

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester – IV

Course Title: Automotive heating & Air conditioning
(Course Code: 4340201)

Diploma programme in which this course is offered	Semester in which offered
Automobile Engineering	4 th semester

1. RATIONALE

HVAC means Heating, Ventilation, and Air Conditioning. Appropriate HVAC provides comfort for people & maintains an effective environment for surroundings. Proper HVAC allows humans to exist in adverse conditions. There was a time when having an air conditioner in a car was considered one of the big features, but today air conditioners have become the standard equipment even in entry-level automobiles. Therefore it is necessary to have fundamental knowledge as well as trouble shooting and maintenance of Automotive HVAC system for students of diploma in automobile engineering. This course fulfill this need.

This course is helpful to students to know basic fundamentals of automotive air conditioning system, methods for trouble shooting of HVAC system used as well as routine maintenance of Automotive HVAC system. The course is designed to have a practical exposure as well as theoretical lectures to make the concepts clear and practice in hand.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop different types of skills leading to the achievement of the following competency.

- **Carry out troubleshooting of Automotive HVAC with safety.**
- **Carryout servicing, repairing and inspection of Automotive HVAC with safety.**

3. COURSE OUTCOMES (COs)

The underpinning knowledge and the relevant skills associated with this competency are to be developed in the student to display the following COs:

- a) Explain Fundamental of Air conditioning System.
- b) Demonstrate trouble shooting of Automotive cooling system with safety.
- c) Demonstrate trouble shooting of Automotive heating system with safety.
- d) Explain various HVAC controls and automatic climate control system.
- e) Perform Automotive HVAC system maintenance, servicing and repair work with safety.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
L	T	P		Theory Marks		Practical Marks		Total Marks
2	0	2	C	CA	ESE	CA	ESE	
			4	30	70	25	25	

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

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) that are the sub-components of the COs. *These PrOs need to be attained to achieve the COs.*

Sr. No	Practical Outcomes (Pros)		Unit No.	Approx. Hrs. required
1	Interpret Vapour Compression cycle using cut-section of Automotive Air Conditioning System.	Any one	I	04
2	Prepare list of different refrigerants, discuss major characteristics and property.		I	04
3	Identify components of Automotive air conditioning system and Explain Function of each Components.	Any two	II	04
4	Trouble Shooting Of Automotive Air-Conditioner System with the help of pressure gage manifold set.		II	04
5	Trouble Shooting Of Automotive Air-Conditioner System with the help of touch, see and hear diagnostic.		II	04
6	Identify and Explain components of Automotive Heating System.	Any one	III	04
7	Trouble Shooting Of Car Heating System.		III	04
8	Locate and Explain parts of ventilation system of Automotive Air Conditioning.		III	04
9	Identify and Explain various controls of Automotive Air Conditioning.	Any one	IV	04
10	Compare various control systems of given any two Automotive Air Conditioning.		IV	04
11	Interpret working of Automatic Climate Control system of the given vehicle.		IV	04
12	Perform Discharge & Evacuation of refrigerant in A.C System with safety.	Any two	V	04
13	Perform Lubrication & Recharging of refrigerant in A.C System with safety.		V	04
14	Perform Leak Detection Test of A.C System with safety.		V	04
15	Perform Servicing Of Air Conditioning System with safety.		V	04
16	Perform servicing of AC compressor and magnetic clutch assembly with safety.		V	04
17	Perform servicing of Car Heating System with safety.		V	04
Total Hrs.				28

Note

- i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.
- ii. Care must be taken in assigning and assessing study report as it is a study report. Study report, data collection and analysis report must be assigned in a group. Teacher has to discuss about type of data (which and why) before group start their market survey.
- iii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Adopt standard practices for handling tools and follow safety rules/follow given instructions.	40
2	Explain thoroughly.	20
3	Answer to question	20
4	Timely completion of tasks	20
Total		100

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practical in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Cut Section of whole assembly of Automotive air conditioning system. <ul style="list-style-type: none"> ● Cut Section of Condenser. ● Cut Section of Compressor. ● Cut Section of Receiver. ● Cut Section of Evaporator. ● Cut Section of Expansion Valve. 	1,2,3
2	Working model of Automobile HVAC system of any Car model <ul style="list-style-type: none"> ● Make: car manufacturer in India ● Power supply: 220 V AC 50 Hz 110 V AC 60 Hz ● Compressor wobble plate type ● Condenser parallel flow type suitable for car ● Evaporator serpentine type with a thermostatic expansion valve, blower motor, and grill. ● Receiver with sight glass and other accessories. ● All ideal controls and safety controls for car ac. ● Single phase electric motor 2 HP ● Suitable 12volt battery to run condenser fan, evaporator fan and to operate magnetic clutch of the compressor. ● Battery Charger to recharge Battery. 	1,2,3,8,9,10

