	What is meant by double acting compressor?	Understand	2

4	Define isentropic efficiency?	Understand	2
5	What factors limit the delivery pressure in reciprocating compressor?	Knowledge	1
6	What is compression ratio? What is meant by inter cooler?	knowledge	1
7	Define brake power, Define mechanical efficiency.	Knowledge	1
8	.List the devices used to measure the cylinder pressure	Knowledge	1
9	What is an indicated power? What are the various losses of IC Engine?	Knowledge	1
10	How do you determine heat losses explain with sankey diagram?	Knowledge	1
11	Define clearance ratio.	knowledge	1
12	What is the function of air compressor?	knowledge	1
13	What is volumetric efficiency in case of compressor?	knowledge	1
	UNIT-IV		
1	Draw neat sketch of simple vapor compression refrigeration system and explain. What are desired properties of refrigerants?	knowledge	1
2	Explain with sketch the working principle of aqua Ammonia refrigeration system.	knowledge	1
3	Describe a simple vapour compression cycle giving clearly its flow diagram	Knowledge	1
4	Explain with sketch the working principle of water-Lithium bromide refrigeration system	knowledge	1
5	What are the factors that affect the performance of a vapour compression system?	understand	2
6	Explain with neat sketch the working of a vapour absorption system	knowledge	1
	UNIT-V		
1	Name four important properties of a good refrigerant.	understand	2
2	What is the difference between air conditioning and refrigeration	Knowledge	1
3	What is the function of the throttling valve in vapour compression geration system?	Knowledge	1

4	In a vapor compression refrigeration system, where the highest temperature will occur?	knowledge	1
5	Name any four commonly used refrigerants	understand	2
6	The vapour absorption system can use low-grade heat energy in the generator. Is true of false	understand	2
7	Why throttle valve is used in place of expansion cylinder for vapour compression refrigerant machine	understand	2
8	Explain unit of Refrigeration	understand	2
9	What is the effect of sub cooling a refrigerant in a vapour compression cycle?	knowledge	1
10	What are the properties of good refrigerant	knowledge	1

Long Answer Questions:

Q. No	Questions	Blooms Taxonomy Level	Course Outcome
	UNIT – I		
1	Give classification of IC Engines.	Knowledge	1
2	Distinguish between SI engines and CI engines	Knowledge	1
3	Sketch and explain the valve timing diagram of a four stroke Otto cycle engine?	Knowledge	1
4	In what respect two stroke engines differs from 4-stroke engine Discuss?	Understand	2
5	List out the properties of fuel for (i) SI engine (ii) CI engine	Understand	2
6	Explain lubrication system for IC engines?	Knowledge	1
6	Explain fuel injection system of an SI engine?	Knowledge	1
7	Explain cooling system for IC engines?	Understand	2
8	Discuss the importance of cooling system for an IC engines. Describe different cooling systems?	Understand	2

9	What are the different lubrication systems available for IC engines?	Understand	2
UNIT – II			
1	Explain the various factors that influence the flame speed	Knowledge	1
2	What is delay period and what are the factors effecting the delay period	Knowledge	1
3	What is meant by abnormal combustion? Explain the phenomenon of knock in S.I. engine	Apply	3
4	What is ignition lag in S.I. engine and how does it affect performance.	Apply	3
5	What are the various types of combustion chambers used in S.I. engines? Explain them briefly.	Apply	3
6	Explain the various factors that influence the flame speed	Apply	3
7	Describe the phenomenon of pre-ignition in S.I. engines and discuss its effect on the performance.	Apply	3
8	Briefly explain the stages of combustion in S.I. engines elaborating the flame front propagation	Apply	3
9	List the parameters by which performance of an engine is evaluated.	Apply	3
10	Explain the phenomenon of knock in CI engines and compare it with SI engine knock	Apply	3
UNIT-111			
1	The following data to a particular twin cylinder two stroke diesel engine. Bore 15 cm stroke 20 cm. speed 400 rpm. Indicated mean effective pressure 4 bar, dead weight on the brake drum 650 N. spring balance reading 25 N Diameter of the brake drum 1 m. Fuel consumption 0.075 kg/min and calorific value of the fuel is 44500 KJ/kg. Determine: 1) Indicated Power 2) Brake Power 3) Mechanical efficiency 4) Indicated thermal efficiency 5) Brake thermal efficiency	analyze	4
2	What is the influence of intake temperature, intake pressure, clearance and compression and expansion indices on the performance of reciprocating air compressor?	Knowledge	1

