Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Sixth**

Course Title : **Automobile Air Conditioning (Elective-II)**

Course Code : **22653**

1. RATIONALE

This is a core technology course. All automotive vehicles are equipped with air conditioning. Hence the fundamental knowledge of air conditioning is most essential for an auto technologist. This course will help in understanding the procedure of inspection, diagnosis and testing of air conditioning, ducts and ventilation systems. The student will develop the ability to use the different tools and equipment to diagnose and perform servicing of HVAC system in vehicles.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching-learning experiences:

- **Maintain vehicle air conditioning and heating systems.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Maintain the automotive Heating, Ventilation and Air-conditioning systems.
b. Select relevant duct system for vehicles.
c. Service various components of automobile Air Conditioning Systems.
d. Troubleshoot air conditioning control systems.
e. Repair Air-conditioning Systems.
f. Maintain comfort heating systems.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical				
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

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

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

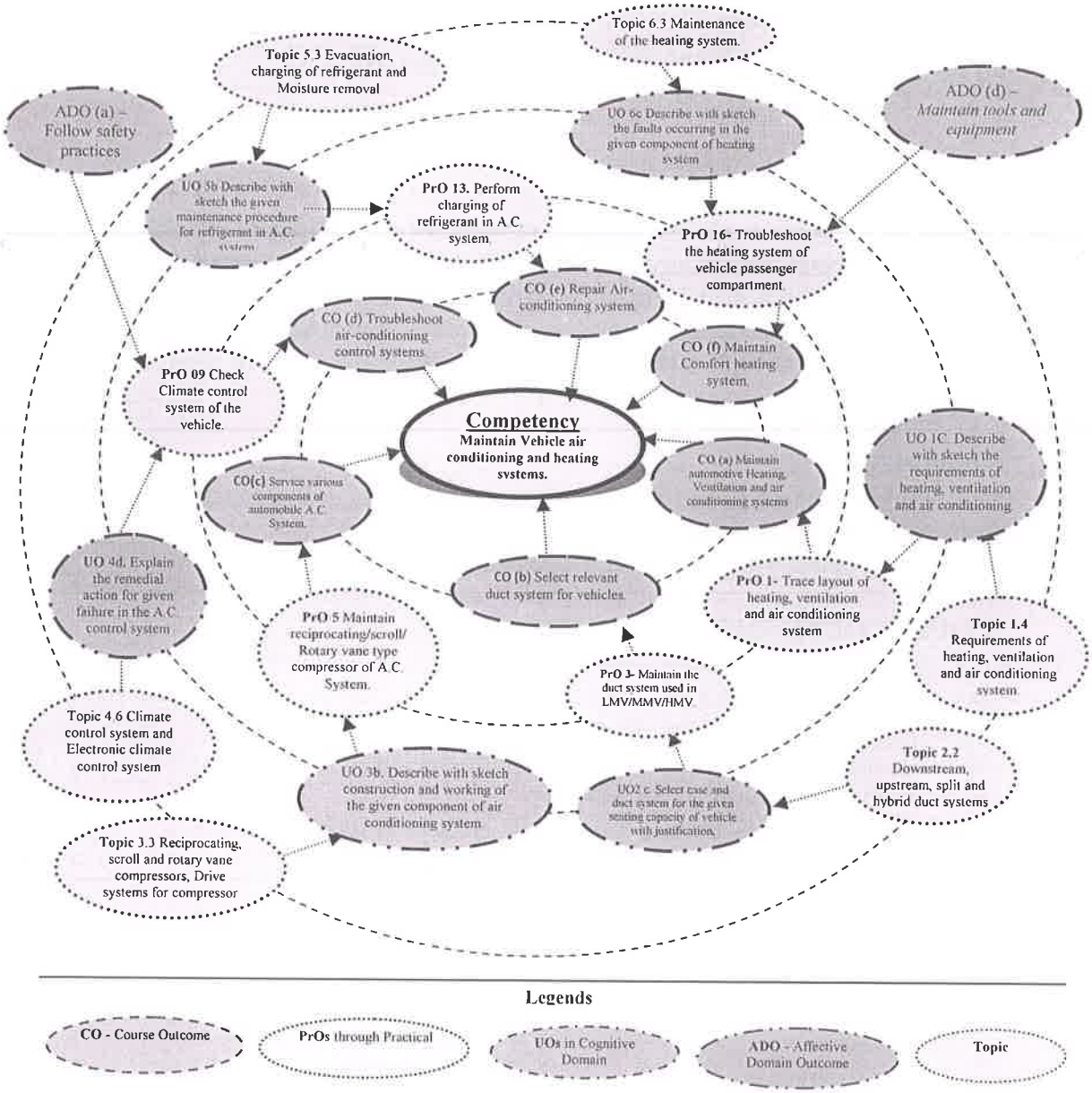

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assesse-d in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Trace layout of heating, ventilation and air conditioning system used in LMV/ MMV/HMV.	I	02
2.	Identify the parts of duct system used in LMV/MMV/HMV.	I	02*
3.	Maintain the duct system used in LMV/MMV/HMV.	II	02
4.	Service air blower and air filter.	II	02*
5.	Maintain reciprocating/Scroll/Rotory vane type compressor of A.C. System	III	02*
6.	Service the Electromagnetic clutch.	III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7.	Maintain drive system of A.C. Compressor.	III	02*
8.	Perform purity test of refrigerant.	III	02
9.	Check Climate control system of the vehicle.	IV	02*
10.	Troubleshoot the AC control system.	IV	02*
11.	Troubleshoot automobile air conditioning system components.	V	02*
12.	Perform refrigerant evacuation from A.C. system.	V	02*
13.	Perform charging of refrigerant in A.C. system.	V	02*
14.	Perform leak detection test of A.C. System.	V	02*
15.	Test the condition of hoses, pipes, and connectors of A.C. system.	V	02*
16.	Troubleshoot the heating system of vehicle passenger compartment.	VI	02*
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1.	Follow safety rules and adopt standard practices for handling tools	20
