

Program Name : Diploma in Mechanical Engineering
Program Code : ME
Semester : Sixth
Course Title : Refrigeration and Air Conditioning (Elective-II)
Course Code : 22660

1. RATIONALE

The 21st century predicts revolutionary developments in Heating, Ventilation and Air Conditioning. Considering the wide and increasing use of Heating, Ventilation and Air Conditioning for domestic, commercial and industrial applications and the challenges put in it is absolutely necessary that Diploma Engineers should learn these systems. They should know the processes, equipment, systems of Heating, Ventilation and Air Conditioning with their functioning, maintenance, repairs and measures to meet the current demand.

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 refrigeration and air-conditioning 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:

- Use refrigeration systems for given application.
- Use relevant refrigerants for different applications.
- Select different refrigeration components for given refrigeration system.
- Select different air conditioning components for given air-conditioning system
- Determine cooling loads for Air-conditioning systems.
- Select relevant tools for maintaining air conditioning systems.

4. TEACHING AND EXAMINATION SCHEME

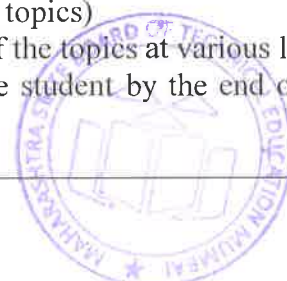
Teaching Scheme			Credit (L+T+P)	Examination Scheme												
L	T	P		Theory						Practical						
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): 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.