3	Explain the use of prong brake and rope brake in measuring the power output of an engine.	Knowledge	1
4	A four stroke gas engine having a cylinder of 250 mm diameter and stroke 450 mm has a volumetric efficiency of 80%, ratio of air to gas is 8: 1, and calorific value of gas is 20 MJ/m^3 at NTP. Find the heat supplied to the engine per working cycle. If the compression ratio is 5, what is the heating value of the mixture per working stroke per m^3 of total cylinder volume?	Apply	3
5	Explain the principle involved in the measurement of brake power	Knowledge	1
6	Explain the method of measurement of smoke?	Knowledge	1
7	By means of sankey diagram explain the energy flow through an engine	Knowledge	1
8	Explain the following as referred to air compressors: (i) Isothermal efficiency, (ii) Volumetric efficiency.	Knowledge	1
9	Describe the methods of finding friction power using Morse test.	Knowledge	1
	UNIT –IV		
1	Describe with diagrams axial flow compressor.	Apply	3
2	Differentiate centrifugal and axial flow compressors	Apply	3
3	Explain the velocity diagrams of an axial-flow compressor	Apply	3
4	An axial flow compressor draws air at 22^0C and compresses it in the pressure ratio of 4:1 the mean blade speed and flow velocity are constant throughout the compressor, Assuming 50% reaction blading , taking isentropic efficiency of 85% and blade velocity as 190 m/s , work input factor as 0.82. Determine: i) Flow velocity ii) Number of stages, take $\alpha 1 = 120$, $\beta 1 = 400$	Analyze	4
5	An 8 stage axial flow compressor takes in air at 200^0C at the rate of 180 kg/min. The pressure ratio is 6 and isentropic efficiency is 0.9. Determine the power required.	Analyze	4

6	Prove that with 50% reaction blading, axial flow compressors have symmetrical balding.	Knowledge	1
7	Explain the working an axial flow compressor with a neat sketch?	Apply	3
8	An axial flow compressor having six stages with 50% reaction compresses air in the pressure ratio of 4:1. The air enters the compressor at 21^0C and flows through it with a constant speed of 100 m/s. The rotating blades of compressor rotate with a mean speed of 180 m/s, isentropic efficiency of the compressor is 85%. Determine i) work done, ii) blade angles	Understand	2
9	What is degree of reaction? Draw the velocity diagrams of an axial flow Compressor when the degree of reaction is 0.5	Apply	3

UNIT-V			
1	Draw neat sketch of simple vapor compression refrigeration system and explain.	Apply	3
2	Explain with sketch the working principle of aqua Ammonia refrigeration system.	knowledge	1
3	Describe a simple vapour compression cycle giving clearly its flow diagram?	Knowledge	1
4	What are the factors that affect the performance of a vapour compression system?	Apply	3
5	Explain with sketch the working principle of water-Lithium bromide refrigeration system.	Apply	3
6	What are desired properties of refrigerants?	Apply	3
7	Explain with neat sketch the working of a vapour absorption system?	Apply	3
8	A simple vapour compression plant produces 5 tonnes of refrigeration. The enthalpy values at inlet to compressor, at exit from the compressor, and at exit from the condenser are 183.19, 209.41 and 74.59 kJ/kg respectively. Estimate: (i) The refrigerant flow rate, (ii) The C.O.P., (iii) The power required to drive the compressor, and (iv) The rate of heat rejection to the condenser	Analyze	4
9	a) Describe the properties of ideal refrigerant – absorbent 1. combination b) Derive an expression to find out the coefficient of performance of the absorption refrigeration system	Apply	3

