Dr. Babasaheb Ambedkar Technological University, Lonere

(Established by Government of Maharashtra, vide Dr. Babasaheb Ambedkar Technological University Act. No XXIX of 2014)

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NEP 2020 BASED CURRICULUM

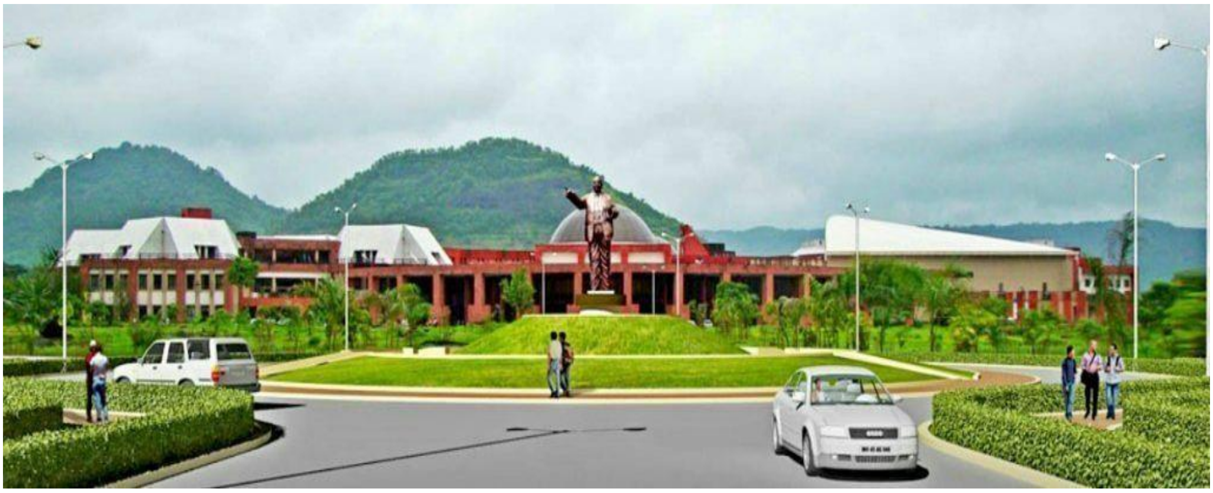
for

UNIVERSITY DEPARTMENT

Third Year B. Tech. in

MECHANICAL ENGINEERING

ACADEMIC YEAR 2025-2026



	Vision	Mission
University	The University is committed to become a leading 'Center of Excellence' in the field of Engineering, Technology and Science as a seat of learning with a national character and international outlook.	The University is committed to provide quality technical education, research and development services to meet the needs of industry, business, service sector and society, at large.
Department of Mechanical Engineering	The vision of the department is to achieve excellence in teaching, learning, research and transfer of technology and overall development of students.	Imparting quality education, looking after holistic development of students and conducting need-based research and extension.

Graduate Attributes:

The Graduate Attributes are the knowledge skills and attitudes which the students have at the time of graduation. These Graduate Attributes identified by National Board of Accreditation are as follows:

1. **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. **Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **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 documentation, make effective presentations, and give and receive clear instructions.
11. **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long Learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives (PEOs):

PEO1	Graduates should excel in engineering positions in industry and other organizations that emphasize design and implementation of engineering systems and devices.
PEO2	Graduates should excel in best post-graduate engineering institutes, reaching advanced degrees in engineering and related discipline.
PEO3	Within several years from graduation, alumni should have established a successful career in an engineering-related multi-disciplinary field, leading or participating effectively in interdisciplinary engineering projects, as well as continuously adapting to changing technologies.
PEO4	Graduates are expected to continue personal development through professional study and self-learning.
PEO5	Graduates are expected to be good citizens and cultured human beings, with full appreciation of the importance of professional, ethical and societal responsibilities.

Program Outcomes:

At the end of the program the student will be able to:

PO1	Apply knowledge of mathematics, science and engineering to analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools.
PO2	Analyze problems of production engineering including manufacturing and industrial systems to formulate design requirements.
PO3	Design, implement and evaluate production systems and processes considering public health, safety, cultural, societal and environmental issues.
PO4	Design and conduct experiments using domain knowledge and analyze data to arrive at valid conclusions.
PO5	Apply current techniques, skills, knowledge and computer-based-methods and tools to develop production systems.
PO6	Analyze the local and global impact of modern technologies on individual organizations, society and culture.
PO7	Apply knowledge of contemporary issues to investigate and solve problems with a concern for sustainability and eco-friendly environment.
PO8	Exhibit responsibility in professional, ethical, legal, security and social issues.
PO9	Function effectively in teams, in diverse and multidisciplinary areas to accomplish common goals.
PO10	Communicate effectively in diverse groups and exhibit leadership qualities.
PO11	Apply management principles to manage projects in multidisciplinary environment.
PO12	Pursue life-long learning as a means to enhance knowledge and skills.

Credit Framework under Four-Years Under Graduate Engineering Programme with Multiple Entry and Multiple Exit options:

- The Four-year Bachelor's Multidisciplinary Engineering Degree Programme allows the students to experience the full range of holistic and multidisciplinary education in addition to a focus on the chosen major and minors as per their choices and the feasibility of exploring learning from different institutions.
- The minimum and maximum credit structure for different levels under the Four-year Bachelor's Multidisciplinary Engineering Under-Graduate Programme with multiple entry and multiple exit options are as given below:

Credit Framework

Level	Qualification Title	Credit Requirement		Semester	Year
		Minimum	Maximum		
4.5	One-Year UG Certificate in Engg./ Tech.	40	44	2	1
5.0	Two-Years UG Diploma in Engg./Tech.	80	88	4	2
5.5	Three-Years Bachelor's Degree in Vocation (B. Voc.) or B. Sc. (Engg./ Tech.)	120	132	6	3
6.0	4-Years Bachelor's degree (B.E./ B.Tech. or Equivalent) in Engg./ Tech. with Multidisciplinary Minor	160	176	8	4
6.0	4-Years Bachelor's degree (B.E./ B.Tech. or Equivalent) in Engg./ Tech.- Honors and Multidisciplinary Minor	180	194	8	4
6.0	4-Years Bachelor's degree (B.E./ B.Tech. or Equivalent) in Engg./ Tech. - Honors with Research and Multidisciplinary Minor	180	194	8	4
6.0	4-Years Bachelor's degree (B.E./ B.Tech. or Equivalent) in Engg./ Tech. - Major Engg. Discipline with Double Minors (Multidisciplinary and Specialization Minors)	180	194	8	4

- There are multiple exit options at each level. The students will be given a specific Qualification mentioned in the table depending on the level at which he/she decides to have an exit, e.g., if a student decides to exit after completion of two years (level 5.0) of the program, he/she will be given a Diploma in Engineering with specific exit condition mentioned in the syllabus of the specific branch. He/she can rejoin the program with the multiple entry option at the level next where he/she chose to exit previously. The student can join at level 5.5 if successfully completed level 5.0 previously at the time of exit.
- Minimum credit requirements of each level are mentioned in the credit framework table.
- There are **4 distinct options available at level 6.0.**
- **First one is basic level 6.0 option** where minimum 160 - maximum 176 credits are mandatory which can be completed as per the Semester-wise Credit distribution structure mentioned in the table given below.
  Here, the Bachelor's Engineering Degree in chosen Engg./ Tech. Discipline with multidisciplinary minor (160 - 176 Credits) i.e. **B. Tech. in Mechanical Engineering with Multidisciplinary Minor** (160 - 176 credits) enables students to take up five-six or required additional courses of 14 credits in the discipline other than Mechanical Engineering distributed over semesters III to VIII. Here in the case of **B. Tech. in Mechanical Engineering with Multidisciplinary Minor** (160 - 176 credits) student is supposed to take up 50% or more Core Courses (mandatory courses, electives, vocational courses, Internship/ Field Projects/ Apprenticeship/Community Engagement Projects, Seminars, and Group Discussions) **from Mechanical Engineering discipline** to complete the 50% or more credits. In addition, the student will have to earn minimum 14 credits from the **multidisciplinary minor bucket**.
- Remaining three level 6.0 options are the advanced options where the student is given an opportunity to get extra qualification by earning some extra credits (18 - 20 extra credits). **These three options are given below:**
    1. Level 6.0: The **Bachelor's Engineering Degree with Honours** in chosen Major Engg./ Tech. Discipline i.e. in Mechanical Engineering with Honours with Multidisciplinary Minor (180 - 194 credits) enables students of Mechanical Engineering to take up five to six additional courses of 18 to 20 credits in the Mechanical Engineering discipline distributed over semesters III to VIII. The mechanism of distribution of these 18 - 20 credits over semesters III to VIII, which are over and above the 160 - 176 Credits prescribed for the duration of four years will be as prescribed by the University from time to time. The **student must have CGPA equal to or greater than 7.5 at the end of second semester to be eligible for this option**.
    2. Level 6.0: **The Bachelor's Engineering Degree with Research** in i.e., in Mechanical Engineering with Research with Multidisciplinary Minor (180 - 194 credits) enables students of Mechanical Engineering to take up a research project of 18 to 20 credits in the Mechanical Engineering discipline distributed over the

semesters VII to VIII. The **student must have CGPA equal to or greater than 7.5 at the end of sixth semester to be eligible for this option**.

3. Level 6.0: The **Bachelor's Engineering Degree in chosen Engg./ Tech. Discipline with Double Minor** (Multidisciplinary Minor and Specialization Minor, 180 - 194 credits), i.e. **B. Tech. in Mechanical Engineering with Multi-disciplinary Minor and with Specialization Minor in Computer Engineering** (180 - 194 credits) enables students to take up five-six additional courses of 14 credits in the discipline other than Mechanical Engineering (for the completion of multidisciplinary minor) and 18 to 20 extra credits in the **Computer Engineering discipline** distributed over semesters III to VIII. Here, the ***other selected discipline* in Engineering should be different from Specialization Minor i. e. Computer Engineering**. This enables students to take up five-six or required additional courses of 18 to 20 credits in the **Computer Engineering** discipline distributed over semesters III to VIII, which are over and above the min.160 - max.176 Credits. The mechanism of distribution of these 18 - 20 credits over the semesters III to VIII, prescribed for the duration of four years will be as prescribed by the University from time to time. **The student must have CGPA equal to or greater than 7.5 at the end of second semester to be eligible for this option**.

