# Study & Evaluation

# Scheme

# Of

# Master of Technology

# In

# Thermal Engineering

[Applicable for 2018-20]
Version 2018

[As per CBCS guidelines given by UGC]

| BOS | BOF | BOM |
|---|---|---|
| 24/3/2018 | 5/6/2018 | 11/6/2018<br>Approved vide agenda number 1.7.1 |

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# Quantum University, Roorkee

***Study & Evaluation Scheme Study Summary***

| | |
|---|---|
| Name of the Faculty | Faculty of Mechanical Engineering |
| Name of the School | Quantum School of Technology |
| Name of the Department | Department of Mechanical Engineering |
| Program Name | Master of Technology in Thermal Engineering |
| Duration | 2 Years |
| Medium | English |

***Evaluation Scheme***

| Type of Papers | Internal Evaluation (%) | End Semester Evaluation (%) | Total (%) |
|---|---|---|---|
| Theory | 40 | 60 | 100 |
| Practical/ Dissertations/Project Report/ Viva-Voce | 40 | 60 | 100 |
| *Internal Evaluation Components (Theory Papers)* | | | |
| Sessional Examination I | 50 Marks | | |
| Sessional Examination II | 50 Marks | | |
| Assignment –I | 25 Marks | | |
| Assignment-II | 25 Marks | | |
| Attendance | 50 Marks | | |
| *Internal Evaluation Components (Practical Papers)* | | | |
| Quiz One | 25 Marks | | |
| Quiz Two | 25 Marks | | |
| Quiz Three | 25 Marks | | |
| Lab Records/ Mini Project | 75 Marks | | |
| Attendance | 50 Marks | | |
| *End Semester Evaluation (Practical Papers)* | | | |
| ESE Quiz | 30 Marks | | |
| ESE Practical Examination | 50 Marks | | |
| Viva- Voce | 20 Marks | | |

**Structure of Question Paper (ESE Theory Paper)**

The question paper will consist of 5 questions, one from each unit. Student has to Attempt all questions. All questions carry 20 marks each. Question Q1 to Q5 will be compulsory and each question will have 3 parts. Each part carries 10 marks each and the student may attempt any 2 parts.

**Important Note:**

1. *The purpose of examination should be to assess the Course Outcomes (CO) that will*

*ultimately lead to attainment of Programme Specific Outcomes (PSOs). A question paper must assess the following aspects of learning: Remember, Understand, Apply, Analyze, Evaluate & Create (reference to Bloom's Taxonomy). The standard of question paper will be based on mapped BL level complexity of the unit of the syllabus, which is the basis of CO attainment model adopted in the university.*

2. *Case Study is essential in every question paper (wherever it is being taught as a part of pedagogy) for evaluating higher-order learning. Not all the courses might have case teaching method used as pedagogy.*

3. *There shall be continuous evaluation of the student and there will be a provision of real time reporting on QUMS. All the assignments will evaluated through module available on ERP for time and access management of the class.*

## *Program Structure – Master of Technology in Thermal Engineering*

### *Introduction*

Master of Technology in Thermal Engineering is a course involving studies on an advanced level of concepts of energy efficiency, renewable energy & environmental preservation, and their entwinement with classical energy technologies and recently discovered technologies. The course covers real-time fluid flow and heat transfer applications in Thermal Energy Systems, Cryogenic Engineering, Refrigeration & Air Conditioning, and other fields. Thermal engineering is a branch of mechanical engineering that studies the regulation of heating and cooling processes in enclosed spaces. It ensures to provide students with an effective learning experience with thought-provoking teaching pedagogy. The curriculum is highly demanding and thoughtfully designed to incorporate all the latest development in the field. The curriculum of post graduate program in thermal engineering aims at creating the right mindset which ensures the creation of innovative, thoughtful, and socially aware engineers. It allows establishing a solid understanding of research to continue professional development in thermal engineering. It allows applying for specialist roles at a renowned manufacturing company. Student will develop the ability to use their math, science, engineering, and technology expertise. Understand, analyse, create, and solve issues related to the application of technology in a variety of industrial contexts in great detail. It also entails developing, choosing, and implementing relevant approaches, resources, modern engineering, and information technology tools to tackle complex engineering problems.

We believe in the practical nature of the domain and focus on learning by doing it practically. Students will gain an ability to specify, fabricate, test, operate, validate and complete documentation of thermo-mechanical systems or processes. Students will gain an ability to apply the acquired software's skills for simulation in the controlled environment and provide viable solutions.

Towards enhancing employability and entrepreneurial ability of the postgraduates the Quantum University increase the practical content in the courses wherever necessary. The total number of credits in 4 semesters programme will be around 66 for all the programmes.

In order to harness regional specialties and to meet region-specific needs the Quantum University modify the content of syllabus as per the regional demands.

**Project**

This course is spread across the semesters, from 3rd semester to fourth semester where student is required to do a project or field work or design/fabrication and test/simulate for a research problem.

**B. Choice Based Credit System (CBCS)**

Choice Based Credit System (CBCS) is a versatile and flexible option for each student to achieve his target number of credits as specified by the UGC and adopted by our university.

The following is the course module designed for the M.Tech (Thermal Engineering) program:

**Core competency:** Students will acquire core competency in Thermal aspects of Mechanical Engineering and in its application areas.

**Program/Discipline Specific Elective Course (DSEC)**:

**Skilled communicator:** The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.

**Critical thinker and problem solver:** The course curriculum also includes components that can be helpful to improve post graduate students to develop critical thinking ability by way of solving problems/numerical using basic
& advance knowledge and concepts of Thermal Engineering.

**Sense of inquiry:** It is expected that the course curriculum will develop an inquisitive characteristic among the students through appropriate questions, planning and reporting experimental investigation.

**Skilled project manager:** The course curriculum has been designed in such a manner as to enabling a postgraduate student to become a skilled project manager by acquiring knowledge about mathematical project management, writing, planning, study of ethical standards and rules and regulations pertaining to scientific project operation.

**Ethical awareness/reasoning:** A postgraduate student requires understanding and developing ethical awareness/reasoning which the course curriculums adequately provide.

**Lifelong learner:** The course curriculum is designed to inculcate a habit of learning continuously through use of advanced ICT technique and other available techniques/books/journals for personal academic growth as well as for increasing employability opportunity.