10	a) What are the desirable characteristics of a Refrigerant - 2. Absorbent pair b) With the help of T-S and P-H charts explain the working of air refrigeration system working on Bell Colemann cycle.	Apply	3

OBJECTIVE QUESTIONS

JNTUH Examination :

UNIT-I

1. In diesel engine the air-fuel mixture is ignited by _____.
2. A two stroke engine may be identified by _____.
3. In a petrol engine mixing of fuel and air occurs in _____.
4. In a diesel engine mixing of fuel and air occurs in _____.
5. As compared to 4 Stroke engine the SFC in 2 Stroke engine is _____.
6. In _____ revolution of the crankshaft are the operation are completed in 4 Stroke engine.
7. Carburetor is used in _____ engine to provide air-fuel mixture.
8. Fuel injector is used in _____ engine.
9. The range of compression ratio in diesel engine is _____.
10. The range of compression ratio in petrol engine is _____.

UNIT- II

1. The knocking tendency in S.I engine reduces with increasing_____.
2. Detonation in S.I .engine can be prevented by_____.
3. Self-ignition of the charge by hot spot in the combustion chamber is _____.
4. Pre –ignition in an engine may be detected by_____.
5. The knocking tendency of a fuel in S.I engine is expressed by _____ number.
6. Increase in compression ratio _____ the flame speed.
7. The rating of C.I engine fuel is given by _____.
8. The self ignition temperature of diesel compared to petrol is _____.
9. Detonation in C.I engine is caused due to _____ delay period.
10. In C.I. engine knocking occurs at _____ of combustion.

UNIT- III

1. The ratio of indicated thermal efficiency to corresponding air standard efficiency is called _____.
2. Morse test is used for multi-cylinder S.I engine to determine _____.
3. Specific fuel consumption is expressed in _____.
4. The thermal efficiency of high speed diesel engine is in the order of _____.
5. The mechanical efficiency of an internal combustion engine is of the order _____.
6. The ratio of BP to IP is known as _____.
7. The ratio BMEP to IMEP gives _____.
8. In terms of torque and RPM, the BP of engine is _____.
9. Brake thermal efficiency is always _____than indicated thermal efficiency.
10. Sankey diagram represents _____.

UNIT-IV

1. Work required to run the compressor is minimum if the compression is _____.
2. In double acting compressor, the air is compressed _____.
3. By used multi-stage compressor with intercooler, a large amount of work will be _____.
4. The volumetric efficiency of air compressor is in the order of _____.
5. The IP of the compressor to the shaft power of the motor is called as _____.
6. Multistage compression gives _____.
7. By providing intercooler between the stages, the work required for compression is _____.
8. If air is compressed in two or more stages in separate cylinders, then the compressor is called _____.
9. The compressor generally used in aircraft engine is _____ compressor.
10. Rotary compressors are used for delivery of _____ quantity of air at _____ pressure.

UNIT-V

1. One Ton of refrigeration is the rate of heat removal at _____.
2. Air refrigeration system operates on _____.
3. In Vapour compression refrigeration system, throttling process takes place in the _____.
4. In Vapour compression refrigeration system, the equipment located between compressor and expansion valve is _____.
5. Coefficient of performance of refrigerator is _____ than one.
6. In a refrigeration system heat is rejected from the refrigerant in a _____.
7. Vapour absorption system makes use of _____.
8. In domestic refrigerator capillary tube is used as _____.
9. COP of Bell-Coleman cycle is _____.
10. _____ is a substance used for heat transfer in a refrigeration system.