2.	Refer workshop manual and include relevant data in the journal.	20
3.	Sketching layouts, components and conclusion	30
4.	Answer to simple questions	20
5.	Timely completion of the task and term-work.	10
Total		**100**

The above PrOs also comprise of the following social skills/ attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/ field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work as a leader/a team member.
e) Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

a. 'Valuing Level' in 1st year
b. 'Organisation Level' in 2nd year
c. 'Characterisation Level' in 3rd yearr.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	General purpose tools (Spanners, ring spanner and socket set)- 6mm to 32 mm	All
2	Air conditioning service tool kit, with refrigerant tester	8, 14 15
3	Working model of Automobile HVAC system of any Car model 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.	2, 3, 4, 9
4	Refrigerant Recovery, Recycling, and recharging Machine Power supply: 220 V AC 50 Hz 110 V AC 60 Hz Evacuating air speed of vacuum pump: 4.5 CFM Compressor power: 3/8 HP Accuracy of electronic scale: 5 g Maximum weight 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
5	Reciprocating/Scroll/Rotary vane type Compressor. (For Dismantling)	5
6	Evaporator of commonly used car A.C. System	6
7	Condenser of commonly used car A.C. System	6
8	Accumulator of commonly used car A.C. System	6
9	Receiver drier of commonly used car A.C. System	6,
10	Electromagnetic clutch of commonly used car A.C. System	6, 7
11	Refrigerant tank for R-134a(Capacity 13.6 kg)	12, 13
12	Halide and Fluorescent Refrigerant Leak Detector (HFC Halogen Gas Refrigerant Leak Detector in automobile air conditioning for R-134a)	14
13	Thermostatic expansion valve of commonly used car A.C. System	6
14	Vacuum pump (Single Stage Rotary Vane R134A, 1/3HP Deep Vacuum Pump of Car AC)	11,9,6
15	Digital Temperature gauge (Temperature range : -20 to 70 ^{o}C)	11
16	High-Low Pressure (Vacuum) gauge for R134A Temperature Scale: Celsius Max Working Pressure: 500PSI Burst pressure: 2500PSI Hose Length: around 55" (inches) Quick disconnect couplers for High/Low fittings included	11

S. No.	Equipment Name with Broad Specifications	PrO. No.
	Each coupler have a shut off valve to prevent loss of refrigerant Blue gauge (low): 2-1/2" diameter, 0-240 PSI with 0-40 VAC Red gauge (high): 2-1/2" diameter, 0-500 PSI Celsius C degree reading Red & Blue 5 feet long charging hose (1/4" FFL x 60 " with knurled fittings) Yellow 5 feet long charging hose (1/4" ACME x 60" with knurled fittings)	
17	Car Heater Blower assembly	16