**C. Program Outcomes of M.Tech Thermal Engineering.**

## Program Outcome (POs) – M. Tech

| | | |
|---|---|---|
| **PO-01** | **Engineering knowledge** | Exhibit in-depth knowledge in engineering specialization. |
| **PO-02** | **Problem analysis** | Think critically and analyze complex engineering problems to make creative advances in theory and practice. |
| **PO-03** | **Design/Development Of Solutions** | An ability to design solutions for engineering problems and to design a component, system, or process that meet the specified needs with appropriate consideration for the public health and safety, along with the cultural, societal, and environmental considerations. |
| **PO-04** | **Conduct Investigations of Complex Problems** | Use research methodologies, techniques and tools, and will contribute to the development of technological knowledge |
| **PO-05** | **Modern tool usage** | Apply appropriate techniques, modern engineering tools to perform modeling of complex engineering problems with knowing the |

| | | |
|---|---|---|
| | | limitations. |
| **PO-06** | **The Engineer and society** | Achieve professional success with an understanding and appreciation of ethical behaviour, social responsibility, and diversity, both as individuals and in team environments. |
| **PO-07** | **Environment and sustainability** | Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge for sustainable development to articulate a comprehensive world view that integrates diverse approaches to sustainability |
| **PO-08** | **Communication** | Communicate complex engineering problems with the engineering community and society, write and present technical reports effectively |
| **PO-09** | **Ethics** | Exhibit professional and intellectual integrity, ethics of research and scholarship and will realize the responsibility towards the community |
| **PO-10** | **Individual and Team work** | An ability to analyse the local and global impact of computing on individuals, organizations, and society. |
| **PO-11** | **Project Management and Finance** | Demonstrate knowledge and understanding of engineering and management principles and apply the same with due consideration to economical and financial factors. |
| **PO-12** | **Life-long learning** | Engage in life-long learning with a high level of enthusiasm and commitment to improve knowledge and competence continuously |

## Program Specific Outcomes (PSOs)

At the end of this programme, Post Graduates will be able to:

**PSO 1:** Analyse the complex engineering problems by applying engineering knowledge in the area of thermal engineering systems.

**PSO 2:** Provide engineering solutions to meet the specified needs with appropriate consideration for comfort, safety, social and environmental aspects.

## Program Educational Objectives(PEOs)

In their careers, our post graduates will be able to:

**PEO 1**: Analyze and solve thermal engineering problems using modern engineering tools in industry or in research.

**PEO 2**: Play key role in collaborative multidisciplinary scientific research with due consideration to economical and financial factors for leading a successful career in industry or to pursue higher education or being an entrepreneur.

**PEO 3**: Engage in life-long learning with professional code of conduct.

**D. Pedagogy & Unique practices adopted:**

""Pedagogy is the method and practice of teaching, especially for teaching an academic subject or theoretical concept". In addition to conventional time-tested lecture method, the institute will emphasize on experiential learning:

*Mini projects*: students are asked to do or given mini projects for developing an aptitude to critically think and find solutions for real world problems, learn working with other people, under deadlines and guidance.

*Flip Presentations*: Students are required to present on latest technology trends in mechanical engineering to enhance their ability to self learn and presentation skill along with developing their confidence level to face an audience.

*Field/Live Projects:* The students, who take up experiential projects in companies, where senior executives with a stake in teaching guide them, drive the learning. All students are encouraged to do some live project other their regular classes.

*MOOCs:* Students may earn credits by passing MOOCs as decided by the college. Graduate level programs may award Honors degree provided students earn pre-requisite credits through MOOCs. University allows students to undertake additional subjects/course(s) (In-house offered by the university through collaborative efforts or courses in the open domain by various internationally recognized universities) and to earn additional credits on successful completion of the same. Each course will be approved in advance by the University following the standard procedure of approval and will be granted credits as per the approval. Keeping this in mind, University proposed and allowed a maximum of two credits to be allocated for each MOOC courses. In the pilot phase it is proposed that a student undertaking and successfully completing a MOOC course through only NPTEL could be given 2 credits for each MOOC course.

For smooth functioning and monitoring of the scheme the following shall be the guidelines for MOOC courses, Add-on courses carried out by the College from time to time.

a) It will necessary for every student to take at least one MOOC Course throughout the programme.

b) There shall be a MOOC co-ordination committee in the College with a faculty at the level of Professor heading the committee and all Heads of the Department being members of the Committee.

c) The Committee will list out courses to be offered during the semester, which could be requested by the department or the students and after deliberating on all courses finalize a list of courses to be offered with 2 credits defined for each course and the mode of credit consideration of the student. The complete process shall be obtained by the College before end of June and end of December for Odd and Even semester respectively of the year in which the course is being offered. In case of MOOC course, the approval will be valid only for the semester on offer.

d) Students will register for the course and the details of the students enrolling under the course along with the approval of the Vice Chancellor will be forwarded to the Examination department within fifteen days of start of the semester by the Coordinator MOOC through the Principal of the College.

e) After completion of MOOC course, Student will submit the photo copy of Completion certificate of MOOC Course to the Examination cell as proof.

f) marks will be considered which is mentioned on Completion certificate of MOOC Course.

g) College will consider the credits only in case a student fails to secure minimum required credits then the additional subject(s) shall be counted for calculating the minimum credits required for the award of degree.

*Special Guest Lectures (SGL) & Extra Mural Lectures (EML):* Some topics/concepts need extra attention and efforts as they either may be high in difficulty level or requires experts from specific industry/domain to make things/concepts clear for a better understanding from the perspective of the industry. Hence, to cater to the present needs of industry we organize such lectures, as part of lecture-series and invite prominent personalities from academia and industry from time to time to deliver their vital inputs and insights.

*Student Development Programs (SDP):* Harnessing and developing the right talent for the right industry an overall development of a student is required. Apart from the curriculum teaching various student development programs (training programs) relating to soft skills, interview skills, research tools etc. that may be required as per the need of the student and industry trends, are conducted across the whole program. Participation in such programs is solicited through volunteering and consensus.

*Industry Focused programmes:* Establishing collaborations with various industry partners to deliver the programme on sharing basis. The specific courses are to be delivered by industry experts to provide practice-

based insight to the students.

*Special assistance program for slow learners & fast learners:* write the note how would you identify slow learners, develop the mechanism to correcting knowledge gap. Terms of advance topics what learning challenging it will be provided to the fast learners.