X. GATE QUESTIONS:

1. Air enters a diesel engine with a density of 1.0 kg/m3. The compression ratio is 21. At steady state,the air intake is 30 × 10-3 kg/s and the net work output is 15 kW. The mean effective pressure (inkPa) is _____

2. The COP of a Carnot heat pump operating between 6 °C and 37 °C is _____

3. A rope-brake dynamometer attached to the crank shaft of an I.C. engine measures a brake power of 10 kW when the speed of rotation of the shaft is 400 rad/s. The shaft torque (in N-m) sensed by thedynamometer is _____

4. For the same values of peak pressure, peak temperature and heat rejection, the correct order ofefficiencies for Otto, Dual and Diesel cycles is

5. An air-standard Diesel cycle consists of the following processes:
   1-2: Air is compressed isentropically.

2-3: Heat is added at constant pressure.
3-4: Air expands isentropically to the original volume.
4-1: Heat is rejected at constant volume.
If γ and T denote the specific heat ratio and temperature, respectively, the efficiency of the cycle is ---

6. Refrigerant vapor enters into the compressor of a standard vapor compression cycle at -10°C (h = 402 kJ/kg) and leaves the compressor at 50°C (h = 432 kJ/kg). It leaves the condenser at 30°C(h = 237 kJ/kg). The COP of the cycle is _____

7. Air in a room is at 35°C and 60% relative humidity (RH). The pressure in the room is 0.1 MPa. The saturation pressure of water at 35°C is 5.63 kPa. The humidity ratio of the air (in gram/kg of dryair) is _____

8. Propane ($C3H_8$) is burned in an oxygen atmosphere with 10% deficit oxygen with respect to thestoichiometric requirement. Assuming no hydrocarbons in the products, the volume percentage of CO in the products is _____

9. The heat removal rate from a refrigerated space and the power input to the compressor are 7.2 kW and 1.8 kW, respectively. The coefficient of performance (COP) of the refrigerator is _____

10. A piston-cylinder device initially contains 0.4 m3 of air (to be treated as an ideal gas) at 100 kPa and 80oC. The air is now isothermally compressed to 0.1 m3. The work done during this process is _____ kJ. **(Take the sign convention such that work done on the system is negative)**

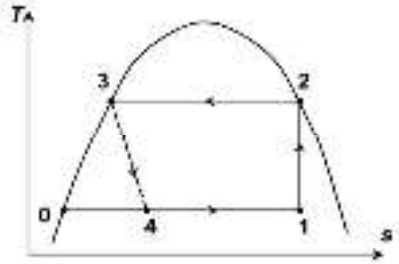
11. A refrigerator uses R-134a as its refrigerant and operates on an ideal vapour-compression refrigeration cycle between 0.14 MPa and 0.8 MPa. If the mass flow rate of the refrigerant is 0.05kg/s, the rate of heat rejection to the environment is _____ kW.
Given data:
At P = 0.14 MPa, h=236.04 kJ/kg, s= 0.9322kJ/kg-K
At P = 0.8 MPa, h= *272.05*kJ/kg (superheated vapour)
At P = 0.8 MPa, h=*93.42* kJ/kg (saturated liquid)

12. The partial pressure of water vapour in a moist air sample of relative humidity 70% is 1.6 kPa, the total pressure being 101.325 kPa. Moist air may be treated as an ideal gas mixture of water vapour and dry air. The relation between saturation temperature (Ts in K) and saturation pressure (p inkPa) for water is given by $\ln(ps/po) = 14.317 - 5304/Ts$, where p = 101.325 kPa. The drybulb temperature of the moist air sample (in □C) is _____

13. In a mixture of dry air and water vapor at a total pressure of 750 mm of Hg, the partial pressure of water vapor is 20 mm of Hg. The humidity ratio of the air in grams of water vapor per kg of dry air (gw/kgda) is _____