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – 1 Heating, Ventilation and Air-conditioning System	1a. Explain the specified human comfort parameters with justification. 1b. Explain with justification the process of controlling the given comfort factor. 1c. Describe with sketch the requirements of heating, ventilation and air conditioning in the given type of vehicle. 1d. Describe with sketch ventilation system of the given type of vehicle.	1.1 Environmental and safety aspects in heating, Ventilation and air conditioning systems. 1.2 Human comfort control: comfort zone, air movement, wind chill factor, odor problems and effects of humidity. 1.3 Modes of Heat transfer: convection, radiation, evaporation and conduction. 1.4 Requirements of heating, ventilation and air conditioning system in- light motor vehicle, Heavy goods vehicle and Heavy passenger vehicle 1.5 Controlled and uncontrolled ventilation 1.6 Vapour compression refrigeration cycle and basic components.
Unit – II Case and Duct System	2a. Explain with sketch the construction of the given section of case and duct. 2b. Describe with sketch the construction of the given type of duct. 2c. Select case and duct system for the given seating capacity of vehicle with justification. 2d. State remedial actions for the given symptoms relevant to case and duct aggregates with justification	2.1 Air intake section, core section, and distribution section. 2.2 Downstream, upstream, split and hybrid duct systems. 2.3 Rear heating and cooling system. 2.4 Air Filter and Air blower in A.C. system 2.5 A.C. System operational Precautions
Unit– III Air Conditioning System	3a. Redraw the given A.C. system layout including the missing components. 3b. Describe with sketch construction and working of the given component of air conditioning system. 3c. List precautionary measures	3.1 General layout of Automotive Air conditioning system. 3.2 Evaporator, condenser, accumulator. Receiver, and driers. 3.3 Reciprocating, scroll and rotary vane compressors, Drive systems for compressor. 3.4 Refrigerant: Properties, types,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	required for packaging and storage of the given A.C. accessories. 3d. Explain with sketch the construction and working of the given type of metering device of vehicle air conditioning system.	Packaging and storage, color code and purity test 3.5 Electromagnetic clutch 3.6 Metering devices: thermostatic Expansion valve, and its Types, i.e. H valve, block type, internally equalized, externally equalized and fixed orifice tube. 3.7 Throttling action, modulating action and controlling action, remote bulb. 3.8 Symptoms, Faults, causes and remedies in Compressor , Electromagnetic clutch
Unit– IV A.C. System Control Devices	4a. Select A.C. control system for the given vehicle with justification. 4b. Describe with sketch the construction of the given components of vacuum control system. 4c. Describe with sketch the working of the given sensor. 4d. Explain the remedial action for given failure in the A.C. control system with justification.	4.1 System controls – Vacuum control system and electronic temperature control system 4.2 Vacuum operated devices i.e. vacuum reserve tank, vacuum restrictor, vacuum motor, check valve and check relays. 4.3 Switches - high- Side temperature switch, low-side temperature switch, high-pressure switch, low- pressure switch, Pressure regulator, ambient switch and superheat switch. 4.4 Sensors- sun load sensor, outside temperature sensor and in-car temperature sensors. 4.5 A.C. Control devices: Aspirator, blower clutch control, heater control, and time delay relay for heater control. 4.6 Climate control system and Electronic climate control system
Unit– V Maintenance of Air Conditioning System	5a. Describe with sketch procedure for testing the given A.C. System. 5b. Describe with sketch maintenance procedure for refrigerant in the given A.C. System. 5c. List safety precautions while using type of tool/equipment for servicing the given A.C. System. 5d. Describe with sketch the maintenance procedure of specified accessory of the given A.C. System.	5.1 Inspection of A.C. System: Visual and acoustic, sight glass, 5.2 Leak test and Temperature test, 5.3 Evacuation, charging of refrigerant and Moisture removal 5.4 Service equipment and tools: Vacuum pump, Manifold and gauge i.e. Low side and high side, gauge calibration recovery unit and recycling unit, Halide (Freon) and Fluorescent leak detector, nitrogen leak tester. 5.5 Hoses and connectors: System hoses, charging hose with shut off valve and connectors.
Unit– VI Heating	6a. Explain with sketch the given type of heating system in the	6.1 Heating system: Function, Heater core, Control Valve, Heater Hoses, Blower

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
System	vehicle. 6b. Describe with sketch the maintenance procedure for the given component of heating System. 6c. Describe with sketch the faults occurring in the given component of heating system. 6d. Explain with sketch the remedial action for given fault in the heating system.	6.2 Types of heating system, 6.3 Maintenance of the heating system: Fault diagnosis, remedial action

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

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	Heating, Ventilation and Air-conditioning System	10	02	04	04	10
II	Case and Duct System	08	-	04	04	08
III	Air conditioning system	16	04	06	08	18
IV	A.C.System Control Devices	12	02	06	06	14
V	Maintenance of Air conditioning system	12	02	04	06	12
VI	Heating System	06	02	02	04	08
Total		**64**	**12**	**26**	**32**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist a student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may 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 about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare journal of practical.
b) Undertake micro-projects.
c) Collect the information on refrigerant and list essential properties of refrigerant.
d) Visit the Automobile Service station and observe the servicing of AC system.
e) Collect the information on different types of compressor used in AC System.
f) Collect the catalog of various automotive manufacturers and write a report on Climate Control System in vehicles.