*Induction program:* Every year 3 weeks induction program is organized for 1st year students and senior students to make them familiarize with the entire academic environment of university including Curriculum, Classrooms, Labs, Faculty/ Staff members, Academic calendar and various activities.

*Mentoring scheme:* There is Mentor-Mentee system. One mentor lecture is provided per week in a class. Students can discuss their problems with mentor who is necessarily a teaching faculty. In this way, student's problems or issues can be identified and resolved.

*Extra-curricular Activities:* organizing & participation in extracurricular activities will be optional for postgraduate students to develop confidence & face audience boldly. It shapes out their leadership qualities along with planning & organizing skills. Students can undertake various cultural, sports and other competitive activities within and outside then campus. This helps them build their wholesome personality.

*Career & Personal Counseling:* - Identifies the problem of student as early as possible and gives time to discuss their problems individually as well as with the parents. Counseling enables the students to focus on behavior and feelings with a goal to facilitate positive change. Its major role lies in giving: Advice, Help, Support, Tips, Assistance, and Guidance.

*Participation in Flip Classes, Project based Learning(A2 Assignment), Workshops, Seminars & writing & Presenting Papers:* Departments plan to organize the Flip Classes, Project based Learning(A2 Assignment), workshops, Seminars & Guest lecturers time to time on their respective topics as per academic calendar. Students must have to attend these programs. This participation would be count in the marks of general Discipline & General Proficiency which is the part of course scheme as non-credit course.

*Formation of Student Clubs, Membership & Organizing & Participating events:* Every department has the departmental clubs with the specific club's name. The entire student's activity would be performed by the club. One faculty would be the coordinator of the student clubs & students would be the members with different responsibility.

*Capability Enhancement & Development Schemes:* The Institute has these schemes to enhance the capability and holistic development of the students. Following measures/ initiatives are taken up from time to time for the same: Career Counseling, Soft skill development, Remedial Coaching, Bridge Course, Language Lab, Yoga and Meditation, Personal Counseling

*Library Visit & Utilization of QLRC:* Students may visit the library from morning 10 AM to evening 8 PM. Library created its resources Database and provided Online Public Access Catalogue (OPAC) through which users can be accessed from any of the computer connected in the LAN can know the status of the book. Now we are in process to move from OPAC to KOHA.

# Quantum School of Technology
## Master of Technology in Thermal Engineering – PC: 01-4-01

## CURRICULUM (2018-20), V 1.0

### BREAKUP OF COURSES

| Sr. No | CATEGORY | CREDITS |
|---|---|---|
| 1 | Program Core (PC) | 27 |
| 2 | Program Electives (PE) | 15 |
| 3 | Project | 15 |
| 4 | Seminar | 6 |
| 5 | General Proficiency (GP) | 3 |
| TOTAL NO. OF CREDITS | | **66** |

### SEMESTER-WISE BREAKUP OF CREDITS

| Sr. No | CATEGORY | SEM 1 | SEM 2 | SEM 3 | SEM 4 | TOTAL |
|---|---|---|---|---|---|---|
| 1 | Program Core | 19 | 5 | 3 | - | 27 |
| 2 | Program Electives | - | 9 | 6 | - | 15 |
| 3 | Projects/Dissertation | - | - | 4 | 11 | 15 |
| 4 | Seminar | 2 | 2 | 2 | - | 6 |
| 5 | GP | 1 | 1 | 1 | | 3 |
| | **TOTAL** | **22** | **17** | **16** | **11** | **66** |

## SEMESTER 1

| Course Code | Category | Course Title | L | T | P | C | Version | Course Prerequisite |
|---|---|---|---|---|---|---|---|---|
| ME4107 | PC | Optimization Techniques | 2 | 2 | 0 | 3 | 1.0 | Nil |
| ME4101 | PC | Advanced Fluid Mechanics | 3 | 1 | 0 | 4 | 1.0 | Nil |
| ME4102 | PC | Advanced Thermodynamics | 3 | 1 | 0 | 4 | 1.0 | Nil |
| ME4103 | PC | Advanced Heat Transfer | 3 | 1 | 0 | 4 | 1.0 | Nil |
| ME4108 | PC | Instrumentation and Measurements | 3 | 0 | 0 | 3 | 1.0 | Nil |
| ME4170 | FW | Seminar I | 2 | 0 | 0 | 2 | | |
| ME4140 | PC | Advanced Thermal Engineering Lab | 0 | 0 | 2 | 1 | 1.0 | Nil |
| GP4101 | GP | General Proficiency | 0 | 0 | 0 | 1 | | |
| | | **Total** | **16** | **5** | **2** | **22** | | |

**Contact Hrs: 23**

## SEMESTER 2

| Course Code | Category | Course Title | L | T | P | C | Version | Course Prerequisite |
|---|---|---|---|---|---|---|---|---|
| ME4201 | PC | Simulation Modeling and Analysis | 3 | 2 | 0 | 4 | 1.0 | Nil |
| | PE | Program Elective I | 3 | 0 | 0 | 3 | | Nil |
| | PE | Program Elective II | 3 | 0 | 0 | 3 | | Nil |
| | PE | Program Elective III | 3 | 0 | 0 | 3 | | Nil |
| ME4240 | PC | Simulation Lab | 0 | 0 | 2 | 1 | 1.0 | Nil |
| ME4270 | FW | Seminar II | 2 | 0 | 0 | 2 | | |
| GP4201 | GP | General Proficiency | 0 | 0 | 0 | 1 | | |
| | | **Total** | **14** | **2** | **2** | **17** | | |

**Contact Hrs: 18**

## SEMESTER 3

| Course Code | Category | Course Title | L | T | P | C | Version | Course Prerequisite |
|---|---|---|---|---|---|---|---|---|
| ME4307 | PC | Research Methodology | 2 | 0 | 0 | 2 | 1.0 | Nil |
| | PE | Program Elective IV | 3 | 0 | 0 | 3 | | Nil |
| | PE | Program Elective V | 3 | 0 | 0 | 3 | | Nil |
| ME4340 | PC | Research Methodology Lab | 0 | 0 | 2 | 1 | 1.0 | Nil |
| ME4370 | FW | Seminar III | 2 | 0 | 0 | 2 | | Nil |
| ME4371 | FW | Project | 0 | 0 | 8 | 4 | | Nil |
| GP4301 | GP | General Proficiency | 0 | 0 | 0 | 1 | | |
| | | **Total** | **10** | **0** | **10** | **16** | | |

