

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

**COURSE CURRICULUM
COURSE TITLE: THERMAL ENGINEERING-II
(COURSE CODE: 3351901)**

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	5 th Semester

1. RATIONALE.

Subject knowledge of thermal engineering is required in many industries. The objective of this course is to establish basic fundamental and practical knowledge in the field of internal combustion engine, refrigeration, air conditioning, eco-friendly fuels, etc. These are major fields of mechanical engineering. Student will be able to understand different systems and apply its competencies in major fields in related industries. Knowledge of alternate fuels is required as emerging field and today's need of society which will be provided by the course content.

2. LIST OF COMPETENCY.

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competencies:

- **Apply concepts, laws and principles of thermal engineering to operate & maintain the machines/ equipment/ devices.**

3. COURSE OUTCOMES (COs).

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- i. Analyze performance of ICEs by operating them and observing changes in thermodynamic properties during each stroke of ICEs (and by using thermodynamic diagrams.)
- ii. List characteristics and properties of alternate fuels used for ICEs.
- iii. Analyse the performance of Vapour Compression Refrigeration System (VCRS), by operating them and observing the changes in properties of refrigerant during each process on VCRS (and using thermodynamic charts/diagrams.)
- iv. Explain working of various air-conditioning equipments and aids including ducts and fans
- v. Carryout maintenance task by using suitable tools and equipment

4. TEACHING AND EXAMINATION SCHEME.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
L	T	P		Theory Marks		Practical Marks		Total Marks
2	0	2	4	ESE	PA	ESE	PA	
				70	30	20	30	

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, ESE -End Semester Examination; PA - Progressive Assessment.

5. COURSE DETAILS.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Internal combustion engines.	1a. Classify ICES 1b. Compare ICE with External Combustion engine- ECE 1c. Explain the working principle of the ICES 1d. Describe ICES with classification. 1e. Explain terminology used in ICES. 1f. Describe working of ICES with functions of each element. 1g. Describe combustion process in CI & SI engines. 1h. List the steps to perform testing of ICES.	1.1 IC Engine-concept (comparison with External Combustion engine- EC), classification, working principle and terminology used. 1.2 Main components of IC engine and their functions. 1.3 Petrol engines (Spark Ignition-SI) & diesel engines (Compression Ignition-CI)-two strokes and four strokes both: i) Working principles. ii) Cycles on P-V and T-s diagram. iii) Elements-sketch, working and functions. iv) Various systems- cooling, fuel injection (includes carburetion, fuel pump, fuel injectors, Multi Point Fuel Injection (MPFI), etc.), ignition, governing (quality, quantity and hit and miss governing), exhaust, etc. v) Comparison between SI & CI Engines. vi) Theoretical and actual valve timing diagrams. 1.4 MPFI- need and working. 1.5 Concept of scavenging and turbocharger.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		turbocharger. 1.6 Concept of Common Rail Direct Injection System-(CRDI) for diesel engine. 1.7 Performance testing of IC engines and its heat balance sheet (Simple numerical examples) with familiarization with testing as per BIS.
Unit- II Alternate fuels.	2a. List characteristics and properties of fuels used for ICEs. 2b. Explain needs and types of alternate fuels & their applications. 2c. Explain system requirements for alternate fuels with suitable diagrams.	2.1 Alternatives fuels: Types, properties, compositions, advantages, disadvantages and implementation issues- includes mainly Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG) and Biodiesel. Effect of these fuels from pollution point of view. 2.2 Supply system requirement for CNG and LPG as alternate fuel in vehicle. 2.3 Conversion devices/ kits for SI Engines- vaporizer/ PRV for fuel compatibility, piping and allied needs.
Unit- III Refrigeration.	3a. Describe the processes and elements of VCRS with functions of each element. 3b. Operate VCRSs, observe the changes in properties of refrigerant during each process on VCRS and calculate / analysis the performance using thermodynamic charts/ diagrams. 3c. List characteristics of refrigerants used for VCRSs. 3d. Explain thermodynamic cycles based on second law of thermodynamics by using thermodynamic diagrams. 3e. Detect the leakages in VCRS by using appropriate tools and equipment. 3f. Evacuate and recharge the refrigerant in VCRS.	3.1 Introduction to refrigeration. 3.2 Reversed Carnot cycle & Bell column cycle. (No numerical) 3.3 Unit of refrigeration & basic terminology. 3.4 Vapor compression refrigeration cycle (VCRS), working with the help of P-V, T-s & P-h diagrams. 3.5 VCRS components, types, their construction, working, applications, (components include compressor- Reciprocating, Rotary, Screw and scroll; condensers- Air cooled and water cooled; evaporators- Dx type, flooded, shell and tube type; expansion devices -Automatic, thermostatic expansion valve and capillary tube, High side float valve).