Semester-wise Credit distribution structure for Four Year UG Engineering Program - One Major, One Minor

Semester		**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total Credits**
Basic Science Course	BSC/ESC	06-08	08-10		--	--	--	--	--	14-18
Engineering Science Course		10-08	06-04		--	--	--	--	--	16-12
Programme Core Course (PCC)	Program Courses	--	02	08-10	08-10	10-12	08-10	04-06	04-06	44-56
Programme Elective Course (PEC)		--	--	--	--	04	08	02	06	20
Multidisciplinary Minor (MD M)	Multidisciplinary Courses		-	02	02	04	02	02	02	14
Open Elective (OE) Other than a particular program		--	--	04	02	02	--	--	--	08
Vocational and Skill Enhancement Course (VSEC)	Skill Courses	02	02	--	02	--	02	--	--	08
Ability Enhancement Course (AEC -01, AEC-02)	Humanities Social Science and Management (HSSM)	02	--	--	02	--	--	--	--	04
Entrepreneurship/Economics/ Management Courses		--		02	02	--	--	--	--	04
Indian Knowledge System (IKS)			02		--	--	--	--	--	02
Value Education Course (VEC)		--	--	02	02	--	--	--	--	04
Research Methodology	Experiential Learning Courses	--	--	--	--	--	--		04	04
Comm. Engg. Project (CEP)/Field Project (FP)		--	--	02	--	--	--	-	-	02
Project		--	--	--	--	--	--		04	04
Internship/ OJT		--	---			--	--	12	-	12
Co-curricular Courses (CC)	Liberal Learning Courses	02	02		--	--	--	--	-	04
Total Credits (Major)		**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**160-176**

It is necessary to follow the Semester-wise Credit distribution structure for Four-year UG Engineering Program as prescribed above.

- There are seven vertical categories with specific credits distributed in specific semesters.
- Student can choose a Program Elective Course (PEC) in that specific semester from the given subjects.

- Multidisciplinary course (MDM) and Open Elective (OE) courses can be chosen from the MDM and OE Buckets depending on student's choice. Completion of total credits given in the last column of the table for each vertical is mandatory.
- The students can complete 40% of the courses through online platforms like NPTEL/SWAYAM. The NPTEL/SWAYAM course content should be at least 80% similar to the course content in the syllabus.

General Rules and Regulations:

1. The normal duration of the course leading to B. Tech. degree will be EIGHT semesters.

2. The normal duration of the course leading to M. Tech. degree will be FOUR semesters.

3. Each academic year shall be divided into 2 semesters, each of 20 weeks duration, including evaluation and grade finalization, etc. The Academic Session in each semester shall provide for at least 90 Teaching Days. The semester that is typically from Mid-July to November is called the ODD SEMESTER, and the one that is from January to Mid-May is called the EVEN SEMESTER. For the First year B. Tech. and M. Tech. Classes, the schedule will be decided as per the admission schedule declared by Government of Maharashtra.

4. The schedule of academic activities for a Semester, including the dates of registration, mid-semester examination, end-semester examination, inter-semester vacation, etc. shall be referred to as the Academic Calendar of the Semester, which shall be prepared by the Dean (Academic), and announced at least TWO weeks before the Closing Date of the previous Semester.

5. The Academic Calendar must be strictly adhered to, and all other activities including co-curricular and/or extra-curricular activities must be scheduled so as not to interfere with the Curricular Activities as stipulated in the Academic Calendar.

Registration:

1. Lower and Upper Limits for Course Credits Registered in a Semester, by a Full-Time Student of a UG/PG Programme:
   A full-time student of a particular UG/PG programme shall register for the appropriate number of course credits in each semester/session that is within the minimum and maximum limits specific to that UG/PG programme as stipulated in the specific Regulations pertaining to that UG/PG programme.
2. Mandatory Pre-Registration for higher semesters: In order to facilitate proper planning of the academic activities of a semester, it is essential for every institute to inform to Dean (Academics) and COE regarding details of total no. of electives offered (Course-wise) along

with the number of students opted for the same. This information should be submitted within two weeks from the date of commencement of the semester as per academic calendar.

3. PhD students can register for any of PG/ PhD courses and the corresponding rules of evaluation will apply.
4. Under-Graduate students may be permitted to register for a few selected Post Graduate courses, in exceptionally rare circumstances, only if the Departmental Under-Graduate Committee (DUGC) / Departmental Post-Graduate Committee (DPGC) is convinced of the level of the academic achievement and the potential in a student.

Course Pre-Requisites:

1. In order to register for some courses, it may be required either to have exposure in, or to have completed satisfactorily, or to have prior earned credits in, some specified courses.
2. Students who do not register on the day announced for the purpose may be permitted LATE REGISTRATION up to the notified day in academic calendar on payment of late fee.
3. REGISTRATION IN ABSENTIA will be allowed only in exceptional cases with the approval of the Dean (Academic) / Principal.
4. A student will be permitted to register in the next semester only if he fulfils the following conditions:
   - i) Satisfied all the Academic Requirements to continue with the programme of Studies without termination
   - ii) Cleared all Institute, Hostel and Library dues and fines (if any) of the previous semesters;
   - iii) Paid all required advance payments of the Institute and hostel for the current semester;
   - iv) Not been debarred from registering on any specific ground by the Institute.

Evaluation System:

1. Absolute grading system based on absolute marks as indicated below will be implemented from academic year 2023-24, from the first year B. Tech.

Percentage of Marks	Letter Grade	Grade Point
91 - 100	EX	10.0
86 - 90	AA	9.0
81- 85	AB	8.5
76 - 80	BB	8.0
71 - 75	BC	7.5
66 - 70	CC	7.0
61 - 65	CD	6.5
56 - 60	DD	6.0
51 - 55	DE	5.5
40 - 50	EE	5.0
<40	FF	0.0

2. Class is awarded based on the CGPA of all eight semesters of B. Tech. Program.

CGPA	**Class**
5.00 to 5.49	Pass class
5.50 to 5.99	Second Class
6.00 to 7.49	First Class
7.5 and above	Distinction
[Percentage of Marks = (CGPA - 0.5)*10.0]	

3. A total of 100 Marks for each theory course are distributed as follows:

Mid Semester Exam (MSE) Marks	20
Continuous Assessment Marks	20
End Semester Examination (ESE) Marks	60

4. A total of 100 Marks for each practical course are distributed as follows:

Continuous Assessment Marks	60
End Semester Examination (ESE) Marks	40

- It is mandatory for every student of B. Tech. to score a minimum of 40 marks out of 100, M. Tech. to score a minimum of 45 marks out of 100 with a minimum of 20 marks out of 60 marks in End Semester Examination for theory course.
- This will be implemented from the first year of B. Tech. starting from Academic Year 2023-24.

5. Description of Grades:

EX Grade: An ‘EX’ grade stands for outstanding achievement.

EE Grade: The ‘EE’ grade stands for minimum passing grade.

The students may appear for the remedial examination for the subjects he/she failed for the current semester of admission only and his/her performance will be awarded with EE grade only.

FF Grade: The ‘FF’ grade denotes very poor performance, i.e. failure in a course due to poor performance.

6. Evaluation of Performance

a. **Semester Grade Point Average (SGPA)**

The performance of a student in a semester is indicated by Semester Grade Point Average (SGPA) which is a weighted average of the grade points obtained in all the courses taken by the student in the semester and scaled to a maximum of 10. (SGPA is to be calculated up to two decimal places). A Semester Grade Point Average (SGPA) will be computed for each semester as follows:

$$SGPA = \frac{\left[\sum_{i=1}^{n} c_i g_i\right]}{\left[\sum_{i=1}^{n} c_i\right]}$$

where,

'n' is the number of subjects for the semester,

'c_i' is the number of credits allotted to a particular subject, and

'g_i' is the grade-points awarded to the student for the subject based on his/her performance as per the table **given in point No. 1.**

SGPA will be rounded off to the second place of decimal and recorded as such.

b. **Cumulative Grade Point Average (CGPA):**

An up to date assessment of the overall performance of a student from the time he entered the Institute is obtained by calculating Cumulative Grade Point Average (CGPA) of a student. The CGPA is weighted average of the grade points obtained in all the courses registered by the student since s/he entered the Institute. CGPA is also calculated at the end of every semester (up to two decimal places). Starting from the first semester at the end of each semester (S); a Cumulative Grade Point Average (CGPA) will be computed as follows:

$$CGPA = \frac{\left[\sum_{i=1}^{m} c_i g_i\right]}{\left[\sum_{i=1}^{m} c_i\right]}$$

where,

m is the total number of subjects from the first semester onwards up to and including the semester S,

c_i is the number of credits allotted to a particular subject, and

g_i is the grade-points awarded to the student for the subject based on his/her performance as per the above table.

CGPA will be rounded off to the second place of decimal and recorded as such.

7. Attendance Requirements:

a. All students must attend every lecture, tutorial and practical classes.

b. To account for approved leave of absence (e.g. representing the Institute in sports, games or athletics; placement activities; NCC/NSS activities; etc.) and/or any other such contingencies like medical emergencies, etc., the attendance requirement shall be a minimum of 75% of the classes actually conducted. If the student failed to maintain 75% attendance, he/she will be detained for appearing the successive examination. The Dean (Academics)/ Principal is permitted to give 10% concession for the genuine reasons as such the case may be. In any case, the student will not be permitted for appearing the examination if the attendance is less than 65%.

c. The course instructor handling a course must finalize the attendance 3 calendar days before the last day of classes in the current semester and communicate clearly to the students by displaying prominently in the department and also in report writing to the head of the department concerned.

d. The attendance records are to be maintained by the course instructor and s/he shall show it to the student, if and when required.

8. Transfer of Credits:

The courses credited elsewhere, in Indian or foreign University/Institutions/ Colleges/Swayam Courses by students during their study period at DBATU may count towards the credit requirements for the award of degree. The guidelines for such transfer of credits are as follows:

a) 20 % of the total credit will be considered for respective calculations.
b) Credits transferred will be considered for overall credits requirements of the programme.
c) Credits transfer can be considered only for the course at same level i.e. UG, PG etc.
d) A student must provide all details (original or attested authentic copies) such as course contents, number of contact hours, course instructor /project guide and evaluation system for the course for which he is requesting a credits transfer. S/he shall also provide the approval or acceptance letter from the other side. These details will be evaluated by the concerned Board of Studies before giving approval. The Board of Studies will then decide the number of equivalent credits the student will get for such course(s) in DBATU. The complete details will then be forwarded to the Dean, Academics for approval.
e) A student has to get minimum passing grades/ marks for such courses for which the credits transfers are to be made.
f) Credits transfers availed by a student shall be properly recorded on academic record(s) of the student.
g) In exceptional cases, the students may opt for higher credits than the prescribed.