**Contact Hrs: 20**

## SEMESTER 4

| Course Code | Category | Course Title | L | T | P | C | Version | Course Prerequisite |
|---|---|---|---|---|---|---|---|---|
| ME4470 | FW | Dissertation | 0 | 0 | 4 | 11 | | |
| | | **Total** | **0** | **0** | **4** | **11** | | |

**Contact Hrs: 04**

Program Electives

| Elective | Course Code | Course Title | L | T | P | C | Version | Course Prerequisite |
|---|---|---|---|---|---|---|---|---|
| I | ME4202 | Cryogenic Engineering | 3 | 0 | 0 | 3 | 1.0 | Nil |
| | ME4203 | Transit Refrigeration | 3 | 0 | 0 | 3 | 1.0 | Nil |
| | ME4206 | Refrigeration Machinery | 3 | 0 | 0 | 3 | 1.0 | Nil |
| II | ME4204 | Finite Element Analysis | 3 | 0 | 0 | 3 | 1.0 | Nil |
| | ME4205 | Computational Fluid Dynamics | 3 | 0 | 0 | 3 | 1.0 | Nil |
| | ME4210 | Design of Heat Exchangers | 3 | 0 | 0 | 3 | 1.0 | Nil |
| III | ME4207 | Jet & Rocket Propulsion Systems | 3 | 0 | 0 | 3 | 1.1 | Nil |
| | ME4208 | Gas Turbine and Compressor | 3 | 0 | 0 | 3 | 1.0 | Nil |
| | ME4209 | Fire Dynamics Engineering | 3 | 0 | 0 | 3 | 1.1 | Nil |
| IV | ME4301 | Alternative Fuels | 3 | 0 | 0 | 3 | 1.0 | Nil |
| | ME4302 | Solar Energy Technology | 3 | 0 | 0 | 3 | 1.0 | Nil |
| | ME4304 | Nuclear Engineering | 3 | 0 | 0 | 3 | 1.0 | Nil |
| V | ME4303 | Energy Storage Techniques | 3 | 0 | 0 | 3 | 1.0 | Nil |
| | ME4305 | Energy Management In Thermal Systems | 3 | 0 | 0 | 3 | 1.0 | Nil |
| | ME4309 | Air-Conditioning System Design | 3 | 0 | 0 | 3 | 1.0 | Nil |

| ME4107 | Title: Optimization Techniques | L T P C<br>2 2 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To provide the concepts of various classical and modern methods of for constrained and unconstrained problems in both single and multivariable. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Classical Optimization | 9 |
| Introduction to Optimization: Classification of Optimization, Design vector and constraints, Constraint surface, Objective function, Classification of Optimization Problems. Single variable optimization, Multi-variable: Direct substitution method, Lagrange's method of multipliers, Karush-Kuhn-Tucker conditions. | | |
| Unit II | Linear Programming | 7 |
| Linear Programming: Statement of an LP problem, Simplex method, Dual simplex method. | | |
| Unit III | One Dimensional Optimization | 8 |
| Unimodal function, Unrestricted search, Exhaustive search, Dichotomous search, Interval halving method, Fibonacci method, Golden section method, Direct root methods: Newton-Raphson and Quasi Newton methods. | | |
| Unit IV | Unconstrained Optimization Techniques | 6 |
| Direct Search Methods: Random search methods, Grid search method, Univariate method, Hookes and Jeeves' method, Powell's method, Dynamic Programming. | | |
| Unit V | Modern Methods of Optimization | 6 |
| Genetic algorithms, simulated annealing, fuzzy optimization, neural-network based methods, Aunt and colony approach. | | |
| Text Books | 1. Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley and Sons<br>2. Fox, R. L., Optimization Methods for Engineering Design, Addison Wesley | |
| Reference Books | 1. H N Wagner, Operations Research, Prentice Hall<br>2. N D Vohra, Quantitative Techniques in Management, Tata McGraw-Hill | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 24.03.2018 | |
| Date of approval by the Academic Council | 11.06.2018 | |

**Course Outcome For ME4107**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to first develop a basic understanding of different optimization techniques and then apply them through numerical problems for some of the important techniques of classical optimization | 3 | s |
| CO2 | Students should be able to understand the principles of optimization through linear programming and applying the learnings though numerical problems | 3 | s |
| CO3 | Students should be able to understand the different techniques of one-dimensional optimization and applying the learnings though numerical problems | 3 | em |
| CO4 | Students should be able to understand the different unconstrained optimization techniques and applying the learnings though numerical problems | 2 | em |
| CO5 | Students should be able to understand the modern methods of optimization techniques and applying the learnings though numerical problems | 2 | em |

**CO-PO Mapping for ME4107**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped- 3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 3 | 3 | 3 | 2 | 0 | 0 | 2 | 0 | 1 | 1 | 2 | 3 | 2 | 3 | 2 | 1 |
| CO 2 | 3 | 2 | 3 | 3 | 2 | 0 | 0 | 2 | 0 | 1 | 2 | 1 | 3 | 1 | 3 | 2 | 2 |
| CO 3 | 3 | 3 | 2 | 3 | 2 | 0 | 0 | 2 | 0 | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 |
| CO 4 | 2 | 3 | 2 | 3 | 3 | 0 | 0 | 2 | 0 | 1 | 1 | 2 | 3 | 2 | 3 | 2 | 1 |
| CO 5 | 2 | 3 | 3 | 3 | 2 | 0 | 0 | 1 | 0 | 1 | 2 | 2 | 3 | 2 | 2 | 2 | 2 |
| Avg | 2.6 | 2.8 | 2.6 | 3 | 2.2 | 0 | 0 | 1.8 | 0 | 1 | 1.6 | 1.8 | 3 | 1.8 | 2.6 | 2 | 1.3 |