3	Air Conditioning & Heater Service Tool Kit.	4,5,7,15.16,17
4	HFC Halogen Gas refrigerant leak Detector in automobile air conditioning for R-134a.	4,14
5	Electric refrigerant leak Detector in automobile air conditioning for R-134a.	4,14
6	Car Heater with Blower Assembly.	6,7
7	Refrigerant Recovery , Recycling and Recharging Machine <ul style="list-style-type: none"> ● Power supply: 220 V AC 50 Hz 110 V AC 60 Hz ● Evacuating air speed of vacuum pump. 4.6 CFM ● Compressor Power. 4/9 HP ● Accuracy of electronic scale: 5 g ● Maximum Wight of the electronic scale: 50 Kg ● Drying filter: 500 cc, 3/8 connecting port ● Capacity of refrigerant tank: 23.5 L 13.6 L ● Maximum Working pressure. 17.5 bar ● Maximum recovery speed: 0.5 kg/min ● Maximum recharging speed: 2 kg/min 	12,13
8	Digital Temperature Gauge	9,10
9	Pneumatic Gun. <ul style="list-style-type: none"> ● Nozzle Size:- 0.3 mm – 0.5 mm ● Body Material;- Mild Steel Color:- any ● Air Pressure:- 30 PSI – 90 PSI 	15
10	Pressure Gauge Manifold Set.(R 134a)	4,12,13,14,15

7. AFFECTIVE DOMAIN OUTCOMES

The following *sample* Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs. More could be added to fulfil the development of this course competency.

- a) Work as a leader/a team member.
- b) Follow ethical practices.
- c) Practice environmentally friendly methods and processes. (Environment related)**

The ADOs are best developed through the field based exercises/project work. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- i. 'Valuing Level' in 1st year
- ii. 'Organization Level' in 2nd year.
- iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit I Fundamental of Air conditioning System.	1.a.Explain Basic Concept of Air conditioning System. 1.b.Discuss types and properties of Refrigerants, and refrigerant oil. 1.c. Recognize need of ecofriendly refrigerant.	1.1. Requirement of Air conditioning system. 1.2. Air conditioning system basic terminology. 1.2.1. Refrigeration cooling load, Cooling capacity and 1 ton of refrigerant. 1.2.2. Air Conditioning 1.2.3. Dry bulb Temperature, Wet Bulb Temperature and Dew point temperature. 1.2.4. Humidity and Relative Humidity. 1.2.5. Latent Heat of Condensation& Latent Heat of Evaporation. 1.2.6. Modes of heat transfer. 1.2.7. Moist air, saturated air and unsaturated air. 1.3 Types and properties of air conditioning refrigerant and Refrigerant Oil. 1.4 Effect of air conditioning refrigerants on the environment. 1.5 Concept of ecofriendly refrigerants.
Unit II Automotive Cooling System.	2.a.Explain working cycle of automotive cooling system. 2.b.Describe Constructional and functional details of Automotive cooling system Components. 2.c. Identify cause and suggest remedial measures for various troubles in automotive cooling system.	2.1 Basic working cycle of Automotive cooling system 2.2 Major components Automotive cooling system 2.2.1 Magnetic clutch. 2.2.2 Types of compressors. 2.2.3 Condensers. 2.2.4 Receiver Drier and Filter. 2.2.5 Accumulator. 2.2.6 Expansion valves and heat sensing tube. 2.2.7 Orifice tube. 2.2.8 Evaporator. 2.3 Trouble shooting of automotive cooling system. 2.3.1 Based on complain. 2.3.2 Based on component defect. 2.3.3 Various Contaminant and their effects.