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:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Demonstrate students thoroughly before they start doing the practice.
g) Encourage students to refer different websites to have a deeper understanding of the subject.
h) Observe continuously and monitor the performance of students in the Lab.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at 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 preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/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 not be less than ***16 (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. Similar micro-projects could be added by the concerned faculty:

a) Prepare a chart showing the layout and construction details of all the components of automobile air conditioning system. Followings steps to be strictly followed (This fulfill CO-a and Co-c).
   i. Visit Automobile service station.
   ii. Collect information from internet, Manufacturer catalog, on air conditioning system, Human Comfort Parameters, Control Points.
   iii. Specifications of components used in vehicle A.C. System.
   iv. Collect videos of components on dismantling and assembling.
b) Prepare a cut section model of A.C. Compressor. Followings steps to be strictly followed (This fulfill CO-c and Co-e)
   i. Obtain used model of A.C. Compressor of any vehicle.
   ii. Collect the technical specification of obtained Compressor from service manual/catalogue/manufacturer website.
   iii. Prepare cut section model in college workshop.
   iv. Prepare a proper display of cut section model.
c) Perform a Market survey for different types of Refrigerants available in the market. Followings steps to be strictly followed (This fulfill CO-a and Co-e)
   i. Survey Market and collect information on availability of refrigerants.
   ii. List desirable properties of refrigerant.
   iii. Find its effect on the environment.
   iv. Compare refrigerants on the basis of its properties.

d) Prepare a chart on aggregates of Climate Control System of car air conditioning system. Followings steps to be strictly followed (This fulfill CO-a and Co-d)
   i. Collect information on Climate control system.
   ii. Prepare the sketch of components of Climate control system.
   iii. Write function of each aggregate.
   iv. Refer Manufacturer/Service Manual to find the specification of each component.
   v. Prepare a chart showing its construction and working.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Automobile Air Conditioning	Dwiggins, Boyce H.	Delmar Cengage Learning; 8th Revised edition, 1995 New Delhi ISBN: 978-0827358188
2	Automotive Heating & Air Conditioning Manual	Haynes, John H. ; Stubblefield, Mike	Haynes Manuals N. America, Incorporated, 2011, ISBN1563929139
3	Basic Refrigeration and Air Conditioning	Ananthanarayanan, P. N.	McGraw Hill Education; New Delhi n (2013), ISBN-10: 9781259062704
4	Automotive Heating and Air Conditioning	Halderman , J. D.	Pearson Prentice Hall; 7 edition (2014) ISBN: 978-0133514995
5	Textbook of Refrigeration & Air conditioning	Khurmi, R. S. ; Gupta , J. K.	S. Chand Limited, New Delhi (2008) ISBN: 8121927811, 9788121927819
6	Refrigeration and Air-Conditioning	Arora; Domkundwar	Dhanpatrai & Son's, New Delhi ISBN: 9780000229663

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a) http://nptel.ac.in/courses/112105129/pdf/R&AC%20Lecture%2026.pdf for selection of suitable refrigerant in a refrigeration
b) http://nptel.ac.in/courses/112105128/20 for Basic of Compressor
c) https://www.youtube.com/watch?v=nHZEAe08sE8 for understanding working of HVAC system.
d) https://www.youtube.com/watch?v=I5rrZSu4PxQ For Understanding the working of Car AC
e) https://www.youtube.com/watch?v=Pdq8JAlct6s For Procedure to Recharge refrigerant in AC System
f) https://www.youtube.com/watch?v=F5w3lR88fqQ For Procedure to evacuate refrigerant from AC System
g) https://www.2carpros.com/articles/re-charge-an-air-conditioner-system for evacuation and charging of A.C. System
h) https://www.youtube.com/watch?v=Yyf30wStUE4 for Leak Detection in A.C. System
i) https://www.youtube.com/watch?v=e31HCvckZAU for Leak Detection in A.C. System
j) https://www.youtube.com/watch?v=WncHNLdU4EA for trouble diagnosis of A.C. System
k) https://www.youtube.com/watch?v=FzbM0YoUZgo for cleaning air conditioner evaporator
l) https://www.youtube.com/watch?v=rulXlnG2Unk for Servicing of Compressor in car
m) https://www.youtube.com/watch?v=UW1GDiOa0kE for how To Diagnose Car Air Conditioning Problems