| ME4101 | Title: Advanced Fluid Mechanics | L T P C<br>3 1 0 4 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To understand the laws of fluid flow for ideal and viscous fluids and to represent the real solid shapes by suitable flow patterns and to analyze the same for aerodynamics performances. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Non Viscous Flow | 7 |
| Lagrangian and Eulerain Descriptions of fluid motion- Path lines, Stream lines, Streak lines, stream tubes , velocity of a fluid particle, types of flows, Equations of three dimensional continuity equation- Stream and Velocity potential functions. | | |
| Unit II | Potential Flow Theory | 7 |
| Condition for irrotationality, circulation and vorticity Accelerations in Carte systems normal and tangential accelerations, Euler's, Bernoulli equations in 3D, Continuity and Momentum Equations. | | |
| Unit III | Principles of Viscous Flow | 7 |
| Derivation of Navier-Stoke's Equations for viscous compressible flow, Exact solutions to certain simple cases: Plain Poisoulle flow, Coutte flow with and without pressure gradient, Hagen Poisoulle flow, Blasius solution. | | |
| Unit IV | Boundary Layer Concepts | 8 |
| Prandtl's contribution to real fluid flows, Prandtl's boundary layer theory, Boundary layer thickness for flow over a flat plate, Approximate solutions, Creeping motion (Stokes), Oseen's approximation - Von-Karman momentum integral equation for laminar boundary layer, Expressions for local and mean drag coefficients for different velocity profiles. | | |
| Unit V | Compressible Fluid Flow | 7 |
| Thermodynamic basics, Equations of continuity, Momentum and Energy, Acoustic Velocity Derivation of Equation for Mach Number, Flow Regimes, Mach Angle, Mach Cone, Stagnation State Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers, Isothermal Flow in Long Ducts, Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks, Supersonic. | | |
| Text Books | 1. Schlichting H, Layer Theory, Springer Publications<br>2. Yuman S.W, Foundations of Fluid Mechanics, Prentice-Hall of India | |
| Reference Books | 1. D. Rama Durgaiah, Fluid Mechanics and Machinery, New Age Pub<br>2. William F. Hughes and John A. Brighton, Fluid Dynamics, Tata Mc. | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 24.03.2018 | |
| Date of approval by the Academic Council | 11.06.2018 | |

**Course Outcome For ME4101**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to understand about basics of fluid mechanics and concepts related to fluid statics. | 3 | s |
| CO2 | Students should be able to know advanced concepts related to potential flow theory | 3 | s |
| CO3 | Students should be able to understand the various concets related to principle to viscous flow. | 2 | s |
| CO4 | Students should be able to understand the boundary layer concept in depth. | 3 | s |
| CO5 | Students should be able to understand concepts related to compressible fluid flow | 3 | em |

**CO-PO Mapping for ME4101**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped- 3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PE O 2 | PE O 3 |
| CO 1 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 3 | 3 | 2 | 3 | 2 | 2 |
| CO 2 | 3 | 2 | 1 | 2 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 3 | 1 | 2 |
| CO 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 0 | 0 | 0 | 1 | 3 | 3 | 3 | 3 | 2 | 2 |
| CO 4 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 3 | 3 | 3 | 3 | 1 | 3 |
| CO 5 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 1 | 3 | 3 | 3 | 3 | 2 | 3 |
| Avg | 2.6 | 2.8 | 2.4 | 1.6 | 1.8 | 1.6 | 1.5 | 0 | 0 | .3 | 1.6 | 1.8 | 3 | 1.8 | 2.6 | 2 | 1.3 |

| ME4102 | Title: Advanced Thermodynamics | L T P C<br>3 1 0 4 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To develop the ability to use the thermodynamics concepts for various applications like availability analysis and thermodynamic relations, to analyses the real gas behavior and chemical thermodynamics. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Recapitulation of fundamentals | 7 |
| Basic definition and concepts; The basic laws of Thermodynamics, Entropy flow and entropy production, 3rd law of Thermodynamics, Availability in steady flow open system and in a closed system, Irreversibility and effectiveness | | |
| Unit II | Properties of pure substances | 7 |
| P-V-T surfaces, phase diagram, phase changes, various properties diagram, 1st order phase transition and 2nd order phase transition, Clapeyron's equation, Ehrenfest's equations, Maxwell's equations, equation for internal energy, enthalpy, entropy, specific heat and joule Thompson coefficient, Bridgeman tables for thermodynamic relations | | |
| Unit III | Real Gas behaviour | 7 |
| Different equations of state – fugacity – compressibility - principle of corresponding states - Use of generalized charts for enthalpy and entropy departure - fugacity coefficient, Lee – Kesler generalized three parameter tables. Fundamental property relations for systems of variable composition. Partial molar properties. Real gas mixtures - Ideal solution of real gases and liquid - activity - equilibrium in multi phase systems - Gibbs phase rule for non – reactive components. | | |
| Unit IV | Statistical thermodynamics | 8 |
| Microstates and Macrostates: thermodynamic probability - degeneracy of energy levels - Maxwell – Boltzman, Fermi, Diarc and Bose-Einstein statistics, microscopic interpretation of heat and work, evaluation of entropy, partion function | | |
| Unit V | Chemical thermodynamics | 7 |
| Gibb's theorem, Gibbs function of mixture of inert ideal gases, Chemical equilibrium, Thermodynamic equation for phase, Degree of reaction, equation of reaction, law of mass action, heat of reaction and Vant Hoff Isober, Phase Equilibrium for a Single-Component System and Multi-Component System | | |
| Text Books | 1. P.K. Nag, Basic and Applied Thermodynamics, TMH<br>2. Holman, Thermodynamics, Mc Graw Hill | |
| Reference Books | 1. Michael Boles and Yunus Cengel, Thermodynamics: An Engineering Approach, TMH<br>2. G.J. Van Wylen, Thermodynamics<br>3. M. Zemansky, Heat and Thermodymics<br>4. Sonntag R.E. and Van Wylen, G., Introduction to Thermodynamics, Classical and Statistical Themodynamics, John Wiley and Sons. | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 24.03.2018 | |
| Date of approval by the Academic Council | 11.06.2018 | |

**Course Outcome For ME4102**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to understand fundamental concepts of thermal engineering | 3 | Em |
| CO2 | Students should be able to understand the advanced properties of pure substance and able to apply different equations. | 3 | s |
| CO3 | Students should able to understand the application of thermodynamics in real gas behaviour. | 3 | s |
| CO4 | Students should able to apply the basic knowledge of thermodynamics to understand the statical thermodynamics | 3 | s |
| CO5 | Students should be able to understand chemical thermodynamics and able to analyse different reactions | 3 | em |