Dr. Babasaheb Ambedkar Technological University Lonere University

Department of Mechanical Engineering

Third year Course Structure for B. Tech. Program as per NEP 2020

w.e.f. 2025-26

(Only for University Department)

Semester V										
Course Category	**Course Code**	**Course Title**	**Teaching Scheme**			**Evaluation Scheme**				
			L	**T**	**P**	**CA**	**MSE**	**ESE**	**Total**	**No. of Credits**
PCC	25UD1612PC501	Applied Thermodynamics	2	1	-	20	20	60	100	3
PCC	25UD1612PC502	Machine Design – I	2	1	-	20	20	60	100	3
PCC	25UD1612PC503	Theory of Machines- II	2	1	-	20	20	60	100	3
PE	25UD1612PE504A 25UD1612PE504B 25UD1612PE504C 25UD1612PE504D 25UD1612PE504E 25UD1612PE504F	1. Engineering Tribology 2. Fluid Machinery 3. Electric Vehicles 4. Industry 4.0 5. Fundamentals of Automobile Design 6. Finite Element Analysis	3	-	-	20	20	60	100	3
MDM	25UD1612MDM505A/ 25UD1612MDM505B	MDM Bucket## Manufacturing Processes/ Fluid Mechanics	3	-	-	20	20	60	100	3
VSEC	25UD1612SE506	Seminar	-	-	2	60	-	40	100	1
PCC Lab	25UD1612PCL507	Applied Thermodynamics Lab	-	-	2	60	-	40	100	1
	25UD1612PCL508	Computer Aided Engineering Lab	-	-	2	60	-	40	100	1
	25UD1612PCL509	Theory of Machines- II Lab	-	-	2	60	-	40	100	1
Field Project		Industrial Training –II (To be started)	-	-	2	-	-	-	-	-
Field Project	25UD1612FT510	Industrial Training –I (To be evaluated)	-	-	4	60	-	40	100	2
		Total	**12**	**3**	**14**	**400**	**100**	**500**	**1000**	**21**

Semester VI											
Course Category	**Course Code**	**Course Title**	**Teaching Scheme**			**Evaluation Scheme**				**No. of Credits**
			L	**T**	**P**	**CA**	**MSE**	**ESE**	**Total**	
PCC	25UD1612PC601	Heat Transfer	2	1	-	20	20	60	100	3
PCC	25UD1612PC602	Manufacturing Processes-II	2	1	-	20	20	60	100	3
PCC	25UD1612PC603	Machine Design-II	2	1	-	20	20	60	100	3
PCC	25UD1612PC604	Refrigeration and Air conditioning	2	1	-	20	20	60	100	3
PE	25UD1612PE605A 25UD1612PE605B 25UD1612PE605C 25UD1612PE605D 25UD1612PE605E	1. Advanced Automobile Design 2. Process Equipment Design 3. Robotics 4. IC Engines 5. Introduction to Quantum Computing	3	-	-	20	20	60	100	3
MDM	25UD1612MDM606	MDM Bucket## Theory of Machines	3	-	-	20	20	60	100	3
	25UD1612FP607	Technical Project for Community Service	-	-	4	60	-	40	100	2
PCC Lab	25UD1612PCL608	Manufacturing Processes-II Lab	-	-	2	60	-	40	100	1
	25UD1612PCL609	Machine Design Practice	-	-	2	60	-	40	100	1
	25UD1612PCL610	Heat Transfer and Refrigeration Air Conditioning Lab	-	-	2	60	-	40	100	1
Field Project		Industrial Training –II (To be completed)	-	-	4	-	-	-	-	-
		Total	**14**	**4**	**14**	**360**	**120**	**520**	**1000**	**23**

Exit Option-III: Qualifier for UG Bachelor's Degree

- ***This should contain the well-defined project activity which is equivalent to 10 Credits.***
- ***To be completed during vacation after Third Year in the industry/institute.***
- ***It should be carried out for the duration of 08 Weeks.***
- ***The project/training should be evaluated by a panel of examiners.***

Semester V

Course Code: 25UD1612PC501
Course Title: Applied Thermodynamics

Teaching Scheme	Examination Scheme
Lecture: 2 hrs/week Tutorial: 1 hrs/week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Course Outcomes: At the end of the course, students will be able to:

CO1	Describe the Concepts of the Fuels and combustion
CO2	Analyze the steam boilers including the Boiler performance
CO3	Analyze vapour power cycles
CO4	Examine the Steam Nozzles, Turbines and condenser
CO5	Understand the Reciprocating and rotary compressor

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1		2			1						
CO2	2	1	2			1						
CO3	3		1		1							
CO4	3	1										
CO5	1	1	1									

Course Contents

Unit 1: Fuels and Combustion

Types of fuels, calorific values of fuel and its determination, combustion equation for hydrocarbon fuel, determination of minimum air required for combustion and excess air supplied conversion of volumetric analysis to mass analysis, fuel gas analysis.

Unit 2: Steam Generators

Classification of boilers, boiler details, requirements of a good boiler, Package boiler, High pressure and super critical boilers, Boiler Mountings and Accessories.
Boiler Draught: Classification of draught, natural draught, efficiency of the chimney, draught losses,

types of boiler draught.
Performance of Boilers: Equivalent evaporation, boiler efficiency, boiler trial and heat balance, Introduction to IBR.

Unit 3: Vapor Cycles and Steam Nozzles

Ideal Rankine cycle, Reheat and Regeneration, Calculation of thermal efficiency, specific steam/fuel consumption, work ratio for above cycles.
Steam Nozzles: Types of Nozzles, General relationship between area, velocity and pressure. Choked flow, Condition for maximum discharge, Nozzle efficiency, supersaturated flow through nozzles

Unit 4: Steam Turbines

Advantages and classification of steam turbines, compounding of steam turbines, velocity diagrams, work one done and efficiencies, governing of turbines.
Condensers, Cooling Towers: Elements of steam condensing plants, advantages of using condensers, types of condensers, thermodynamic analysis of condensers, efficiencies, cooling towers.

Unit 5: Reciprocating Air Compressor

Classification constructional details, theoretical and actual indicator diagram, FAD, multi staging, condition for maximum efficiency, capacity control.
Rotary Compressor – Concepts of Rotary compressors, Root-blower and type compressors, Centrifugal compressors.

Texts:

1. T. D. Eastop, A. McConkey, “Applied Thermodynamics”, Addison Wesley Longman.
2. Rayner Joel, “Basic Engineering Thermodynamics”, Addison Wesley Longman.

References:

1. P. K. Nag, “Basic and Applied Thermodynamics", Tata McGraw Hill Publications.
2. P. K. Nag, “Power Plant Engineering”, Tata McGraw Hill Publications, 2nd edition.

Course Code: 25UD1612PC502
Course Title: Machine Design - I

Teaching Scheme	Examination Scheme
Lecture: 2 hrs/week Tutorial: 1 hrs/week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand and apply the phases of mechanical design, material selection, standardization, and ergonomic/aesthetic aspects.
CO2	Analyze machine components under static loading using theories of failure and design of joints.
CO3	Evaluate components under fluctuating loads and perform fatigue design using Goodman and Soderberg criteria.
CO4	Design shafts, keys, and couplings based on strength and torsional rigidity criteria using relevant codes.
CO5	Design threaded joints, power screws, and springs considering mechanical stresses and functional efficiency.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	1	1	1	1					2
CO2	3	3	2	2	2	1						1
CO3	3	3	3	2	2	1	1					2
CO4	3	2	3	2	3	1						1
CO5	3	2	3	2	3	1						1

Course Contents

Unit 1: Introduction to Mechanical Design & Design Against Static Loads

Mechanical Engineering Design: Definition, Meaning, Importance, Phases of Design: Traditional vs. Industrial Design Process, Design Considerations: Aesthetic, Ergonomic, Standardization, Preferred Numbers, Use of Design Data Book and ISO 9000, Selection of Materials: Weighted Point Method, Common Engineering Materials and Their Properties (CI, MS, Brass, Copper), Stresses and Strain: Axial, Bending, and Torsion, Introduction to Concurrent Engineering and Integrated Design
Static Loading: Simple problems on static loading, Design of Cotter Joint, Design of Knuckle Joint

Unit 2: Design Against Fluctuating Loads & Theories of Failure

Types of Loading: Static vs Fluctuating, Stress Concentration: Causes, Factors & Reduction, Endurance Limit, Fatigue Failure, Notch Sensitivity, Design for Finite and Infinite Life,

Cumulative Damage Soderberg and Goodman Diagrams
Theories of Failure: Maximum Normal Stress Theory, Maximum Shear Stress Theory, Maximum Distortion Energy Theory, Comparison of Theories, Combined Loading Applications.

Unit 3: Design of Shafts, Keys and Couplings

Types of Shafts: Transmission Shafts, Spindles, Axles, Design for Strength and Rigidity (Torsional & Bending), ASME Code for Shaft Design, Types of Keys: Flat, Square; Design and Fitment, Splined Shafts Overview, Design of Rigid Couplings: Muff, Flange, Design of Flexible Couplings: Bush pin, etc.

Unit 4: Design of Power Screws and Welded Joints

Power Screws: Types of Threads, Terminology, Torque for Lifting/Lowering, Self- Locking, Efficiency, Overall and Thread Efficiency, Design of Screw, Nut, Compound, Differential Screws, Introduction to Recirculating Ball Screw, Welded Joints: Types (Butt, Fillet), Strength Calculations, Welded Joints under Eccentric Load and Bending.

Unit 5: Design of Mechanical Springs

Springs: Types and Applications, Terminology and Material Selection, Helical Compression Springs: Stress-Deflection Equation, Wahl's Factor, End Styles, Shot Peening, Design of Tension and Compression Springs, Torsion Springs, Multi-leaf Springs, Nipping Concept.

Text:

1. V. B. Bhandari; *Design of Machine Elements*; Tata McGraw Hill Publication.

References:

1. Shigley J. E. & Mischke C. R.; *Mechanical Engineering Design*; Tata McGraw Hill.
2. M. F. Spotts; *Design of Machine Elements*; Pearson Education.
3. Robert L. Norton; *Machine Design: An Integrated Approach*; Pearson Education.

Course Code: 25UD1612PC503
Course Title: Theory of Machines - II

Teaching Scheme	Examination Scheme
Lecture: 2 hrs/week Tutorial: 1 hrs/week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Pre-Requisites: Engineering Mechanics, ToM - I

Course Outcomes: At the end of the course, students will be able to:

CO1	Identify and select type of belt drive for a particular application
CO2	Evaluate gear tooth geometry and select appropriate gears, gear trains
CO3	Characterize flywheels as per application requirement
CO4	Understand gyroscopic effects in ships, airplanes, and road vehicles.
CO5	Understand free and forced vibrations of single degree freedom systems

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1		2			1				2
CO2	2	3			1							3
CO3	2	2		1								2
CO4	2	3		2								3
CO5	2	3		3								3

Course Contents

Unit 1: Belt Drives

Flat belts: Effect of slip, Creep, crowing of pulley, Length of belt, Centrifugal tension, Initial tension in belts, ratio of belt tensions, power transmitted.
Belts: Advantages of V-Belts over Flat Belt, ratio of belt tensions, torque transmitted.

Unit 2: Toothed Gears

Classification of gears, Terminology of spur gears, Conjugate action, Involute and cycloidal profiles, Path of contact, Arc of contact, Contact ratio, Interference, Undercutting, Backlash. Introduction to Internal gears.
Helical gear terminology, Normal and transverse module, Virtual number of teeth.

Unit 3: Worm Gear, Bevel Gear & Gear Trains

Introduction & terminology of Worm gears & Bevel gears, concept of virtual number of teeth in bevel gear, Efficiency of worm gear.
Types of gear trains, Simple, Compound & Reverted Gear Trains, their Velocity ratios, Simple Epicyclic Gear Train & its Velocity Ratios.

Unit 4: Flywheel and Gyroscope

Flywheel: Turning moment diagram, Energy stored in the flywheel, Fluctuation of energy and speed, Determination of mass of flywheel for four stroke single cylinder IC Engine & simple Punching Press.
Gyroscope: Principles of gyroscopic action, Precession and gyroscopic acceleration, gyroscopic couple, Effect of the gyroscopic couple on Aeroplane, Naval ships and four wheelers.