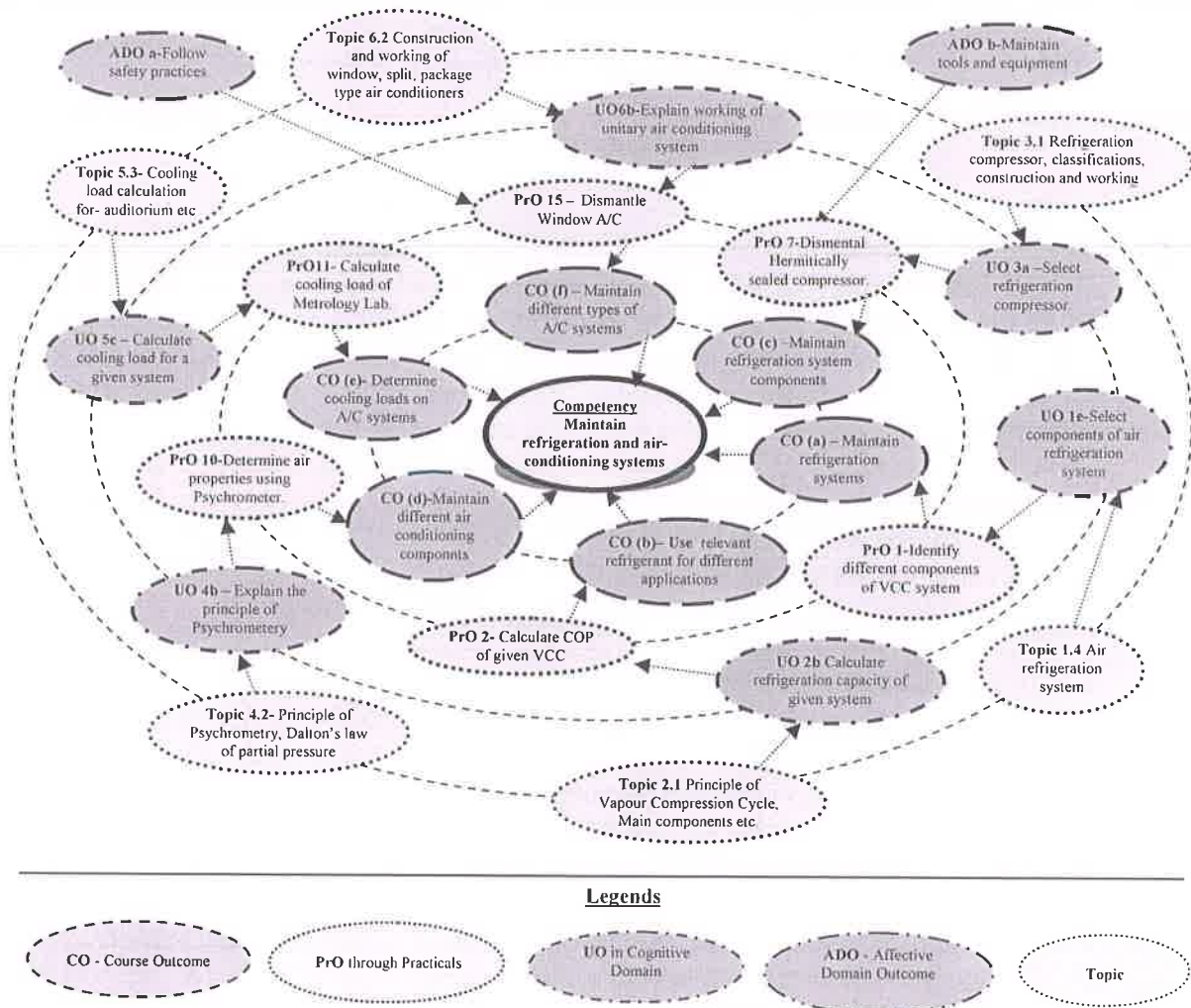


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify different components of Vapour compression cycle with their specification.	I	02*
2	Troubleshoot VCC system for Refrigerant leakage.	II	02
3	Charge the VCC system.	II	02
4	Identify the different components of House hold refrigerator with specification.	II	02
5	Dismantle Hermitically sealed compressor.	III	02*
6	Assemble Hermitically sealed compressor.	III	02*
7	Dismantle and assemble defrosting system of Household refrigerator.	III	02
8	Determine air properties using Psychrometer.	IV	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	Calculate cooling load of Institute's Metrology laboratory.	V	02*
10	Identify different components of Unitary Air conditioner with specifications.	VI	02
11	Dismantle the Window Air conditioner.	VI	02
12	Troubleshoot the Window Air conditioner.	VI	02*
13	Assemble Split Air conditioner.	VI	02
14	Troubleshoot the split Air conditioner.	VI	02*
15	Perform piping operations like tube/pipe cutting, swedging, brazing, insulation	VI	02
16	Dismantle Air conditioner of a car.	VI	02
17	Troubleshoot Air conditioner of a car	VI	02*
18	Assemble Air conditioner of a car.	VI	02
	Total		36

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 judicious mix of minimum 12 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	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	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:



- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year.

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	Vapour compression Test rig consisting of Hermitically sealed compressor 1TR capacity, Air cooled condenser, Expansion devices like TEV and capillary tube, Evaporator coils.	1,2
2	Water cooler test rig up to 100 liters capacity	1,3
3	Testing equipment like halide torch	4,5
4	Charging system, Vacuum pump, Charging kit	4,5
5	Household refrigerator test rig	6
6	Hermitically sealed compressor	7,8
7	Psychrometer digital	9,10,11,12,13
8	Anemometer	9,10,11,12,13
9	Window air conditioner	14,15
10	Split air conditioner	14,15
11	Window/split air conditioner test rig 1.5 Tr capacity	17

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 – I Refrigeration	1a. Calculate COP of Carnot and Bell colemen cycle for the given condition 1b. Explain with sketches the significance of the given diagram 1c. Draw the PV and TS diagram for the given criteria 1d. Select components of air refrigeration system for given application with justification.	1.1 Necessity of Refrigeration, Unit of Refrigeration, concept of COP (actual and Theoretical) 1.2 Reversed Carnot cycle and its representation on PV and TS diagram 1.3 Bell colemen cycle and its representation on PV and TS diagram with simple numerical. 1.4 Air refrigeration system, component of air refrigeration system, Its applications
Unit-II Refrigeration Cycles and Refrigerants	2a. Calculate Actual and theoretical COP of given Vapour compression cycle. 2b. Calculate the refrigeration capacity for the given system 2c. Select relevant application of Multistage VCC for	2.1 Principle of Vapour Compression Cycle, Main components, Representation on P-H and T-S diagram, conditions- dry compression, effect of superheating, effect of undercooling, Calculation of Refrigeration capacity and Power required. Multistage Vapour Compression Refrigeration system, its