**CO-PO Mapping for ME4102**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped- 3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 2 | 3 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 2 | 1 | 3 | 3 |
| CO 2 | 3 | 2 | 3 | 3 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 3 | 3 | | 3 | 3 | 3 |
| CO 3 | 2 | 3 | 3 | 3 | 0 | 3 | 2 | 3 | 0 | 0 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO 4 | 2 | 2 | 3 | 2 | 0 | 3 | 3 | 3 | 0 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO 5 | 3 | 3 | 2 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 2 | 3 | 2 |
| Avg | 2.6 | 2.8 | 2.4 | 2.1 | 0.2 | 2.6 | 1.5 | 0 | 0 | .3 | 1.6 | 1.8 | 3 | 1.8 | 2.6 | 2 | 1.3 |

| ME4103 | Title: Advanced Heat Transfer | L T P C<br>3 1 0 4 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To develop the ability to use the heat transfer concepts for thermal analysis and sizing of heat exchangers and to achieve an understanding of the basic concepts of phase change processes. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 7 |
| Brief Introduction to different Modes of heat transfer- Conduction- General heat conduction equation, Boundary conditions , Steady simplified heat transfer in Cartesian coordinates , Finned surfaces- 1-D Heat transfer with internal heat generation. | | |
| Unit II | Transient heat conduction | 8 |
| Lumped system analysis, Heisler charts, Semi-infinite solid, Product solution- 2D, steady state heat conduction, Use of conduction shape factors-Transient heat conduction, Analytical solution- Finite Difference methods for Heat Conduction Problems- 1 D and 2 D steady state and Unsteady heat conduction, Implicit and Explicit methods. | | |
| Unit III | Convection | 8 |
| Concept of boundary layer- Hydrodynamic and Thermal boundary layer concepts-Equations of Motion and Energy-Methods to determine heat transfer coefficient- Dimensional Analysis, Importance of Non , Dimensional numbers, Analogies between Heat and Momentum Transfer-External flows and integral methods for flow over a flat plate-Application of empirical relations to various geometrics.<br>Dimensionless parameters of Free convection-An Approximate Analysis of Laminar Free Convection on Vertical Plate-Free convection on a Horizontal Plate, Cylinder and Sphere- Combined free and forced convection. | | |
| Unit IV | Boiling and condensation | 5 |
| Boiling curve, Correlations, Nusselt's theory of film condensation on a vertical plate, Assumptions and correlations of film condensation for different geometrics. | | |
| Unit V | Radiation | 8 |
| Concept of View factor- Methods of Determining View factors-Radiant heat exchange in Grey, Non- Grey bodies with Transmitting, Reflecting and Absorbing media- Secular surface, gas radiation, Radiation from flames | | |
| Text Books | 1. Yunus A.Cengal, Heat and Mass Transfer: A practical Approach, Tata McGraw - Hill<br>2. O P Single, Heat and Mass Transfer, Macmillan India Ltd. | |
| Reference Books | 1. P.S. Ghoshdastidar, Heat Transfer, Oxford Press<br>2. Sarit K. Das, Engg. Heat and Mass Transfer, Dhanpat Rai<br>3. F.P. Incropera and D.P. DeWitt, Fundamentals of Heat and Mass Transfer, John Wiley and Sons | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 24.03.2018 | |
| Date of approval by the Academic Council | 11.06.2018 | |

**Course Outcome For ME4103**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to Understand the modes of heat transfer and its governing laws and also acquire skills to calculate heat transfer in steady state conditions in one dimension | 3 | Em |
| CO2 | Students should be able to understand and calculate the 1D and 2D heat transfer in transient conditions and also able to solve problems using finite difference technique. | 3 | s |
| CO3 | Students should be able to analyse convective heat transfer in different geometries and should know the use of emperical relations | 3 | s |
| CO4 | Students should able to analyse different phase change heat transfer. | 3 | s |
| CO5 | Students should be able to evaluate heat transfer by radiation from different complex geometries. | 4 | s |

**CO-PO Mapping for ME4103**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 2 | 3 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 2 | 1 | 3 | 3 |
| CO 2 | 3 | 2 | 2 | 3 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 3 | 3 | 1 | 3 | 3 | 3 |
| CO 3 | 3 | 3 | 2 | 3 | 0 | 2 | 2 | 3 | 0 | 0 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO 4 | 3 | 3 | 3 | 3 | 0 | 3 | 2 | 3 | 0 | 0 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO 5 | 3 | 3 | 2 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 2 | 3 | 2 |
| Avg | 3 | 2.8 | 2.2 | 2.2 | 0 | 2.3 | 1.1 | 1.1 | 0 | 0 | 0.5 | 3 | 2.8 | 1.8 | 2.2 | 3 | 2.8 |

| ME4108 | Title: Instrumentation and Measurements | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To develop the understanding of methods for measuring various thermal quantities using various instruments and principles involved. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Measurement characteristics | 7 |
| Instrument Classification, Characteristics of Instruments – Static and dynamic, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments, Reliability of instruments | | |
| Unit II | Microprocessors based measurements | 7 |
| Data logging and acquisition – elements of microcomputer interfacing, intelligent instruments in use | | |
| Unit III | Measurement of physical quantities | 6 |
| Measurement of thermo-physical properties, instruments for measuring temperature, pressure and flow, use of sensors for physical variables. | | |
| Unit IV | Advanced measurement techniques | 8 |
| Shadowgraph, Schlieren, Interferometer, Laser Doppler Anemometer, Hot wire Anemometer, Heat flux sensors, Telemetry in measurement. | | |
| Unit V | Measurement analysers | 8 |
| Orsat apparatus, Gas Analyzers, Smoke meters, gas chromatography, spectrometry | | |
| Text Books | 1. Raman, C.S., Sharma, G.R., Mani, V.S.V, Instrumentation Devices and Systems, Tata McGraw Hill | |
| Reference Books | 1. Holman, Experimental methods for engineers, J.P. McGraw-Hill<br>2. Barney, Intelligent Instrumentation, Prentice Hall<br>3. Prebrashensky, V., Measurements and Instrumentation in Heat Engineering, MIR Publishers<br>4. Morris,A.S, Principles of Measurements and Instrumentation, Prentice Hall | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 24.03.2018 | |
| Date of approval by the Academic Council | 11.06.2018 | |

**Course Outcome For ME4108**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to understand various measurement instruments and their Characteristics | 2 | Em |
| CO2 | Students should be able to Understand the working and use of microprocessor-based instruments | 3 | Em |
| CO3 | Students should be able to understand the instruments used to measure the physical quantities | 2 | em |
| CO4 | Students should be able to understand the advanced measurement technique such as heat flux sensors, Hot wire Anemometer etc. | 2 | s |
| CO5 | Students should be able to understand the Working Principle of Measurement analyzers such as Orsat Apparatus, Gas Analyzers etc. | 2 | s |