Unit 5: Vibrations

Mechanical Vibration: Basic concepts and definitions of Vibration, Single degree of freedom system, Undamped free vibrations, Natural frequency of Longitudinal & transverse vibrations of shaft with point loads (neglecting inertia), Introduction to damped free vibrations & equation of motion, Types of damping. Critical or whirling Speed of shaft in undamped system. Introduction to forced vibrations, Torsional Vibrations: Natural frequency & modes of single and two rotor system.

Texts:

1. S. S. Rattan, "Theory of Machines," Tata McGraw Hill Publications, New Delhi.
2. Thomas Beven, "Theory of machines," CBS Publishers, Delhi, 1984.
3. Kelly, Graham S., "Mechanical Vibrations," Schaum's Outline Series, McGraw Hill, New York, 1996.
4. Rao, J.S., "Introductory Course on Theory and Practice of Mechanical Vibration", New age International (P) Ltd, New Delhi, 2nd edition, 1999.

References:

1. Rao Singiresu, "Mechanical Vibrations", Pearson Education, New Delhi, 4th edition 2004.
2. J. E. Shigley, J. J. Vicker, "Theory of Machines and Mechanisms", Tata McGraw Hill International.

Course Code: 25UD1612PE504A
Course Title: Engineering Tribology

Teaching Scheme	Examination Scheme
Lecture: 3 hrs/week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the basic concepts and importance of tribology.
CO2	Evaluate the nature of engineering surfaces, their topography and surface characterization techniques
CO3	Analyse the basic theories of friction and frictional behavior of various materials
CO4	Select a suitable lubricant for a specific application
CO5	Compare different wear mechanisms

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	2	1	2	2		1						
CO3	2	3	1	2	1	1	1					
CO4	2	2	2		1	1	2		1		1	
CO5	1	1	1	1	1							

Course Contents

Unit 1: Introduction

Definition of tribology, friction, wear and lubrication; importance of tribological studies.
Surface Topography: Methods of assessment, measurementof surface roughness different statistical parameters (R_a, R_z, R_{max}, etc.). Contact between surfaces, deformation between single and multiple asperity contact, contact theories involved.

Unit 2: Friction

Coulomb and Amontons' laws of friction, its applicability and limitations, comparison between static, rolling and kinetic friction, friction theories, mechanical interlocking, molecular attraction, electrostatic forces and welding, shearing and ploughing, models for asperity deformation.

Unit 3: Lubrication

Types of lubrication, viscosity, characteristics of fluids as lubricant, hydrodynamic lubrication, Reynold's equation, elasto-hydrodynamic lubrication: partial and mixed, boundary lubrication, various additives, solid lubrication.

Unit 4: Sliding Wear

Sliding wear: Abrasion, adhesion and galling, testing methods pin-on-disc, block-on-ring, etc., theory of sliding wear, un-lubricated wear of metals, lubricated wear of metals, fretting wear of metals.

Unit 5: Abrasion and Erosion Wear

Wearing by plastic deformation and brittle fracture; Wear by hard particles: Two-body abrasive wear, three-body abrasive wear, erosion, effects of hardness, shape and size of particles.

Texts:

1. I. M. Hutchings, "Tribology, Friction and Wear of Engineering Materials", Edward Arnold, London.
2. R. C. Gunther, "Lubrication", Baily Brothers and Swinfen Limited.

References:

1. J. Halling, "Principles of Tribology", McMillan Press Limited.
2. Cameron Alastair, "Basic Lubrication Theory", Wiley Eastern Limited.
3. M. J. Neale, "Tribology Handbook", Butterworths.

Course Code: 25UD1612PE504B
Course Title: Fluid Machinery

Teaching Scheme	Examination Scheme
Lecture: 3 hrs/week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 03 hrs)

Pre-Requisites: Fluid Mechanics

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand and apply momentum equation
CO2	Understand and explain Hydrodynamic Machines
CO3	[redacted] difference between impulse and reaction turbines
CO4	Find efficiencies, draw velocity triangles
CO5	[redacted] governing mechanisms for hydraulic turbines
CO6	[redacted] working of various types of pumps, draw velocity diagrams, do simple calculations
CO7	Design simple pumping systems

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1									1
CO2	3		3				2					1
CO3	3	2										1
CO4	3	3	2									1
CO5			3									1
CO6	3	3	3	1	1							1
CO7	3	3		3								1

Course Contents

Unit 1: Momentum Equation and its Applications

Impulse momentum, Principle, Fixed and moving flat inclined plates, Curved vanes, Series of plates and vanes, Velocity triangle and their analysis, Water wheels. Hydrodynamic Machines: Classification, General theory, Centrifugal head, Fundamental equations, and Euler's equation, Degree of reaction, Head on machine, various efficiencies, Condition for maximum hydraulic efficiency.

Unit 2: Hydraulic Turbines

Impulse Turbines: Impulse principle, Construction of Pelton wheel, Velocity diagrams and its

analysis, Number of buckets, Jets, Speed ratio, Jet ratio.
Reaction Turbines: Constructional details of Francis, Kaplan and Propeller turbine, Deciaz turbine, and Draft tube types, Efficiencies, Cavitation.

Unit 3: Governing of Turbines

Methods of governing, Performance characteristics, Safety devices, Selection of turbines, Unit quantities, Specific speed, Principles of similarity and model testing.

Unit 4: Centrifugal Pump

Construction, Classification, Terminology related to pumps, Velocity triangle and their analysis, Cavitation, NPSH, Thoma's cavitation factor, Priming, Methods of priming, Specific speed, Performance characteristics, Actual thrust and its compensation, Troubleshooting.
Multistage Pumps: Pump H-Q characteristics and system H-Q Characteristics, Series and parallel operation of pumps, Systems in series and parallel, Principle of model testing and similarity.

Unit 5: Special Purpose Pumps

Chemical pumps, nuclear pumps, Sewage pumps, Submersible deep well pumps, Pump installation, Energy efficient pumps.
Failure of Pumping System: Pump failures, Remedies, Source failure, Causes and remedies, Trouble shooting.
Miscellaneous Pumps: Reciprocating pump, Gear pump, Vane pump, Lobe pump, etc., Application field (no mathematical treatment).

Texts:

1. P. N. Modi, S. M. Seth, "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard Book House, Rajsons Publications Pvt. Ltd., 20th edition.
2. R. K. Bansal, "A Text Book of Fluid Mechanics and Hydraulic Machines", Lakshmi Publications Pvt. Ltd., 9th edition.

Reference:

1. Yunus A. Çengel, John M. Cimbala, Fluid Mechanics: Fundamentals and Applications, McGraw Hill, 3rd edition, 2014.

Course Code: 25UD1612PE504C
Course Title: Electric Vehicles

Teaching Scheme	Examination Scheme
Lecture: 3 hrs/ week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Course Contents

Unit 1: Introduction to EV

Past, Present & Feature of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs, Comparison of EV Vs IC Engine.

Unit 2: EV System

EV Configuration: Fixed & variable gearing, single & multiple motor drive, In-wheel drives EV Parameters: Weight, size, force, energy & performance parameters.

Unit 3: EV Propulsion: Electric Motor

Choice of electric propulsion system, block diagram of EV propulsion system, concept of EV Motors, single motor and multi-motor configurations, fixed & variable geared transmission, In-wheel motor configuration, classification of EV motors, Electric motors used in current vehicle applications, Recent EV Motors, Comparison of Electric Motors for EV applications Required Power Electronics & Control: Comparison of EV power devices, introduction to power electronics converter, four quadrant DC chopper, three-phase full bridge voltage-fed inverter, soft-switching

EV converters, comparison of hard-switching and soft-switching converter, three-phase voltage-fed resonance DC link inverter, Basics of Microcontroller & Control Strategies.

Unit 4: EV Motors and Controls

EV Motor Drive: DC Motor: Type of wound-field DC Motor, Torque speed characteristics DC-DC Converter, two quadrant DC Chopper, two quadrant zero voltage transition converter- fed dc motor drive, speed control of DC Motor.
Induction Motor Drive: Three Phase Inverter Based Induction Motor Drive, Equal Area PWM, Three Phase Auxiliary resonant snubber (ARS) Inverter Type (ZVC & ZCS), Single Phase ARS Inverter Topology, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control.

Unit 5: Energy Sources & Charging

Different Batteries and Ultracapacitors, Battery characteristics (Discharging & Charging) Battery Chargers: Conductive (Basic charger circuits, Microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication methods.
Charging Infrastructure: Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move- and-charge zone.

References:

1. C.C. Chan, K.T. Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
3. Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz M. Ebrahimi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles”, 3rd Edition, CRC Press, 2018.
4. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

Course Code: 25UD1612PE504D
Course Title: Industry 4.0

Teaching Scheme	Examination Scheme
Lecture: 3 hrs/week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Course Contents

Unit 1: Introduction to Industry 4.0

History and evolution of industrial revolutions, the core principles of Industry 4.0, impact of Industry 4.0 on various types of industries.

Unit 2: Cyber-Physical Systems (CPS)

Physical and digital systems interaction, interaction of sensors, actuators, and control systems, etc. AR/VR techniques, components of AR/VR systems, Applications of VR and AR in design, training, and manufacturing processes.

Unit 3: Internet of Things (IoT) and Industrial Internet of Things (IIoT)

Role of interconnected devices, Data analytics and it’s applications in modern manufacturing systems

Unit 4: Data Analytics and Big Data

Representation of large datasets, search techniques for large databases, data analytics, applications of Big data.

Unit 5: Cloud Computing

Cloud technologies, applications of cloud computing in manufacturing industry, Cloud-based design tools and data storage.

Texts:

1. Wankhede Vishal, Sahlot Pankaj; Industry 4.0 for Manufacturing Systems: Concepts, Technologies and Applications, CRC Press, 2025.
2. Refaey Mahmoud, Tygi Amit Kumar; Artificial Intelligence Applied to Industry 4.0, Wiley Publication, 2024.

Course Code: 25UD1612PE504E
Course Title: Fundamentals of Automobile Design

Teaching Scheme	Examination Scheme
Lecture: 3 hrs/week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Course Outcomes: At the end of the course, students will be able to:

CO1	Identify the different parts of the automobile.
CO2	Explain the working of various parts like engine, transmission, clutch, brakes etc.
CO3	Demonstrate various types of drive systems
CO4	Apply vehicle troubleshooting and maintenance procedures.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Course Contents

Unit 1: Introduction to Styling

Introduction to Styling, Basic of Design - Introduction to Design, Good Design & it's Examples of All Time, Industrial Design & its use. Design Process - Typical Product Life Cycle, Automotive Design Process (for production release), Design Studio (Automotive studio) Process or Product Conceptualization Process, Case Study. CAS Surfaces or Digital Clay Models, Class A Surfaces - Role of Class A surface Engineer, Requirements for a Surface to fulfil "Class A Surface" Standards, Case Studies for Class A Surfaces, Class A Surface Creation for Bonnet.