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	3g. Perform various refrigerant tubing operations.	3.6 Performance of VCRS based on coefficient of performance (COP), simple numerical. 3.7 Effect of change in operating conditions (condenser pressure, evaporator pressure, sub cooling, superheating) on performance of VCRS & its representation on P-h diagram (with suitable numerical examples). 3.8 Application of VCRS: Ice Plant, cold storage, water cooler, domestic refrigerator, deep freezer- block diagram, components, working. 3.9 Basic concept of Vapor absorption refrigeration system. 3.10 Refrigerant classification, Desirable properties of refrigerants, and properties & applications of commonly used refrigerants including R22, R134a, Hydro Carbon-HC and R717 (Ammonia), need of new refrigerants.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit-IV Air-Conditioning	4a. Plot and interpret various air conditioning processes on psychometric chart. 4b. Measure various air properties. 4c. Explain working of various air-conditioning equipment.	4.1 Introduction to air conditioning. 4.2 Air conditioning- types and its applications. 4.3 Psychrometry- properties of air. 4.4 Representation of psychrometry properties on chart (simple numerical using chart). 4.5 Various air conditioning processes on psychometric charts. 4.6 Dessert cooler, window and split air conditioners- components and working. 4.7 Ducts- need, types with applications, constructional materials, and installation, common troubles with their remedies. 4.8 Air conditioning fans-types, constructional features, applications and common troubles with their remedies.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY).

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Internal Combustion (I. C.) Engines.	11	10	8	8	26
II	Alternate Fuels.	02	4	2	0	6
III	Refrigeration.	10	8	8	8	24
IV	Air-Conditioning.	05	4	4	6	14
	Total	28	26	22	22	70

Legends: R = Remember U= Understand; A= Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

NOTES:

1. This specification table shall be treated as only general guideline for students and Teachers. The actual distribution of marks in the question paper may vary from above Table.

2. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.
3. If midsem test is part of continuous evaluation, unit numbers I (Up to 1.3 only) and III (Up to 3.8 only) are to be considered.
4. In the optional numerical question, numerical of same chapter should be asked.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills (**outcomes in psychomotor and affective domain**) so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

*Note: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes** (as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx. Hours. required
1	ALL	Preparatory Activity: <ol style="list-style-type: none"> a. Student will recall and write basic thermodynamic units. b. Teacher will demonstrate working of I.C. Engine. <ol style="list-style-type: none"> i) Demonstrate and explain working and function of I.C. Engine. ii) Demonstrate working of two stroke and four stroke engine. 	02
2	I	Demonstration of IC engine parts: <ol style="list-style-type: none"> a. Demonstrate and explain dismantling, assembling, working and inspection of fuel pump, fuel injector, carburetor and multipoint fuel injection system. b. Sketch and explain working of fuel pump, fuel injector, carburetor and multipoint fuel injection system. c. List dismantling and assembling methods/ steps in logical sequence. d. Record observations during inspection. 	04
3	I	Valve timing diagram: <ol style="list-style-type: none"> a. Write specifications of IC engine undertaken for valve timing diagram. 	02