**CO-PO Mapping for ME4108**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PE O 2 | PE O 3 |
| CO 1 | 3 | 2 | 3 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 2 | 1 | 3 | 3 |
| CO 2 | 3 | 2 | 2 | 3 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 3 | 3 | 1 | 3 | 3 | 3 |
| CO 3 | 3 | 3 | 2 | 3 | 0 | 2 | 2 | 3 | 0 | 0 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO 4 | 3 | 3 | 3 | 3 | 0 | 3 | 2 | 3 | 0 | 0 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO 5 | 3 | 3 | 2 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 2 | 3 | 2 |
| Avg | 3 | 2.8 | 2.2 | 2.2 | 0 | 2.3 | 1.1 | 1.1 | 0 | 0 | 0.5 | 3 | 2.8 | 1.8 | 2.2 | 3 | 2.8 |

| ME4140 | Title: Advanced Thermal Engineering Lab | L T P C<br>0 0 2 1 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | The lab is mainly intended to conduct experiments on various Thermal Engineering devices to study the performance and its applications. | |

**List of Experiments**

1. Study Compressibility factor measurement of different real gases.
2. To calculate Dryness fraction estimation of steam.
3. Performance analysis of two stage reciprocating compressor.
4. Performance test and analysis of exhaust gases of an I.C. Engine.
5. Heat Balance sheet, Volumetric Efficiency and air fuel ratio estimation of an I.C. Engine.
6. Performance analysis of Air conditioning unit.
7. Performance analysis of heat pipe.
8. Study of solar flat plate collector.

| | |
|---|---|
| Mode of Evaluation | Internal and External Examinations |
| Recommendation by Board of Studies on | 24.03.2018 |
| Date of approval by the Academic Council | 11.06.2018 |

**Course Outcome For ME4140**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should able to understand intricacies of solar plate collector and behaviour of different real gas. | 2 | Em |
| CO2 | students should able to evaluate the performance parameters of IC engine, heat pipe, AC unit and receprocating compressor | 5 | S |
| CO3 | students should able to evaluate the dryness fraction of steam | 5 | S |

**CO-PO Mapping for ME4140**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 1 | 3 | 3 | 1 |
| CO 2 | 3 | 3 | 1 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 3 | 2 | 3 |
| CO 3 | 3 | 3 | 2 | 2 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 2 | 2 | 3 |
| Avg | 3 | 3 | 1 | 1.6 | 0 | 2 | 0.6 | 0 | 0 | 0 | 0 | 3 | 2.8 | 1.6 | 2.6 | 2.6 | 2.6 |

| ME4201 | Title: Simulation Modeling and Analysis | L T P C<br>3 2 0 4 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To develop representational modes of real processes and systems. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 6 |
| A review of basic probability and statistics, random variables and their properties, Estimation of means variances and correlation. | | |
| Unit II | Physical Modeling | 6 |
| Concept of System and environment, Continuous and discrete systems, Linear and non-linear systems, Stochastic activities, Static and Dynamic models, Principles of modeling, Basic Simulation modeling, Role of simulation in model evaluation and studies, advantages of simulation | | |
| Unit III | System Simulation | 8 |
| Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies, Simulation software packages. | | |
| Unit IV | System Dynamics | 8 |
| Growth and Decay models, Logistic curves, System dynamics diagrams. Probability Concepts in Simulation: Stochastic variables, discrete and continuous probability functions, Random numbers, Generation of Random numbers, Variance reduction techniques, Determination of length of simulation runs. | | |
| Unit V | Simulation of Mechanical Systems | 8 |
| Simulation of Mechanical Systems: Building of Simulation models, Simulation of translational and rotational mechanical systems, Simulation of hydraulic systems. | | |
| Text Books | 1. Bernard Zeigler Tag Kim Herbert Praehofer, Theory of Modeling and Simulation, Springer<br>2. VP Singh, System Modelling and Simulation, New Age International Limited Publication | |
| Reference Books | 1. Mohsen Guizani, Ammar Rayes, Bilal Khan, Ala Al-Fuqaha, Network Modeling and Simulation: A Practical Perspective<br>2. Birta,Luois, Modelling and Simulation, Springer | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 24.03.2018 | |
| Date of approval by the Academic Council | 11.06.2018 | |

**Course Outcome For ME4201**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to understand the basic probability and statistic, random variables and their properties | 2 | Em |
| CO2 | Students should be able to understand the Physical modeling methods and Various techniques | 2 | Em |
| CO3 | Students should be able to study the various methods which is use in system simulation | 2 | S |
| CO4 | Students should be able to understand the concept and techniques of system dynamics | 2 | s |
| CO5 | Students should be able to understand the methods which is use to for the simulation of mechanical system | 2 | s |

**CO-PO Mapping for ME4201**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 2 | 3 | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 2 | 2 | 2 | 3 |
| CO 2 | 2 | 2 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 2 | 2 | 2 | 3 |
| CO 3 | 3 | 3 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 2 | 2 | 3 | 3 |
| CO 4 | 2 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 2 | 2 | 2 |
| CO 5 | 2 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 3 | 3 | 3 | 3 |
| Avg | 2.2 | 2.8 | 2.2 | 2.6 | 2. | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 2.2 | 2.2 | 2.2 | 2.8 |

| ME4240 | Title: Simulation Lab | L T P C<br>0 0 2 1 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To learn the modeling and simulation analysis of various thermal engineering application using analysis software. | |

**List of Experiments**

1. Study of Simulation software.
2. Analysis of Discharge of Water from a Reservoir.
3. Simulation of 2-D steady state heat conduction in a slab.
4. Simulation of counter flow heat exchanger.
5. Analysis of Transient Temperature Distribution in a Slab.
6. Analysis of Temperature Distribution on an Insulated Wall.
7. Analysis of auto pilot system.
8. Analysis of servomotor system.

| | |
|---|---|
| Mode of Evaluation | Internal and External Examinations |
| Recommendation by Board of Studies on | 24-03-2018 |
| Date of approval by the Academic Council | 11-06-2018 |

**Course Outcome For ME4240**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to study the simulation software | 2 | Em |
| CO2 | Students should be able to simulate the various heat transfer processes | 3 | S |
| CO3 | Students should be able to analysis of various heat transfer instruments by using simulation software | 4 | S |