Unit 2: Introduction to Body in White

Introduction & familiarization to Body in White (BIW), various type of BIW, Types of BIW sub system, various aggregates of BIW. Bonnet Design Case Study: Function of Bonnet, Defined Input to Bonnet, Intended Input to Bonnet Design. Steps in Bonnet design, Study of Class A Surfaces, Hood Package Layout, Typical Sections, Block Surfaces in 3D, Dynamic Clearance Surfaces in 3D, Hood Structural Members, CAE 1 (Durability, Crash), Panel Detail Design, Body Assembly Process, CAE 2 (Durability, crash, individual panel level), Design Updating & Detailing Prototypes, Design Updating & Production Release.

Unit 3: Computer Aided Engineering (CAE)

Introduction to CAE & its importance in the PLM, Introduction to FEA & its applications (NVH, Durability & Vehicle Crashworthiness). Introduction of Pre-Processor, Post-Processor & Solvers. Importance of discretization & Stiffness Matrix (for automobile components). Importance of oil canning on an automobile hood with Case study related to Durability Domain. Modal analysis on the hood (Case Study related to NVH Domain). Introduction of vehicle crashworthiness & Bio-mechanics (Newtonian laws, energy management, emphasis of impulse in car crashes). Head impact analysis as a Case study on the hood of an automobile (Eurocamp test regulation). Importance of Head performance criteria (HPC). Introduction to failure criteria (By explaining the analogy of using uni- axial test results for predicting tri-axial results in reality), Mohr's Circle, Von-Mises stress criteria, application of various failure criteria on brittle or ductile materials.

Unit 4: Noise-Vibration-Harshness (NVH)

Introduction to CAD, CAM & CAE, FEA - Definition, Various Domains – NVH, Dura, Crash, Occupant Safety, CFD. Implicit vs. Explicit Solvers, Degree of Freedom, Stiffness Matrix, Pre-Post & Solver; Types of solvers, Animation. Durability -Oil Canning, Oil Canning on Hood, Scope of work, Loading, Boundary Conditions, Results & Conclusions. NVH – Constrained Modal Analysis, Constrained Modal Analysis on Hood, Scope of work, Loading, Boundary Conditions, Results & Conclusions. Crash – Vehicle Crashworthiness, Energy Management, Biomechanics, Head Impact Analysis on Hood, Importance of Failure Criteria, Von-Mises Stress.

Unit 5: Sheet Metal

Sheet metal design & Manufacturing Cycle, Simultaneous Engineering (SE) feasibility study, Auto Body & its parts, important constituents of an automobile, sheet metal, sheet metal processes. Type of draw dies, Draw Model development & its considerations. Forming Simulations, Material Properties, Forming Limit Curve (FLD), Pre-Processing, Post-Processing, Sheet metal formability- Simulation.
Die Design –Sheet metal parts, Sheet metal operations (Cutting, Non-Cutting etc.), Presses, Various elements used in die design, Function of each element with pictures, Types of dies, Animation describing the working of dies, Real life examples of die design. Fixture Design - Welding (Spot/Arc Welding), Body Coordinates, 3-2-1 principle, Need for fixture, Design considerations, Use of product GD&T in the fixture design, fixture elements. Typical operations in Sheet metal Fixture (Manual/Pneumatic/Hydraulic fixture), Typical unit design for sheet metal parts (Rest/Clamp/Location/Slide/Dump units/Base), Types of fixture (Spot welding/ Arc welding/ Inspection fixture/Gauges)

Tools related training (Approx. 20 Hrs on Self Study Mode):

The students should choose a suitable software tool depending on the availability:
AutoCAD, AutoCAD Electrical, AutoCAD Mechanical, AutoCAD P&ID, Autodesk 3ds Max, Autodesk Alias, Autodesk Sketch Book, Automotive, CATIA V5, CATIA V6, FEA, Autodesk Fusion 360, Autodesk Inventor, Autodesk Navisworks, Autodesk Ravit, Autodesk Showcase, Autodesk Simulation, PTC Creo, PTC Pro ENGINEER, Solid Edge, SOLIDWORKS.

Texts:

1. Curt Larson, "Datum Principles: Flexible Parts: Applications for Automotive Body-in-White and Interior Trim (Dimensional Management Series Book 1)", Right Tech, Inc., Kindle Edition.
2. Curt Larson, "Datum Principles: Flexible Parts: Applications for Automotive Body-in-White and Interior Trim (Dimensional Management Series Book 2)", Right Tech, Inc., Kindle Edition.
3. Vukato Boljanovic, "Sheet Metal Forming Processes and Die Design", Industrial Press Inc., Kindle Edition.

References:

1. Video Lectures and reference material available at Ready Engineer Portal from TATA Technologies
2. Ibrahim Zeid, "CAD/CAM Theory and Practice", Tata McGraw-Hill Publication
3. Mikell P. Grover "Automation, Production Systems and Computer-Integrated Manufacturing", Pearson Education, New Delhi.
4. P. Radhakrishnan & S. Subramanyan "CAD/CAM/CIM" Willey Eastern Limited New Delhi.
5. On Wubiko, C., "Foundation of Computer Aided Design", West Publishing Company. 1989
6. R.W. Heine, C. R. Loper and P. C. Rosenthal, Principles of Metal Casting, McGraw Hill, New York, 1976.
7. J. H. Dubois and W. I. Pribble, Plastics Mold Engineering Handbook, Van Nostrand Reihnhold, New York, 1987.
8. N. K. Mehta, Machine Tool Design, Tata McGraw-Hill, New Delhi, 1989.
9. Geoffrey Boothroyd, Peter Dewhurst and Winston Knight; Product Design for Manufacturing and Assembly, 2nd Edition
10. C. Howard, Modern Welding Technology, Prentice Hall, 1979.
11. Grieves, Michael, Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303
12. Stark, John; Product Lifecycle Management: Paradigm for 21st Century Product Realization, Springer Verlag, 2004; ISBN 1852338105.

Course Code: 25UD1612PE504F
Course Title: Finite Element Analysis

Teaching Scheme	Examination Scheme
Lecture: 3 hrs/week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Course Outcomes: At the end of the course, students will be able to:

CO1	Identify the different parts of the automobile.
CO2	Explain the working of various parts like engine, transmission, clutch, brakes etc.,
CO3	Demonstrate various types of drive systems
CO4	Apply vehicle troubleshooting and maintenance procedures.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Course Contents

Unit 1: Introduction

Finite Element Analysis (FEA) and its need, Advantages and limitations of Finite Element Analysis, FEA procedure.

Unit 2: Elements of Elasticity

Stress at a point, Stress equation of equilibrium, 2-D state of stress, Strains and displacements, Stress-strain relationship for 2-D state of stress, Plane stress and plane strain approach.

Unit 3: Relevant Matrix Algebra

Addition, subtraction and multiplication of matrices, Differentiation and integration of matrices, Inverse of a matrix, Eigen values and eigen vectors, Positive definite matrix, Gauss elimination.

Unit 4: One-Dimensional Problems

Introduction, FE modeling, Bar element, Shape functions, Potential energy approach, Global stiffness matrix, Boundary conditions and their treatments, Examples.

Unit 5: Trusses and Frames and Two-dimensional Problems

Introduction, Plane trusses, Element stiffness matrix, Stress calculations, Plane frames, examples. Two-dimensional Problems Introduction and scope of 2-D FEA, FE modeling of 2-D problem, Constant strain triangle, other finite elements (no mathematical treatment included), Boundary conditions.

Texts:

1. T. R. Chandrupatla, A.D. Belegundu, “Introduction to Finite Elements in Engineering”, Prentice Hall of India Pvt. Ltd., 3rd edition, New Delhi, 2004.
2. P. Seshu, “A Textbook of Finite Element Analysis”, Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
3. R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, “Concepts and Applications of Finite Element Analysis”, John Wiley & Sons, Inc.

References:

1. K. J. Bathe, “Finite Element Procedures”, Prentice Hall of India Pvt. Ltd., 2006.

Course Code: 25UD1612SE506
Course Title: Seminar

Scheme	Examination Scheme
Contact duration: 2 hrs/week Credit: 1	Continuous Assessment: 60 Marks Presentation/Oral: 40 Marks

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Course Contents

Students are expected to select a topic in the emerging areas in consultation with concern guide and prepare a presentation and seminar report based on the available literature.

Course Code: 25UD1612PCL507
Course Title: Applied Thermodynamics Lab

Practical Scheme	Examination Scheme
Practical: 2 hrs/week Credits: 1	Continuous Assessment: 60 Marks Practical/Oral Exam: 40 Marks

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Concepts of Bomb Calorimeter and calorimeter
CO2	Evolution of steam power plant
CO3	Efficiency evaluation of Compressor
CO4	Exposure to software through minor project based on steam power plant

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

List of Experiments/Assignments

Any six experiments out of the following list:

1. Determination of calorific value by Bomb calorimeter
2. Measurement of dryness fraction of steam using separating & throttling calorimeter.
3. Performance and heat balancing of boiler.
4. Trial on convergent/convergent-divergent type nozzle
5. Performance evaluation of steam turbine (Impulse).
6. Performance evaluation of surface condenser.
7. Flue gas analysis using emission measuring instruments
8. Study & trial on single stage/two-stage reciprocating air compressor

Any Two **experiments from the following list:**

1. Performance calculations of single cylinder VCR diesel engine.
2. Performance calculations of multi-cylinder petrol engine.
3. Performance calculations of multi-cylinder diesel engine.

Course Code: 25UD1612PCL508
Course Title: Computer Aided Engineering Lab

Practical Scheme	Examination Scheme
Practical: 2 hrs/ week Credit: 1	Continuous Assessment: 60 Marks Practical/Oral Exam: 40 Marks

Pre-Requisites: MD-CAD

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

List of Experiments/Assignments

1. Introduction to Computer Aided Engineering: CAE Process, types of elements, Boundary conditions, solver, visualization

At least four problems, one on each out of the following types of problems to be solved using any of the CAE software like Ansys, Abaqus, FEAST etc.

2. Analysis of Plane Truss
3. 2D & 3D beam analysis
4. Static analysis of plate with a hole or any other similar problems
5. Static analysis of simple machine elements such as connecting rod
6. Simple problem on CFD analysis
7. Modal Analysis.

Course Code: 25UD1612PCL509
Course Title: Theory of Machines - II Lab

Practical Scheme	Examination Scheme
Practical: 2 hrs/ week Credits: 1	Continuous Assessment: 60 Marks Practical/Oral Exam: 40 Marks

Pre-Requisites: ToM-II Theory

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain various types of gear drives, gear boxes, gear trains, belt and rope drives.
CO2	Interpreting physical principles and phenomenon of gyroscopic & flywheel.
CO3	Measure vibration parameters in single degree of freedom systems.
CO4	Evaluating natural frequency of 1 DoF.
CO5	Measure critical speed of a single rotor system.
CO6	Understand behavior of epicyclic gear train.