<p>Unit III Automotive Heating & HVAC Ventilation System.</p>	<p>3.a.Explain working cycle of automotive heating system.</p> <p>3.b.Describe Constructional and functional details of Automotive heating system Components.</p> <p>3.c. Explain working of electric heating system.</p> <p>3.d.Describe functions of various components of ventilation system of automotive A/C.</p> <p>3.e.Describe various types of automotive A/C unit.</p> <p>3.f. Identify cause and suggest remedial measures for various troubles in automotive heating system.</p>	<p>3.1.Basic working cycle of Automotive heating system.</p> <p>3.2. Major components Automotive heating system.</p> <p>3.2.1 engine cooling system component</p> <p>3.2.2 Heater Core</p> <p>3.2.3 Heater Hoses</p> <p>3.2.4 Heater Control Valve</p> <p>3.2.5 HVAC Control Panel</p> <p>3.3.Working of electric heating system.</p> <p>3.4.Ventilation of Automotive AC System.</p> <p>3.4.1 Air Distribution system.</p> <p>3.4.2 Duct System.</p> <p>3.4.3 Different Outlets and Grills/vents</p> <p>3.4.4 Blower</p> <p>3.4.5 Air Filters</p> <p>3.5 Types of Air Conditioning Unit</p> <p>3.5.1 Based on its working.</p> <p>a) Heater Cooler Independent System</p> <p>b) Reheat Air Conditioning System</p> <p>c) Semi-air mixed type Air Conditioning System</p> <p>d) Full air mixed type Air Conditioning System</p> <p>3.5.2 Based on its location.</p> <p>i) Dash type air condition system</p> <p>ii) Boot type air conditioning system</p> <p>iii) Dual air conditioning system</p> <p>3.6 Trouble shooting of Automotive Heating System.</p>
<p>Unit IV Various controls and Automatic climate control.</p>	<p>4.a.Describe Different controls used in automotive A/C system.</p> <p>4.b.Explain working of semi-Automatic temperature Control System & its input sensors.</p>	<p>4.1.Controls of Automotive AC system</p> <p>4.1.1. Pressure Switch</p> <p>4.1.2. Evaporator Pressure Regulator</p> <p>4.1.3. Humidifier and Dehumidifier</p> <p>4.1.4. Thermistor Switch</p> <p>4.1.5. Vacuum operated device</p>

	<p>4.c.Explain working of Automatic temperature Control System & its input sensors.</p> <p>4.d. Explain working of automatic climate Control System.</p> <p>4.e.Demonstrate Safe operation while working with Automotive A/C system.</p>	<p>4.2.Semi-Automatic Temperature Control (SATC) and its Input Sensors.</p> <p>4.3.Automatic Temperature Control (ATC) and its Input Sensors.</p> <p>4.4.Automatic climate control.</p> <p>4.5.Safety while working with Automotive AC system.</p>
<p>Unit V HVAC Maintenance, Servicing and Repairing.</p>	<p>5.a.Carry out inspection of automotive A/C system by various methods.</p> <p>5.b.Carry out refrigerant leak test with the help of various technics.</p> <p>5.c.Carry out routine service of automotive A/C system.</p> <p>5.d. Carry out discharging, and charging of automotive A/C system.</p> <p>5.e.Carry out servicing of A/C compressor, evaporator, condenser, heater core and hoses of automotive A/C system.</p>	<p>5.1 Inspection of A.C system –Visually and with the help of sight glass.</p> <p>5.2 leak test of refrigerant</p> <p>5.2.1. Electronic leak detector unit</p> <p>5.2.2. Soap Bubble method</p> <p>5.2.3. Water Immersion method</p> <p>5.2.4. Fluorescent dye and Ultra violate rays method</p> <p>5.3 Periodic service (Routine Service) of Automotive AC System.</p> <p>5.4 Automotive charging and discharging methods:</p> <p>5.4.1. Discharging A.C system and Evacuating A.C system.</p> <p>5.4.2. Charging A.C system using various methods. (Liquid Charging, Vapour charging, top up cane charging, Charging with recovery unit)</p> <p>5.4.3. Adding oil in Automotive A.C system.</p> <p>5.5 Servicing steps/procedure of following components:</p> <p>5.5.1. Compressor and Magnetic clutch and shaft seal replacement</p> <p>5.5.2. Hose pipe fitting and connection checking.</p> <p>5.5.3. Evaporator, condenser, Heater core.</p>

Note: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamental of Air conditioning System.	05	8	6	0	14
II	Automotive Cooling System.	06	4	6	4	14
III	Automotive Heating & HVAC Ventilation System.	06	4	6	4	14
IV	Various control and Automatic climate control.	05	6	8	0	14
V	HVAC Maintenance, Servicing and Repairing.	06	3	3	8	14
	Total	28	25	29	16	70

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related *co-curricular* activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of each activity. They should also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

- Charts can be prepared.
- Small report on any topic given by concern faculty.
- Small groups of students can be formed for assigned work. Assigned work should be such that it covers market survey, team work, presentation, time management, quality development.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- Massive open online courses (*MOOCs*) may be used to teach various topics/sub topics.
- Guide student(s) in undertaking micro-projects.
- 'L' in section No. 4** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature is to be given to the students for *self-learning*, but to be assessed using different assessment methods.
- With respect to *section No.10*, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
- Guide students on how to address issues on environment and sustainability**