		<ul style="list-style-type: none"> b. Perform and record angles and strokes. c. Prepare valve timing diagram. d. Interpret valve timing diagram. 	
4	I	<p>Perform test and prepare heat balance sheet of IC Engine. (Petrol and Diesel-both separately);</p> <ul style="list-style-type: none"> a. Write specifications of IC engine undertaken for test. b. Demonstrate and perform test on IC engine. c. Observe and record test parameters. d. Derive required parameters- Indicated Power (IP), Break Power (BP), fuel consumption for varying load, efficiency, etc. e. Observe and record parameters required for heat balance sheet (For full load conditions). f. Prepare heat balance sheet. g. Interpret test results and heat balance sheet. 	04
5	III	<p>Refrigeration tubing operations:</p> <ul style="list-style-type: none"> a. Demonstrate VCRS on any car/Bus from tubing point of view. b. Demonstrate various tubing tools and tubing operations. c. Perform various tubing operations. d. Sketch and explain VCRS demonstrated on any vehicle. e. Sketch and explain various tools used for refrigeration tubing. f. Describe tubing operations with neat sketches. Also state applications of each. 	02
6	III	<p>Leak detection, evacuation and refilling of the refrigerant:</p> <ul style="list-style-type: none"> a. Demonstrate leak detection, evacuation and refilling of refrigerant. b. Demonstrate working of equipment / tools / instruments / devices used to demonstrate leak detection, evacuation and refilling of refrigerant. c. Explain various leak detection techniques. d. Sketch and explain working of equipment / tools / instruments / devices used to demonstrate leak detection, evacuation and refilling of refrigerant. e. List and explain the steps followed to perform leak detection, evacuation and refilling of refrigerant. f. Conclude your observations. 	04
7	III	<p>COP of VCRS:</p> <ul style="list-style-type: none"> a. Sketch block diagram of VCRS. b. Write specifications of each component of VCRS taken for performance. (Of compressor, condenser, expansion device and evaporator). c. Perform, observe and record the parameters required to determine refrigeration effect (RE), work done (WD), mass flow rate and COP. 	02

		<p>d. Determination RE, WD, mass flow rate and COP.</p> <p>e. Plot the actual VCRS cycle on P-h chart and T-s diagram.</p> <p>f. Interpret the performance.</p>	
8	III	<p>Determination of properties of air:</p> <p>a. List and define various properties of air.</p> <p>b. List, sketch, demonstrate and explain working of various psychometric instruments.</p> <p>c. Perform, observe and record the properties.</p> <p>d. Calculate properties (Teacher will assign) of air from the readings taken.</p> <p>e. Given the data (Teacher will assign the data for four to five processes.), plot the processes on psychometric chart.</p>	02
9	III	<p>Determination of capacity of window / split air-conditioner.</p> <p>a. Sketch block diagram of setup.</p> <p>b. Perform, observe and record the parameters required to determine the capacity.</p> <p>c. Determine the capacity.</p> <p>d. Thumb rules to estimate the capacity.</p>	02
10	IV	<p>Industrial visit: (ANY TWO)</p> <p>a. Visit cold storage plant, ice plant and air-conditioning plant to observe VCRS, different kinds of ducting.</p> <p>b. Visit any Industry working on I C Engine manufacturing/ running or power plant working on I C Engine. (D.G. Power Plant.)</p> <p>c. Visit any petrol/ diesel/ CNG/ LPG station and study different fuel filling systems along with different parameters affected.</p> <p>d. Student will visit and prepare industrial visit report.</p>	04
Total Hours			28

Notes:

- a. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher. PA component of practical marks is dependent on continuous and timely evaluation of exercises.
- b. Term work report must not include any photocopy/ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only.
- c. Student activities are compulsory and are part of term work.
- d. Term work content of industrial visit report should also include following.
 - i. Brief details of industry/ site visited.
 - ii. Type, location, processes / products, rough layout, human resource, etc of industry.
 - iii. Details, description and broad specifications of machineries/ processes observed.
 - iv. Safety norms and precautions observed.

- v. Student's own observation on industrial environment, productivity concepts, quality consciousness and quality standards, cost effectiveness, culture and attitude.
- vi. Any other details / observations asked by accompanying faculty.
- e. For practical ESE part, students are to be assessed for competencies achieved. They should be assigned the necessary data and should be given to:
 - i. Any one performance type experience to perform.
 - ii. Identify the locations of parts on VCRS and ICEs and to explain functions of them.