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	<p>given system with justification.</p> <p>2d. Select relevant Refrigerant for given application with justification.</p>	<p>necessity, advantages and applications.</p> <p>2.2 Vapour Absorption Cycle, principle, its component, working of Aqua – Ammonia Vapour absorption system, working of Li-Br absorption system, Electrolux refrigerator- working, main components, applications. Comparison between Vapour Compression system. and Vapour absorption system</p> <p>2.3 Refrigerants, desirable properties, classification, designation of refrigerant, selection of refrigerant for relevant applications, System vacuumisation Charging processes, leak testing methods and process.</p> <p>2.4 Montreal protocol, Kyoto protocol. Concept of Ozone Layer Depletion, Green House effect, Global warming, Eco friendly Refrigerants.</p> <p>2.5 Applications of Refrigeration, Household refrigerators, Water coolers, name of Manufacturers and their products with capacity.</p>
Unit– III Refrigeration System Components	<p>3a. Select relevant Refrigeration compressor for given refrigeration system with justification.</p> <p>3b. Select relevant condenser for given refrigeration system with justification.</p> <p>3c. Select relevant evaporator for given refrigeration system with justification.</p> <p>3d. Select relevant Expansion device for given refrigeration system with justification.</p> <p>3e. Explain the working of specified auxiliary devices used in refrigeration system</p> <p>3f. Describe the process to maintain the given refrigeration systems component.</p>	<p>3.1 Refrigeration compressor, classifications, construction and working of hermitically sealed compressor, open type compressor, rotary compressors- centrifugal, Screw and Scroll compressors and their applications.</p> <p>3.2 Condensers- classifications, working of air and water-cooled condensers, evaporative condensers, comparison and applications.</p> <p>3.3 Evaporators- Classification- working of finned type, bared tube, plate type, flooded, shell and tube type evaporators, their applications. Chillers- Direct expansion and flooded type chillers, working and applications.</p> <p>3.4 Expansion device- classifications, capillary tube, automatic expansion valve, Thermostatic expansion valve, selection, working and application.</p> <p>3.5 Other components- Drier, Solenoid valve, Thermostatic switch, defrosting devices, working and applications.</p>
Unit– IV Basics of Air Conditionin	<p>4a. Explain the principle of Psychrometry for the given situation</p>	<p>4.1 Air conditioning- necessity, types of air conditioning- comfort air conditioning, industrial air conditioning, applications.</p>

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
g	4b. Represent the given psychrometric processes in Psychrometric chart 4c. Select relevant auxiliary components for given air conditioning system. 4d. Describe the procedure to maintain the given air conditioning component.	4.2 Principle of Psychrometry, Dalton's law of partial pressure, air properties. 4.3 Psychrometric processes, Representation of processes on Psychrometric. chart. Types and construction of Psychrometers. 4.4 Components used for air conditioning- Humidifiers, dehumidifiers, filters, heating and cooling coils.
Unit –V Cooling Load Calculation	5a. List human comfort conditions 5b. Identify the relevant sources of heat gain for the given situation with justification. 5c. Calculate cooling load for the given situation.	5.1 Comfort condition, heat exchange by human body with environment, factors affecting on human comfort. 5.2 Calculation of Sensible and Latent heat gain sources. 5.3 Cooling load calculation for- auditorium, Metrology laboratory, class room.
Unit –VI Air Conditioning Systems	6a. Classify Air conditioning system 6b. Explain working of Unitary air conditioning system 6c. Explain the constructional features of central air conditioning 6d. Select relevant components for given air distribution system 6e. Select the insulating material for given air conditioning system. 6f. Describe the procedure to maintain the given type of air conditioning system.	6.1 Classification of air conditioning system- Summer and winter, Year around air conditioning, construction, application, comparison. 6.2 Construction and working of window, split, package type air conditioners. 6.3 Central air conditioning- types, direct and indirect central air conditioning construction, capacity, application. 6.4 Concept of air handling unit, air distribution system- closed perimeter system, extended perimeter system, radial duct system, losses in ducts, construction and application of supply, return and make up ducts, grills diffusers, types of fans and blowers. 6.5 Insulation- purpose, types of insulation, material and their properties. 6.6 Introduction to Automobile Air conditioning system.