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	1	1	1	1	1	2
CO2	2	2	2	2	2	2	1	1	1	1	1	2
CO3	3	3	3	3	3	2	1	1	1	1	1	2
CO4	2	3	3	3	3	2	1	1	1	1	1	2
CO5	2	2	2	2	1	2		1	1	1	1	1
CO6	3	2	2	2	1	2		1	1	1	1	1

List of Experiments/Assignments (Any 8)
Term work should consist of chosen experiments from the below given list:

1. Study of various types of gear boxes such as Industrial gear box, Synchromesh gear box, Differential gear box, etc.
2. To draw conjugate profile for any general shape of gear tooth.
3. To generate gear tooth profile and to study the effects under cutting and rack shift using models.
4. To determine speed vs. lift characteristic curve of a centrifugal governor and to find its coefficient of insensitiveness and stability.
5. Verification of principle of gyroscope and gyroscopic couple using motorized gyroscope.
6. To determine the natural frequency of damped vibration of a single degree of freedom system and to find its damping coefficient.
7. To verify natural frequency of torsional vibration of two rotor system and position of node.
8. To determine critical speed of a single rotor system.
9. To determine transverse natural frequency of a beam experimentally using frequency measurement set-up.

10. To determine the frequency response curve under different damping conditions for the single degree of freedom system.
11. To study shock absorbers and to measure transmissibility of force and motion.
12. Study of epicyclic gear train and its dynamic behavior.

Course Title: Industrial Training-II
(To be started)

Duration of Training: 4 weeks	**Examination Scheme**
Credits: 2	Continuous Assessment: 60 Marks Presentation/Oral Exam: 40 Marks

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Minimum of 4 weeks which can be completed partially in the third and fourth semester or in one semester itself in the vacation period/duration.

In this training, it is expected that students undergo industrial training for a variety of fields including power systems, automation, product design, and more. These fields provide practical experience in areas like electrical, mechanical, computer science, and electronics. Training often focuses on hands-on experience with equipment, software, and processes relevant to specific industries.

Course Code: 25UD1612FT510
Course Title: Industrial Training-I
(To be evaluated)

Scheme	Examination Scheme
Credits: 2	Continuous Assessment: 60 Marks Presentation/Oral Exam: 40 Marks

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

The evaluation of training completed by the students in the vacation period after III and IV semesters will be done for assessing the student's performance and the effectiveness of the training.

The evaluation process aims to gauge the student's development of technical skills, professional conduct, and ability to apply theoretical knowledge in a practical setting.

For example: Technical skills, project completion capabilities, problem solving, work ethics, communication skills, report writing skills, presentation skills etc.

For this, evaluation will be done and will be reflected in the semester V result.

Semester VI

Course Code: 25UD1612PC601
Course Title: Heat Transfer

Teaching Scheme	Examination Scheme
Lecture: 2 hrs/ week Tutorial: 1 hrs/ week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Describe the concept of conduction
CO2	Understand the extended surfaces including performance parameters and its applications
CO3	Analyze the concept of forced and free convection
CO4	Understanding and analyze the heat exchanger, understanding the boiling
CO5	Understand the concept of Radiations and evaluation of view factor and radiation shields

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1			1				1			
CO2	3	2			1							
CO3	3	1			2		2		1			
CO4	3	3		1	1				1			
CO5	3	3	3		1		2					

Course Contents

Unit 1: Introduction

Heat transfer mechanism, conduction heat transfer, Thermal conductivity, Convection heat transfer, Radiation heat transfer, laws of heat transfer Steady State Conduction: General heat conduction equation, Boundary and initial Conditions, one dimensional steady state conduction: the slab, the cylinder, the sphere, composite systems.

Unit 2: Overall Heat Transfer and Extended Surfaces

Thermal contact resistance, Critical radius of insulation, Electrical analogy, and Overall heat transfer coefficient, Heat sources systems, extended surfaces.
Unsteady State Conduction: Lumped system analysis, Biot and Fourier number, Heisler chart.

Unit 3: Principles of Convection

Continuity, Momentum and Energy equations, Hydro dynamic and Thermal boundary layer for a flat plate and pipe flow. Dimensionless groups force convection, turbulent boundary layer heat transfer. Forced Convection: Empirical relations for pipe and tube flow, flow across cylinders, spheres, tube banks. Free Convection**:** Free convection from a vertical, inclined and horizontal surface.

Unit 4: Heat Exchangers and Boiling

Heat Exchangers: Classification of heat exchangers, temperature distribution in parallel counter flow arrangement, the overall heat transfer coefficient, the log mean temperature difference (LMTD) method, the effectiveness – NTU method, selection of heat exchangers, Introduction to TEMA standard. Pool boiling Regimes, Critical Heat flux and Film boiling.

Unit 5: Radiation Heat Transfer

Introduction, thermal radiation, Black body radiation, radiation laws, Radiation properties, Atmospheric and Solar radiation, the View Factor, Radiation heat transfer from black surfaces, gray surfaces, diffuses surfaces, Radiation shield sand the radiation effect.

Texts:

1. F. P. Incoropera, D. P. Dewitt, "Fundamentals of Heat and Mass Transfer, John-Wiley, 5^{th} edition,1990.
2. S. P. Sukhatme, "A Text book on Heat Transfer", Tata McGraw-Hill Publications, third edition.

References:

1. Y. A. Cengel, "HeatTransfer A Practical Approach", Tata McGraw Hill Publications, 3^{rd} edition, 2006.
2. J. P. Holman, "Heat Transfer", Tata McGraw Hill Publications, 9^{th} edition, 2004.

Course Code: 25UD1612PC602
Course Title: Manufacturing Processes - II

Teaching Scheme	Examination Scheme
Lecture: 2 hrs /week Tutorial: 1 hr /week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Pre-Requisites: MP - I

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the mechanics of metal cutting w.r.t. orthogonal and oblique cutting
CO2	Analyse the machinability of materials
CO3	Illustrate the mechanism of abrasive processes
CO4	Identify the various operations involved in the powder metallurgy
CO5	Compare various polymer processing techniques.

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1								
CO2	3	2	1	1	1		1					
CO3	3	1	1	1								
CO4	3	1	1	1			1					
CO5	3	2	1	1								

Course Contents

Unit 1: Mechanics of Metal Cutting

Geometry of single point cutting tools, terms and definitions; chip formation, forces acting on the cutting tool and their measurement; specific cutting energy; plowing force and the "size effect"; mean shear strength of the work material; chip thickness; shear angle theories: Merchant and Lee & Shaffer, friction in metal cutting.

Unit 2: Thermal aspects, Tool wear, and Machinability

Temperature in Metal Cutting: Heat generation in metal cutting; temperature distribution in metal cutting, effect of cutting speed on temperatures, measurement of cutting temperatures.
Tool life and tool wear: progressive tool wear; forms of wear in metal cutting: crater wear, flank wear, tool-life criteria; **Cutting tool materials:** Basic requirements of tool materials, major classes of tool materials: high speed steel, cemented carbide, ceramics, CBN and diamond, tool coatings. Work material and machinability rating; Cutting fluids.

Unit 3: Abrasive Machining and Finishing Operations

Introduction; Abrasives and Bonded Abrasives: Grinding Wheels, Bond Types, Wheel Grade and

Structure; Grinding Process and its parameters: Grinding forces, specific energy, and temperature; Grinding-wheel wear, Grinding Ratio, Dressing, Truing and Shaping of Grinding Wheels, Grindability of Materials and Wheel Selection; Grinding Operations and Machines, Finishing Operations: Honing, lapping, and superfinishing.

Unit 4: Processing of Powder Metals

Introduction; Production of Metal Powders: Methods of Powder Production, Particle Size, Shape, and Distribution, Blending Metal Powders; Compaction of Metal Powders: Equipment, Isostatic Pressing, Sintering; Secondary and Finishing Operations.

Unit 5: Processing of Polymers

Introduction; Extrusion: Miscellaneous Extrusion Processes, Production of Polymer Reinforcing Fibers; Injection Molding: Reaction-injection Molding; Blow Molding; Rotational Molding; Thermoforming; Compression Molding; Transfer Molding; Processing Elastomers.

Texts:

1. Serope Kalpakjian and Steven R. Schmid, “Manufacturing Engineering and Technology”, Addison Wesley Longman (Singapore) Pte. India Ltd., 6th edition, 2009.
2. Geoffrey Boothroyd, Winston Knight, “Fundamentals of Machining and Machine Tools”, Taylor and Francis, 3rd edition, 2006.

References:

1. Milkell P. Groover, “Fundamentals of Modern Manufacturing: Materials, Processes, and Systems”, John Wiley and Sons, New Jersey, 4th edition, 2010
2. Paul DeGarmo, J. T. Black, Ronald A. Kohser, “Materials and Processes in Manufacturing”, Wiley, 10th edition, 2007.
3. M. C. Shaw, “Theory of Metal Cutting”, Oxford and I.B.H. Publishing, 1st edition, 1994.

Course Code: 25UD1612PC603
Course Title: Machine Design - II

Teaching Scheme	Examination Scheme
Lecture: 2 hrs/ week Tutorial: 1 hr/ week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Analyze and design spur and helical gear drives using strength and wear criteria.
CO2	Design bevel and worm gear drives considering force analysis, strength, and thermal aspects.
CO3	Select and design rolling contact bearings using manufacturer data and fatigue considerations.
CO4	Select and analyze belt, chain, and wire rope drives based on application requirements.
CO5	Design brakes, clutches, and flywheels considering torque, energy, and material constraints.

Mapping of course outcomes with program outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2							
CO2	3	3	3	2	2							
CO3	3	2	3	3	2							
CO4	3	2	2	2	2							
CO5	3	2	3	2	2							

Course Contents

Unit 1: Spur and Helical Gears

Gear drives: Classification, law of gearing, terminology.
Spur gear: gear tooth failures, material selection, beam strength (Lewis) equation, velocity factor, service factor, wear strength (Buckingham's equation), estimation of module, dynamic load.
Helical gears: terminology, virtual number of teeth, beam strength, wear strength, effective load, selection from catalogues.

Unit 2: Bevel and Worm Gears

Bevel gears: types, terminology, beam & wear strength, force analysis, mountings, effective load.
Worm gears: terminology, proportions, force analysis, friction, efficiency, strength and wear rating (IS 1443-1974), thermal considerations, lubrication and failure modes.

Unit 3: Rolling Contact Bearings

Types: ball, roller, taper roller bearings. Static and dynamic load capacity, equivalent load, load-life relationship, Stribeck's equation. Selection of bearing life, catalog selection, design for cyclic loads and survival probability other than 90%, lubrication and mountings.

Unit 4: Belts, Chains, and Wire Ropes

Belts: Flat & V belts, materials, geometric relationships, initial tension, centrifugal effect, slip & creep, power transmission, selection from catalogues.
Chains: types, selection criteria, polygon effect, failure modes.
Wire ropes: construction, stress analysis, selection, rope drum design.

Unit 5: Brakes, Clutches and Flywheel

Brakes: Types, energy equations, block brake, pivoted brake, internal expanding brake, thermal aspects.
Clutches: single/multiplate, cone, centrifugal – torque capacity and materials.
Flywheel: introduction, stresses in disc and armed flywheels.