8. SUGGESTED LIST OF STUDENT ACTIVITIES

SR.NO.	ACTIVITY
1	Enlist I C Engine specifications at your institute.
2	Prepare Charts of ICE systems.
3	Prepare chart of CNG/LPG/Diesel/ Petrol engine fuelling system.
4	Search different ICE components from scrap and identify type of defect/ failure.
5	Visit any Industry working on I C Engine manufacturing/ running or power plant working on I C Engine.
6	Visit any petrol/ diesel/ CNG/ LPG station and study different fuel filling systems along with different parameters affected.
7	Enlist VCRS system specifications at your institute.
8	Prepare chart VCRS/ VARS.
9	Visit cold storage plant, ice plant and air-conditioning Plant to observe VCRS or VARS, different kinds of ducting. After visit, student should submit detail industrial report of his understanding.
10	Preparation of small model of VCRS.
11	Built up/ evacuate VCRS available at your institute.
12	Prepare property table for different types of refrigerants/ alternate fuels.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any):

Sr. No.	Unit	Unit Name	Strategies
1	I	Internal Combustion (I.C.) Engines.	Movies, power point presentations, live demonstration, performance with IC engines.
2	II	Alternate Fuels.	Physical demonstration of properties of fuels, movies, lives examples.
3	III	Refrigeration.	Movies, power point presentations, live demonstration, performance with VCRS, industrial visits, Visit of cold storage/ice plants.
4	IV	Air-Conditioning.	Movies, power point presentations, live demonstration, performance of air conditioners, industrial visits.

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Heat Engines.	Pandya and Shah.	Charotar Publishing House.
2.	Thermodynamics and Heat power Engg.	Mathur and Mehta.	Tata Mcgraw- Hill.
3.	Heat Engines.	D. A. Wrangham.	Cambridge University Press.
4.	Thermal Engineering.	R K Rajput.	Laxmi. Publications
5.	A Text book of Thermal Engineering.	R S Khurmi& J.K. Gupta.	S Chand & Co.
6.	I C Engine	Domkundwar	
7.	I C Engine	Mathur and Sharma.	DhanpatRaiPubli.
8.	Principles of Refrigeration	Dossat	Pearson Education
9.	Refrigeration and air conditioning	Arora & Domkundwar	Khanna publication.
10.	A Text Book of Refrigeration and Air Conditioning	R S Khurmi	Eurasia Publishing House
11.	Thermal engineering	P.L.Ballaney	Khanna Publication
12.	Thermal Science and Engineering	Dr. D.S.Kumar	S.K.Kataria & Sons.
13.	Refrigeration & Air-Conditioning.	R.K.Rajput	S.K.Kataria& Sons.

B) List of Major Equipment/ Instrument with Broad Specifications:

SR.NO.	EQUIPMENT	BROAD SPECIFICATION
1	I C Engine test rig- petrol and diesel – both.	Single cylinder/ multi stage- 4 stroke- Petrol and diesel engine test rig with hydraulic / eddy current dynamometers, 3kW or higher capacity- sensors on appropriate places for temperature measurement, arrangement of cam shaft to measure valve timing, flow measuring device at inlet and outlet with computerized data acquisition system and MPFI system (Petrol test rig is preferable with CNG kit fitted).
2	VCRS test rig.	Hermetically sealed compressor of at least half HP with HP/LP cut out, air cooled condenser, expansion valve, evaporator, flow meter/ rotameter for measuring refrigerant flow, solenoid valves/ temperature sensors at compressor in/out, condenser in/ out, expansion in/out, evaporator in/out, pressure gauge at in out of compressor, with Multi-channel digital