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	Refrigeration	06	02	02	04	08
II	Refrigeration cycles and Refrigerants	12	02	06	12	20
III	Refrigeration system components	08	02	02	06	10
IV	Basics of Air conditioning	06	02	02	06	10

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
V	Cooling load calculation	06	02	02	04	08
VI	Air Conditioning system	10	02	04	08	14
Total		48	12	18	40	70

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

Note: This specification table provides general guidelines to assist 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:

- Prepare journals based on practical performed in laboratory.
- Follow the safety precautions.
- Use various mechanical measuring instruments and equipment related to Heating, Ventilation and air conditioning
- Read and use specifications of the Refrigeration and air conditioning equipment.
- Library / Internet survey of HVAC systems
- Prepare power point presentation or animation for understanding constructional details and working of different Centralised air conditioning systems.
- Visit nearby malls/auditoriums/commercial complex/Dairy/Cold storages/Ice cream factory/Ice plant/Cinema Theaters to identify different components of Refrigeration and air conditioning system.

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.
- '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.
- 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).
- With respect to item No.10, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
- Guide student(s) in undertaking micro-projects.
- Correlate subtopics with actual domestic and industrial Refrigeration and air conditioning systems.
- Use proper equivalent analogy to explain different concepts related to Psychrometry.
- Use Flash/Animations to explain various applications of Refrigeration and air conditioning.



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 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 are given here. Similar micro-projects could be added by the concerned faculty:

- a) Prepare a duct layout of your institute building from AHU
- b) Prepare a chart of showing all the components of house hold refrigerator.
- c) Prepare a demonstration model of cold storage.
- d) Calculate Refrigeration capacity of split air conditioner.
- e) Collect different air outlet devices used in Central air conditioning system
- f) Download catalogue of Refrigeration compressors.
- g) Prepare display chart of types of refrigerant used in commercial and Industrial applications.
- h) Visit to nearby Central air conditioning plant/Malls/Showrooms and collect information regarding air conditioning
- i) Conduct market survey of household refrigerators, make, capacity, arrangement, features, commercial terms etc.
- j) Conduct market survey of window air conditioner make, capacity, arrangement, features, commercial terms etc.
- k) Collect information of automobile air conditioning of different vehicles.
- l) Comparative study of various types of compressors with detailed specification & market survey.
- m) Comparative study of various types of condensers with detailed specification & market survey.
- n) Comparative study of various types of evaporators with detailed specification & market survey.
- o) Comparative study of various types of expansion devices with detailed specification & market survey.
- p) Study of different types of refrigerants with properties, designation, selection & applications.
- q) Comparative study of different types of central air-conditioning system with detailed specification and visit analysis report. (viz. AHU,FCU,VAV)

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Refrigeration and Air conditioning	Khurmi R. S.	S Chand publication, New Delhi, (2008), ISBN-10: 8121927811

S. No.	Title of Book	Author	Publication
2	Refrigeration and Air conditioning	Arora C. P.	Tata McGrawHill Publication, New Delhi, (2009), ISBN-13-978-07-008390-5
3	Basic Refrigeration and Air conditioning	Ananthnarayan P. M.	Tata McGrawHill Publication, New Delhi, (2013), ISBN- 9781259062704
4	Refrigeration and Air conditioning	Sapali S. N.	PHI publication, New Delhi, (2013) ISBN - 9788120348721
5	Refrigeration and Air conditioning	Prasad Manohar	New Age International, New Delhi, (2011), ISBN- 9788122414295
6	Refrigeration and Air conditioning	Ameen Ahmdul	PHI Publication, New Delhi, ISBN - 9788120326712
7	Principles of refrigeration	Dossat R. J.	John Wiley and Sons Ltd, UK, (2009) ISBN 978-0130272706

14. SOFTWARE/LEARNING WEBSITES

- a) www.youtube.com/watch?v=52P0KbTNvok
- b) www.youtube.com/watch?v=OXIZhqypNUI
- c) www.youtube.com/watch?v=cobFAMZDS0o&start_radio=1&list=RDcobFAMZDS0o
- d) www.youtube.com/watch?v=cobFAMZDS0o&list=RDcobFAMZDS0o&index=1
- e) www.youtube.com/watch?v=Ll8Ku-mFQxE
- f) www.youtube.com/watch?v=yQGFmBBvw1g&t=134s
- g) www.youtube.com/watch?v=GSWt0zjLgIY
- h) www.youtube.com/watch?v=PL0vU02QC4w
- i) www.youtube.com/watch?v=lMqoKLLi0Y4
- j) www.youtube.com/watch?v=oSLOHCOw3yg
- k) www.youtube.com/watch?v=6UMqdD6ejZQ
- l) www.youtube.com/watch?v=7FxltQ41bZc