Text:

1. V. B. Bhandari; Design of Machine Elements; Tata McGraw Hill Publication

References:

1. Shigley J. E., Mischke C. R.; Mechanical Engineering Design; Tata McGraw Hill
2. M. F. Spotts; Design of Machine Elements; Pearson Education
3. Robert L. Norton; Machine Design: An Integrated Approach, Pearson Education.

Course Code: 25UD1612PC604
Course Title: Refrigeration and Air Conditioning

Teaching Scheme	Examination Scheme
Lecture: 2 hrs/week Tutorials: 1 hr/week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Course Outcomes: At the end of the course, students will be able to:

CO1	Understanding the fundamental principles of refrigeration and analyze of air refrigeration systems.
CO2	Evaluate vapour compression refrigeration systems using P-h and T-s diagrams.
CO3	Underdoing compound vapour compression systems, vapour absorption systems and concept of refrigerants
CO4	Apply psychrometric principles to analyze air conditioning processes and system performance
CO5	Assess air conditioning load calculations, comfort conditions, and duct design methodologies for efficient system design.

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										1
CO2	3	3	2									
CO3	3	3	2	2								1
CO4	3	2	3		2					1		
CO5	3	2	3		3	2	2			1	1	1

Unit 1: Introduction

Introduction, standard rating of refrigerating machine, Concept of coefficient of performance of refrigerator and heat pump. Fundamental methods of refrigeration,
Air Refrigeration System: Reversed Carnot cycle and its limitations, reversed Brayton cycle, application to air craft refrigeration. Bootstrap refrigeration cycle, reduced ambient air-cooling system, Regenerative air cycle system

Unit 2: Vapour Compression System

Wet compression Vs Dry compression, Use of P-h and T-s diagram for problem solving, estimation of compressor displacement, COP and power requirement, Effect of evaporator and condenser temperature on cycle performance, Effects of suction superheating, theoretical and actual cycle, Liquid sub-cooling, liquid-vapour heat exchanger, waste heat recover opportunities.

Unit 3: Compound Vapour Compression System

Multi-evaporator, multi-compressor systems, cascade system. Designation of refrigerant, selection of refrigerant, Desirable Properties, Primary and secondary refrigerants, azeotropes and its uses.
Vapour Absorption System: Aqua-ammonia system, lithium bromide-water system, Electrolux refrigerator, comparison with vapour compression cycle (descriptive treatment only),

Unit 4: Air Conditioning

Psychrometry, properties of moist air, Psychometric charts. Air conditioning processes, bypass factor, Sensible and latent heat loads, SHF, GSHF, RSHF, summer and winter air condition, Heat load calculation, Concept of evaporative cooling.
Introduction to thermal comfort and air conditioning, ET, comfort chart.
Unitary systems; window air-conditioner, split air-conditioners, refrigeration and air-conditioning controls.

Unit 5: Air Conditioning Controls and Duct Design

Air conditioning control: Need and objective, Fundamental flow diagram, Types, Two-way and three-way valves, concept of failsafe design, Principle of air distribution, duct design methods, friction chart, duct materials.

Texts:

1. Arora, C.P., Refrigeration and Air Conditioning, Tata McGraw Hills, New Delhi, 2nd Edition, 2000.
2. Stoeker, W.F. and Jones, J.P., Principles of Refrigeration and Air Conditioning, McGraw Hill, New York, 2nd Edition, 1982.

References:

1. ASHRAE Handbook – Fundamentals and Equipment, 1993.
2. ASHRAE Handbook – Applications, 1961.
3. ISHRAE Handbook
4. NPTEL Lectures by Prof. Ram Gopal, IIT Kharagpur
5. Carrier Handbook
6. Jord R.C., and Priester, G.B., Refrigeration and Air Conditioning, Prentice Hall of India Ltd., New Delhi, 1969.
7. Threlkeld, J.L., Thermal Environmental Engineering, Prentice Hall, New York, 1970.

Course Code: 25UD1612PE605A
Course Title: Advanced Automobile Design

Teaching Scheme	Examination Scheme
Lecture: 3 hrs/ week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Pre-Requisites: Fundamentals of Automobile Design

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Course Contents

Unit 1: Body-in-White (BIW)

Requirement Specification in the Pre-Program Stage, Product Life Cycle & Important Gateways for BIW, Identification of Commodities for BIW, Design Concept & Considerations in BIW, BIW Materials & Grades, GD & T for BIW.

Unit 2: Sheet Metal Working

Sheet Metal Joining – Welds, Adhesives, TWBs. DFMEA, Design Verification – CAE Methods & Gateway supports Part A& B, CAE Analysis – NVH, Crash & Durability, Test Validation & Assessment.

Unit 3: Manufacturing of BIW

Manufacturing – Sequence, Welding & Assembly, Future Trends in BIW, BIW: Examples & Case Studies

Unit 4: Trims

Trims: Requirement Specification in the Pre-Program Stage, Product Life Cycle & Important Gateways for Trims, Identification of Commodities for Trims, Design Requirements & Considerations, Trim Materials in Automotive.

Unit 5: Design of Plastic Part

DFMEA, Design Verification – CAE Methods & Gateway supports, CAE Analysis – Moldflow, Crash & Durability, Test Validation & Assessment
Manufacturing Process, Assembly Sequence, Future Trends & Future Material for Trims, Trims: Examples & Case Studies.

Tools related training (Approx. 20 Hrs on Self Study Mode):
The students should choose a suitable software tool depending on the availability: AutoCAD, AutoCAD Electrical, AutoCAD Mechanical, AutoCAD P&ID, Autodesk 3ds Max, Autodesk Alias, Autodesk Sketch Book, Automotive, CATIA V5, CATIA V6, FEA, Autodesk Fusion 360, Autodesk Inventor, Autodesk Navisworks, Autodesk Ravit, Autodesk Showcase, Autodesk Simulation, PTC Creo, PTC Pro ENGINEER, Solid Edge, SOLIDWORKS.

Texts:

1. Curt Larson, "Datum Principles: Flexible Parts: Applications for Automotive Body-in-White and Interior Trim (Dimensional Management Series Book 1)", Right Tech, Inc., Kindle Edition.
2. Curt Larson, "Datum Principles: Flexible Parts: Applications for Automotive Body-in-White and Interior Trim (Dimensional Management Series Book 2)", Right Tech, Inc., Kindle Edition.
3. Vukato Boljanovic, "Sheet Metal Forming Processes and Die Design", Industrial press Inc., Kindle Edition.

References:

1. Videos from TATA Technologies
2. R. D. Cook, Concepts and Applications of Finite Element Analysis; John Wiley and Sons, 2nd edition, 1981.
3. K.J. Bathe, Finite Element Method and Procedures; Prentice hall, 1996.
4. Ibrahim Zeid, "CAD/CAM Theory and Practice", Tata McGraw Hill Publication,
5. J. H. Dubois And W. I. Prebble, Plastics Mold Engineering Handbook, Van Nostrand Reihnhold, New York, 1987.
6. Geoffrey Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacturing and Assembly, 2nd Edition
7. C. Howard, Modern Welding Technology, Prentice Hall, 1979.
8. Jesper Christensen and Christophe Bastien, "Nonlinear Optimization of Vehicle Safety Structures: Modeling of Structures Subjected to Large Deformations, Butterworth-Heinemann, Kindle Edition
9. Grieves, Michael, Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303
10. Stark, John. Product Lifecycle Management: Paradigm for 21st Century Product Realization, Springer Verlag, 2004. ISBN 1852338105.

Course Code: 25UD1612PE605B
Course Title: Process Equipment Design

Teaching Scheme	Examination Scheme
Lecture: 3 hrs/ week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Course Contents

Unit 1: Introduction

Types of process equipment, constructional requirement and applications.
Factor Influencing Design of Pressure Vessel, Selection of type of vessel, methods of fabrication, effect of Fabrication methods, various criteria in vessel design, economic considerations, design methods of atmospheric storage vessel: storage of fluids, storage of non-volatile liquids, storage of volatile liquids, storage of gases, optimum tank proportion, design consideration for rectors and chemical process vessels.

Unit 2: Design of Tank

Bottom design, shell design, wind girder for open top tank, rub curb angle, self-support rub design, design of rectangular tank.

Unit 3: Pressure Vessels

Unfired process vessel with internal and external pressure, operating condition, selection of material, design condition, stresses, design criteria, design of shell subjected to internal and external pressure, cylindrical vessel under combined loading design of heads and closures: flat head and formed heads for vessel. Design of thick-walled high-pressure vessel, constructional features, materials for high pressure vessels, Thermal expansion for shrink fitting, stress in multi-shell or shrink fit construction, auto-frettage, prestressing. Types for compensation, theoretical determination of stresses around openings, design of reinforcement.

Unit 4: Agitated Vessel

Type of agitators, baffling, power requirement for agitation, design based on torque and bending moment, design based on critical speed, blade design, hub and key design, stuffing box and gland design, turbine agitator design, tall vessels and their design, stress in shell, determination of longitudinal stresses, longitudinal bending stresses due to eccentric loads, determination of resultant longitudinal stresses.

Unit 5: Support for Pressure Vessel

Bracket or lug support: Thickness of the base plate, thickness of web (gusset) plate, column support for bracket base plate for column or leg support. Skirt support: skirt design, skirt bearing plate, anchor bolt design, design of bolting chair. Saddle support: longitudinal bending moment, stresses in shell at saddle.

Texts:

1. Joshi, *Process Equipment Design*, Macmillan India, 1976.
2. Brownell L.E. and E. E. Young, *Process Equipment Design*, Wiley Eastern, New York, 1968.

References:

1. Relevant BIS/ASME/DIN specifications and codes for unfired pressure vessels.
2. Perry R. H. and Chilton C. H. [ed], *Chemical Engineering Handbook*, McGraw - Hill, 6th Edition, 1984.
3. Bhattacharya B.C., *Introduction Chemical Equipment Design [Mechanical Aspect]*, CBS Publishers and Distributors. PSG design Data Book.

Course Code: 25UD1612PE605C
Course Title: Robotics

Teaching Scheme	Examination Scheme
Lecture: 3 hrs/ week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Course Outcomes: At the end of the course, students will be able to:

CO1	List the various components of a typical Robot, grippers, sensors, drive system and describe their functions
CO2	Calculate the word to joint and joint to word coordinates using forward and reverse transformations
CO3	Calculate the gripper forces, drive sizes, etc.
CO4	Develop simple robot program for tasks such as pick and place, arc welding, etc. using some robotic language such as VAL-II, AL, AML, RAIL, RPL, VAL
CO5	Evaluate the application of robots in applications such as Material Handling, process operations and Assembly and inspection
CO6	Discuss the implementation issues and social aspects of robotics

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Course Contents

Unit 1: Introduction

Various basic components of a Robotic system, various configurations, work envelopes, Manipulators, Controllers, etc., Robot Parameters.

Unit 2: Mechanical System in Robotics

Motion conversion, Kinematic chains, position analysis, forward and reverse transformations, natural and joint space coordinates, homogeneous transformation and robot kinematics, Manipulator path control, Robot Dynamics.