		temperature indicator, digital volt meter and ammeter, R-134a refrigerant.
3	Psychrometer& Thermometer-wet bulb and dry bulb.	Digital temperature and Humidity measurement, temperature range of -25 degree C to 60 degree C or higher.
4	Anemometer.	Digital air flow measuring device with flow range measurement of 0.4m/s up to 25m/s with a resolution of 0.1m/s.
5	Refrigeration tool kit.	Standard refrigeration tool kit
6	Tool kit for tubing operations for Refrigeration.	Flaring tool set, single type for tube 4.7mm to 16mm O.D., Swaging tool set, single type for tube 4.7mm to 16mm O.D., Bending spring external type, for copper tube 3mm to 16mm dia., Tube bender of 3 mm to 16 mm DIA, Pipe cutter miniature for copper tube 3mm to 16mm DIA, Pinch of tool, for copper tube, 6mm to 18mm DIA, Ratchet spanner of 6.4 sq.mm reversible, Capillary plague gauge, Pinch of plier/crimping plier tool 6mm –18mm DIA, Piercing plier 6-18mm & reversing valve with access fitting.
7	I C Engine tool kit.	Standard Engine maintenance tool kit available at workshops.
8	Leak detector.	Electronic refrigerant leak detector with microprocessor control. Gas leak detector for halogen gas
9	Refrigerant evacuation pump / vacuum pump.	Two stage rotary vacuum pump capacity approx. 60 – 10rmp capable of evacuating to 50 microns of Hg and fitted with gas ballast, anti such back valve and single phase motor
	Optional Items for evacuation pump/ vacuum pump.	Evacuating and refrigerant charging station, compression a) Rotary two stage vacuum pump and motor (with gas ballast and anti such back) manifold with gauges and valves and capable of pulling vacuum up to 50 microns of Hg and with provision of connecting to a microns level vacuum gauge b) Graduated charging cylinder with provision for temperature correction and all necessary isolating valves II) Evacuating and charging station as above but fitted with weighing scale (up to 2 kg. In lieu of (b) above and with accuracy of +/-1 g for charging hydrocarbons)
10	Window/ split air conditioner test set up.	Test rig containing air conditioner of 1.5 tons- in open condition.
11	Air washer/ cooler.	Air washer test rig.
12	Various fans for demonstration.	Models of fans- includes radial, backward, forward curve blades etc.
13	Brazing kit	Brazing tool kit with suitable Silver and

		copper brazing alloy rods for ¼” to 7/8” tubes – Cu to cu, cu to steel, cu to brass and appropriate flux
14	Pressure gauge and manifold for charging	Pressure guage diameter 63mm with recalibration set, Compound gauge, diameter 63mm, with recalibration set screw, scale vacuum 76mm. Pressure 15 Kg/sq.cm, Two way manifold with gauges and charging pipe
15	Refrigerants	Hc refrigerant in cylinders/disposable containers, 134 A refrigerant in cylinders
16	I C Engine parts	Fuel pump, different types of carburetors, different types of injectors- distributors.
17	I C Engine cut section/ models	Cut model of 4 stroke petrol and diesel engine, cut model of 2 stroke petrol engine, cut model of fuel pump

C) List of Software/Learning Websites

- i. <http://nptel.ac.in/courses/112105128/>
- ii. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Ref%20and%20Air%20Cond/New_index1.html
- iii. <http://www.youtube.com/playlist?list=PLE2DA184A2E479885>
- iv. <http://www.kolpak.com/asset/?id=tuqvr>

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. S. R. Pareek**, Head of Department, Mechanical Engineering, Tolani F. G. Polytechnic, Adipur.
- **Dr. Shah Atul S.**, Lecturer in Mechanical Engineering, Dr. S & SS Ghandhy Collage of Engineering and Technology, Surat.
- **Shri M. N. Patel**, Lecturer in Mechanical Engg, Government Polytechnic, ChhotaUdepur.
- **Shri Haresh G Ranipa**, Lecturer in Mechanical Engineering, Shri N M Gopani Polytechnic, Ranpur.
- **Shri H.R.Sapramer**, Lecturer in Mechanical Engineering, Sir B.P.T.I., Bhavanagar.
- **Shri U.O. Khant** . Lecturer in Mechanical Engg, Government Polytechnic,Rajkot.
- **Shri A. A. Lohia**, Lecturer in Mechanical Engg, Government Polytechnic,Rajkot.

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. S.K.Pradhan**, Associate Professor, Mechanical Engg. NITTTR,Bhopal
- **Dr. A.K.Sarathe**, Associate Professor, Mechanical Engg. NITTTR,Bhopal