14. In a 3-stage air compressor, the inlet pressure is $p1$, discharge pressure is p_4 and the intermediate pressures are $p2$ and $p3$ ($2< p3$). The total pressure ratio of the compressor is 10 and the pressureratios of the stages are equal. If $p1$ = 100 kPa, the value of the pressure $p3$ (in kPa) is _____

15. In the vapour compression cycle shown in the figure, the evaporating and condensing temperaturesare 260 K and 310 K, respectively. The compressor takes in liquid-vapour mixture (state 1) and isentropically compresses it to a dry saturated vapour condition (state 2). The specific heat of the liquid refrigerant is 4.8 kJ/kg-K and may be treated as constant. The enthalpy of evaporation for the refrigerant at 310 K is 1054 kJ/kg.



The difference between the enthalpies at state points 1 and 0 (in kJ/kg) is _____

IES QUESTIONS:

1. In the centrifugal compressor the work input is equal to sum of: (a) pressure head, relative head and dynamic head (b) dynamic head, centrifugal head and relative head (c) pressure head, centrifugal head and dynamic head (d) pressure head, centrifugal head and relative head
2. For a centrifugal compressor with radial vanes, slip factor is the ratio of: (a) isentropic work to Euler work (b) whirl velocity to the blade velocity at the impeller exit (c) stagnation pressure to static pressure (d) isentropic temperature rise to actual temperature rise
3. The specific speed of a centrifugal compressor is generally: (a) less than that of reciprocating compressor (b) independent of compressor type, but depends only on size of compressor (c) higher than that of axial compressor (d) more than specific speed of reciprocating compressor but less than axial compressor.
4. In a centrifugal compressor, the highest Mach number leading to shock wave in the fluid flow occurs at: (a) diffuser inlet radius (b) diffuser outlet radius (c) impeller inlet radius (d) impeller outlet radius.
5. In a centrifugal compressor, an increase in speed at a given pressure ratio causes: (a) increase in flow and increase in efficiency (b) increase in flow and decrease in efficiency (c) decrease in flow and increase in efficiency (d) decrease in flow and decrease in efficiency
6. In an axial flow compressor, the ratio of pressure rise in the rotor blades to the pressure rise in the compressor in one stage is known as: (a) pressure coefficient (b) work factor (c) degree of reaction (d) slip factor

XI. GATE Syllabus:

I.C. Engines: Air-standard Otto, Diesel and dual cycles. Refrigeration and air-conditioning: Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes. Turbomachinery: Impulse and reaction principles, and Compressors

IES SYLLABUS:

CI Engines and SI Engines; Two-stage compressors; Pre-ignition, Final ignition and Carburation, Detonation, Diesel knock; Emission and control, Flame gas analysis, Measurement of Calorific values, Engine cooling.

XII. SUBJECT EXPERTS:

1. Dr.V. Ganeshan, Professor of Mechanical Engineering IIT Madras.
2. Dr.A.V.S.S.K.S.Guptha, Professor of Mechanical Engineering, JNTU, Hyderabad.

XIII. JOURNALS:

1. www.journals.elsevier.com/the-journal-of-chemical-thermodynamics/
2. www.researchgate.net/journal/1874- 396X_The_Open_Thermodynamics_Journal
3. www.springer.com/physics/classical continuum physics/journal/161
4. www.linkedin.com/in/thermodynamics
5. gulib.georgetown.edu/newjour/i/msg04317.htm
6. www.nist.gov/mml/acmd/peer-090913.cfm
7. engineeringpdf.com/thermodynamics-pdf.html

XIV. SEMINARS:

1. Types of IC Engines
2. Combustion in SI Engines
3. Combustion in C I Engines
4. Testing, and Performance of IC Engines
5. Reciprocating Compressors:
6. Dynamic Compressors

XV. CASE STUDIES/SMALL PROJECTS:

1. Types of IC Engines
2. Testing and performance of I C Engines
3. Performance study of Centrifugal Compressors
4. Study of Heavy-duty Industrial Compressors