Unit 3: Drives for Robot

Electrical drives, Stepper motor, Servo motors, DC motors, AC motors, hydraulic and pneumatic drives, hybrid drives, drive selection for robotic joints.

Unit 4: Sensors and End Effectors in Robotics Sensors

Position sensor, velocity sensor, proximity sensors, touch sensors, force sensors, miscellaneous sensors etc.
End Effectors: Types of end effectors, Mechanical Grippers, Design of End Mechanical Grippers, and Other Principles of gripping, Tools and end effectors, Considerations in gripper selection and design.

Unit 5: Robot Programming

Path planning, Lead through (manual and powered) programming, teach pendant mode, programming languages, Simple statements from AL, AML, RAIL, RPL, VAL Languages.
Artificial Intelligence for Robots: Knowledge Representation, Problem representation and problem solving, search techniques in problem solving.
Application of robot in: Material handling, assembly and inspection, process operations, etc. Economic Analysis for robotic implementation.

Text:

1. M. P. Groover, "Industrial Robotics: Technology, Programming and Applications", Tata Mc-Graw Hill Publication.

References:

1. Saeed B. Niku, "Introduction to Robotics, Analysis, Systems, Applications", Pearson Education.
2. Richard D. Klafter, "Robotic Engineering: An Integrated Approach", Prentice Hall of India.

Course Code: 25UD1612PE605D
Course Title: IC Engines

Teaching Scheme	Examination Scheme
Lecture: 3 hrs/week Credits: 3	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration: 3 Hours)

Pre-Requisites: Applied Thermodynamics – I

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand various types of I.C. Engines and Cycles of operation.
CO2	Analyze the effect of various operating variables on engine performance
CO3	Identify fuel metering and fuel supply systems for different types of engines
CO4	Understand normal and abnormal combustion phenomena in SI and CI engines
CO5	Evaluate performance Analysis of IC Engine and Justify the suitability of IC Engine for different application
CO6	Understand the conventional and non-conventional fuels for IC engines and effects of emission formation of IC engines, its effects and the legislation standards

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3						3					
CO2		2										
CO3	2											
CO4	2											
CO5					2		3					
CO6	2											

Course Contents

Unit 1: Fundamentals of IC Engines

Applications, nomenclature, engine components, Engine classification, two and four stroke cycle engines; fundamental difference between SI and CI engines; valve timing diagrams.
Power Cycles: Air standard Otto, Diesel and Dual cycles; Valve timing diagrams, Fuel-Air cycles and deviation of actual cycles from ideal cycles.

Unit 2: Combustion

Introduction, important qualities and ratings of SI Engines fuels; qualities and ratings of CI Engine fuels.
Combustion in S.I. Engines, flame speed, ignition delay, normal and abnormal combustion, effect of engine variables on flame propagation and ignition delay, Combustion in C.I. Engines, combustion of a fuel drop, stages of combustion, ignition delay, combustion knock; Types of SI and CI Engine combustion chambers.

Unit 3: Various Engine Systems and Engine Testing and Performance

Starting systems, fuel supply systems, engine cooling system, ignition system, engine friction and lubrication systems.
Engine Testing and Performance of SI and CI Engines: Parameters, Type of tests and characteristic curves.
Super charging in IC Engine: Types of supercharging.
Engine Emissions and control: Pollutants from SI and CI engines and their control, Introduction to emission regulations such as Bharat and Euro.

Unit 4: Alternate Fuels

Need for alternative fuels, applications, various alternate fuels etc.
Gaseous Fuels, Alcohols, Biodiesels, vegetable oil extraction, Trans-esterification process, properties of alternative fuels and fuel blends.
Fuel Cell Technology: Operating principles, Types, construction, working, application, advantages and limitations.

Unit 5: Layout of Electric Vehicle and Hybrid Vehicles

Advantages and drawbacks of electric and hybrid vehicles, System components, Electronic control system – Different configurations of Hybrid vehicles, Power split device. Basics of Fuel cell vehicles

Texts/ References:

1. V. Ganeshan, "Internal Combustion Engines", Tata McGraw Hill Publications, New Delhi, 3rd edition.
2. J. B. Heywood, "Internal Combustion Engine Fundamentals", Tata McGraw Hill Publications, New York, International Edition, 1988.
3. Dr. S. S. Thipse, "Alternative Fuels", Jaico publications.
4. Dr. S. S. Thipse, "IC Engines", Jaico publications.
5. G. S. Springer and D.J. Patterson, "Engine Emissions, pollutant formation", Plenum Press.
6. ARAI vehicle emission test manual.
7. Gerhard Knothe, Jon Van Gerpen, Jargon Krahl, "The Biodiesel Handbook", AOCS Press, Champaign, Illinois 2005.
8. Richard L Bechtold P.E., Alternative Fuels Guide book, Society of Automotive Engineers, 1997, ISBN 0-76-80-0052-1.
9. N. Watson, M.S. Janota, Palgrave Mcmillan, "Turbocharging the Internal Combustion Engine", Transactions of SAE on Biofuels (Alcohols, vegetable oils, CNG, LPG, Hydrogen, Biogas etc.

Course Code: 25UD1612FP607
Course Title: Technical Project for Community Service (TPCS)

Scheme	Examination Scheme
Contact duration: 4 hrs/ week Credits: 2	Continuous Assessment: 60 Marks Presentation/Demonstration/Oral: 40 Marks

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand, plan, and execute the project with team- 30% weightage
CO2	Students will be able to practice acquired knowledge within the chosen area of technology for project development -20 % weightage
CO3	Identify, discuss, and justify the technical aspects of the chosen project with a comprehensive and systematic approach- 30% weightage
CO4	Communicate and report effectively project related activities and findings - 20 % weightage

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Course Objectives: The main objective of TPCS is to let the students apply the knowledge of theoretical concepts which they have learnt as a part of the curriculum of the undergraduate courses to real time problems or situations related to community and societal issues.

Course Guidelines:

- Students can choose projects based on societal problems or user defined problem which must emulate real-life problems and useful for the community.
- It is desirable that students should work on the project in groups of 2 or 3 but not more than three.
- After making the group, students must decide the title of the project in consultation with the guide and finalize the topic. Topics may be found by looking through recent issues of peer reviewed Journals/Technical Magazines on the topics of potential interest
- Each student is requested to develop a working model/ process/ software package /system on the chosen work and demonstrate before the evaluation committee (Guide & Internal Examiner)
- Finally, students must submit the final report of the project and the format for the same will be given by the department.
- The students will report to the respective guide/supervisor every fortnight to discuss their progress.
- The final evaluation of the project will be done based on the demonstration and presentation. It is mandatory for the student to:

i. appear for final presentation (PPT with informative slides) and viva-voce to qualify for course evaluation
ii. submit a well-documented TPCS report as per the format.

Course Evaluation:

Evaluation weightage for the TPCS is as follows:

- TPCS Supervisor Assessment 30%
- Working model / process / software package / system developed (20%)
- TPCS report (20%)
- Final presentation (with PPT) and viva-voce (30%)
- The student must register for the TPCS project as supplementary examination in the following cases:

  i. he/she is absent for oral presentation and viva-voce
  ii. he/she fails to submit the report in prescribed format
  iii. he/she fails to fulfil the requirements of Mini project evaluation as per specified guidelines.

Course Code: 25UD1612PCL608
Course Title: Manufacturing Processes – II Lab

Practical Scheme	**Examination Scheme**
Practical: 2 hrs/ week Credit: 1	Continuous Assessment: 60 Marks Practical/Oral: 40 Marks

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

List of Experiments/Assignments:

Any 6 **from the following list:**

1. Study of types of chips.
2. Study of the effect of process parameters on cutting ratio and shear angle in oblique turning process.
3. Study of the effect of process parameters on the surface roughness during oblique turning process.
4. Study of the effect of cutting fluid on surface roughness during oblique turning process.
5. Study of the effect of process parameters on tool flank wear during oblique turning process.
6. Study of the effect of process parameters on cutting forces in oblique turning process.
7. Study of the effect of process parameters on cutting forces in end milling process.
8. To develop a manual part program of a given component on CNC Lathe using G and M codes.
9. To develop a manual part program of a given component on CNC Milling machine using G and M code.
10. To develop a manual part program of a given component on CNC Milling machine using pocket milling cycle.
11. To examine the effect of process parameters on surface roughness during Die Sinking EDM.
12. Industrial visit to study manufacturing practices.

Course Code: 25UD1612PCL609
Course Title: Machine Design Practice

Practical Scheme	Examination Scheme
Practical: 2 hrs/ week Credit: 1	Continuous Assessment: 60 Marks Practical/Oral: 40 Marks

Course Outcomes: At the end of the course, students will be able to

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

List of Design Projects/ Assignments:

1. The term work shall consist of 02 design projects based on syllabus of Machine Design I & II. Design project shall consist of 2 full imperial size sheets-one involving assembly drawings with a part list and Overall dimensions and other sheet involving drawing so find Individual Components. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified, wherever necessary, to make it a working drawing.
2. A design report giving all necessary calculations for the design of components and assembly should be submitted in a separate file. Sheets for one of the projects will be drawn using AutoCAD or on any 3-D Design software and computer printout on A3 sheets using plotter and will be attached with the design report.

Course Code: 25UD1612PCL610
Course Title: Heat Transfer and Refrigeration Air conditioning Lab

Practical Scheme	Examination Scheme
Practical: 2 hrs/ week Credit: 1	Continuous Assessment: 60 Marks Practical/Oral: 40 Marks

Pre-Requisites: Heat Transfer, Refrigeration and Air-Conditioning

Course Outcomes: At the end of the course, students will be able to:

CO1	Concepts of 1 D conduction and thermal conductivity
CO2	Concept of extended surfaces
CO3	Concept of forced and natural convection
CO4	Evaluation of emissivity
CO5	Evaluation of Vapour compression cycle and air conditioning process

Mapping of course outcomes with program outcomes:

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

List of Experiments/Assignments

Any three experiments from each section with cycle and system simulation minor project from each section:

Section A

1. Determination of thermal conductivity of a metal rod.
2. Determination of thermal conductivity of insulating powder.
3. Determination of conductivity of a composite slab.
4. Temperature distribution on a fin surface.
5. Determination of film heat transfer coefficient for nature convection.
6. Determination of film heat transfer coefficient for forced convection.
7. Determination of heat transfer coefficient for cylinder in cross flow in forced convection
8. Performance of Double pipe Heat Exchanger / Shell and Tube Heat Exchanger.
9. Determination of emissivity of a metal surface.
10. Determination of Stefan Boltzman's constant.
11. Determination of critical heat flux.
12. Calibration of measuring instruments pressure gauge, thermocouple, flow-meter etc.

Section B

1. Trial on Ice Plant
2. Trail on Vapour compression system
3. Trial on Vapour Absorption system
4. Measurement of DBT and WBT using sling psychrometer
5. Trial on Evaporative Cooler
6. Trial on Air conditioning set-up to verify
    i. Cooling and dehumidification process
    ii. Sensible heating process
    iii. Heating and Humidification process
    iv. Preheating and reheating process.

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