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably being **individually** undertaken to build up the skill and confidence in every student to become problem solver so that she/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should be about **14 - 16 (fourteen to sixteen) student engagement hours** during the course. The student ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

1). Visit any AC Service workshop and prepare report on procedure of troubleshooting, Diagnosis, Testing and Servicing including AC recovery and evacuating.
2). Prepare a chart showing the layout and construction details of all the components of automobile air conditioning system.
3). Make a model/project on a basic Automotive AC system.
4). Prepare Power point presentation for explaining various trouble shooting of air conditioning and heating system.
5). Prepare color printed poster for showing importance of safety at lab/garage/workshop.
6). Prepare a chart on aggregates of Automatic Climate control System of Car air condition system.
7). Perform Market Survey for different types of Refrigerant available in the market.
8). Prepare report on Refrigerants.
9). Prepare videos of component dismantling and assembling.
10). Select any one Electric Automotive air conditioning system, search information from websites and prepare report for the same.
11). Collect the data of different types of control system and writes a report on it.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Automotive Air Conditioning and Climate control Systems.	Steven Daly	Butterworth-Heinemann publications, ISBN-13: 978-0-7506-6955-9
2	Automobile Engineering (Volume – VI)	Anil Chhikara	Satya Prakashan. ISBN-10 8176840785 : ISBN-13 8176840781-978 :
3	Automotive Airconditioning	William H. Carouse & Donald L. Anglin	Tata McGraw-Hill Co., Ltd., New Delhi ISBN : 0-07-014591-1
4	Automotive Airconditioning -	Clifford L.Samuels	Prentice Hall Int. ISBN-10 0130542059 : ISBN-13 0130542052-978 :
5	Automotive heating and air conditioning	Mark Schnubel	Cengage Publication ISBN-10 1133017452 : ISBN-13 1133017455-978 :
6	Basic Refrigeration and Air conditioning	Ananthanarayanan, P.N	McGraw Hill Education; New Delhi n(2013) ISBN-10: 9781259062704
7	Refrigeration and Air-Conditioning	Arora; Domkundwar	Dhanpatrai & Son's, New Delhi, ISBN: 9780000229663

14. SOFTWARE/LEARNING WEBSITES

- a) <https://www.howacarworks.com>
- b) <https://swayam.gov.in>
- c) <http://nptel.ac.in/courses/112105129/pdf/R&AC>
- d) <https://tinyurl.com/57mv2hct> for video link
- e) <https://tinyurl.com/yysu44b6> for web link

15. PO-COMPETENCY-CO MAPPING

Semester IV	Automotive heating & Air conditioning(4340201)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency <ul style="list-style-type: none"> Carry out troubleshooting of Automotive HVAC with safety. Carryout servicing, repairing and inspection of Automotive HVAC with safety. 	3	3	1	2	2	2	2
CO a) Explain Fundamental of Air conditioning System.	3				1		3
CO b) Demonstrate trouble shooting of Automotive cooling system with safety.	3	3		3		2	2
CO c) Demonstrate trouble shooting of Automotive heating system with safety.	3	3	1	3		2	2
CO d) Explain various HVAC controls and automatic climate control system.	3		1				3
CO e) Perform Automotive HVAC system maintenance, servicing and repair work with safety.	3	3		3	2	2	2

Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE**GTU Resource Persons**

S. No	Name and Designation	Institute	Contact No.	Email
1	Mr. D. A. Dave (Retd. HOD Automobile)	Sir BPTI Bhavnagar	9427182407	deven_a_dave@yahoo.co.in
2	Smt. M. N. Vibhakar Lect. Automobile	C. U. Shah Polytechnic Surendranagar	9428868859	mpp3668@hotmail.com
3	Mr. H. T. Shah Lect. Automobile	Govt. Polytechnic, Ahmedabad	8140894595	htshah@gpahmedabad.ac.in
4	Mr. M. J. Gohil Lect. Automobile	Sir BPTI Bhavnagar	9712276060	mjgautodept@gmail.com
5	Mr. N. C. Makwana Lect. Automobile	Sir BPTI Bhavnagar	9725329096	ncmautodept@gmail.com

GTU BOS and Branch Coordinator Persons

Sr. No	Name and Designation	Institute	Contact No.	Email
1	Mr. Shyam Varghese HOD Automobile Branch Coordinator	Sir BPTI Bhavnagar	94263 96640	shyamvarghese@gmail.com
2	Mr. A. K. Nanavati, HOD Automobile	Govt. Polytechnic, Ahmedabad	9426674409	aknanavati@gmail.com