**CO-PO Mapping for ME4240**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped- 3, Moderate- 2, Low-1, Not related- 0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PEO1 | PEO2 | PEO3 |
| CO1 | 2 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 2 | 3 | 2 | 3 |
| CO2 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 2 | 3 | 2 | 3 |
| CO3 | 2 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 2 | 3 | 2 | 3 |
| Avg | 2.6 | 3 | 2.3 | 2.3 | 2.3 | 0 | 0 | 0 | 0 | 0 | 0 | 2.3 | 3 | 2 | 3 | 2 | 3 |

| ME4307 | Title: Research Methodology | L T P C<br>2 0 0 2 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | Understand some basic concepts of research and its methodologies Select and define appropriate research problem and parameters Write a research report and thesis | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 4 |
| Objectives of Research – Limitations in Research – Qualities of a Good Research Worker – Criteria of Good Research – Limitations of Research Concept of Applied and Basic research – Quantitative and Qualitative Research Techniques – Need for theoretical frame work – Hypothesis development – Hypothesis testing with quantitative data. Research design – Purpose of the study: Exploratory, Descriptive, Hypothesis Testing. | | |
| Unit II | Experimental Design | 5 |
| Laboratory and the Field Experiment – Internal and External Validity – Factors affecting Internal validity. Measurement of variables – Scales and measurements of variables. Developing scales – Rating scale and attitudinal scales – Validity testing of scales – Reliability concept in scales being developed – Stability Measures. | | |
| Unit III | Data Collection | 5 |
| Interviewing, Questionnaires, etc. Secondary sources of data collection. Guidelines for Questionnaire Design – Electronic Questionnaire Design and Surveys. Special Data Sources: Focus Groups, Static and Dynamic panels. Review of Advantages and Disadvantages of various Data-Collection Methods and their utility. Sampling Techniques – Probabilistic and non-probabilistic samples. Issues of Precision and Confidence in determining Sample Size. Hypothesis testing, Determination of Optimal sample size. | | |
| Unit IV | Multivariate Statistical Techniques | 5 |
| Data Analysis – Factor Analysis – Cluster Analysis -Discriminant Analysis – Multiple Regression and Correlation – Canonical Correlation – Application of Statistical(SPSS) Software Package in Research | | |
| Unit V | Research Report | 5 |
| Purpose of the written report – Concept of audience – Basics of written reports. Integral parts of a report – Title of a report, Table of contents, Abstract, Synopsis, Introduction, Body of a report – Experimental, Results and Discussion – Recommendations and Implementation section – Conclusions and Scope for future work | | |
| Text Books | 1. C R Kothari, Research Methodology, New Age International<br>2. C. Murthy, Research Methodology, Vindra Publications Ltd. | |
| Reference Books | 1. Donald Cooper and Pamela Schindler, Business Research Methods, TMGH<br>2. Alan Bryman and Emma Bell, Business Research Methods, Oxford University Press<br>3. Ranjit Kumar, Research Methodology, Sage Publications, London | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4307**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to Objectives of Research, Research Techniques,Hypothesis development | 3 | S,Em |
| CO2 | Students should be able to Internal and External Validity, Reliability concept in scales, Stability Measures. | 2 | S |
| CO3 | Students should be able to Interviewing, Questionnaires, Probabilistic, Precision and Optimal sample size. | 3 | S |
| CO4 | Students should be able to Data Analysis, Factor Analysis, Cluster Analysis, Statistical (SPSS) Software | 2 | S |
| CO5 | Students should be able to written reports, Abstract, Synopsis, Experimental, Results and Conclusions | 2 | S,Em |

**CO-PO Mapping for ME4307**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 2 | 2 | 1 | 3 | 0 | 3 | 0 | 2 | 2 | 2 | 3 | 3 | 0 | 1 | 2 | 2 |
| CO 2 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 3 | 1 | 1 | 2 | 3 |
| CO 3 | 3 | 3 | 2 | 2 | 2 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 3 | 3 | 1 | 2 | 2 |
| CO 4 | 3 | 2 | 3 | 3 | 2 | 0 | 1 | 0 | 1 | 1 | 2 | 0 | 3 | 2 | 1 | 1 | 3 |
| CO 5 | 3 | 2 | 3 | 3 | 2 | 0 | 2 | 0 | 2 | 2 | 0 | 0 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2.2 | 2.2 | 2.2 | 2.2 | 0 | 1.8 | 0 | 1.6 | 1.4 | 1.3 | 1 | 3 | 2.2 | 1.2 | 2 | 2.6 |

| ME4340 | Title: Research Methodology Lab | L T P C<br>0 0 2 1 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To learn to prepare reports and charts | |

**List of Experiments**

1. Basics of Excel- data entry, editing and saving, establishing and copying a formula.
2. Functions in excel, copy and paste and exporting to MS word document
3. Graphical presentation of data -Histogram, frequency polygon, pie-charts and bar diagrams.
4. SPSS, opening SPSS, layout, menu and icons analyzing the data using different statistical techniques.

| | |
|---|---|
| Mode of Evaluation | Internal and External Examinations |
| Recommendation by Board of Studies on | 06.06.2019 |
| Date of approval by the Academic Council | 13.07.2019 |

**Course Outcome For ME4340**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to understand and use the Basics Excel commands | 3 | S, Em |
| CO2 | Students should be able to understand the Graphical presentation of data -Histogram, frequency polygon, pie-charts and bar diagrams | 4 | S |
| CO3 | Students should be able to understand the SPSS, layout, menu and analyzing the data using different statistical techniques. | 4 | S |

**CO-PO Mapping for ME4340**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 3 | 2 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 3 | 3 | 0 | 2 | 2 |
| CO 2 | 3 | 2 | 3 | 3 | 2 | 0 | 1 | 0 | 0 | 1 | 2 | 2 | 3 | 2 | 1 | 1 | 3 |
| CO 3 | 3 | 3 | 3 | 3 | 3 | 0 | 2 | 0 | 0 | 2 | 0 | 2 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2.6 | 2.6 | 2.6 | 2.3 | 0 | 1.6 | 0 | 0 | 1 | 1.2 | 2 | 3 | 2.2 | 1 | 2 | 2.3 |

## Program Electives

| ME4202 | Title: Cryogenic Engineering | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.1 | |
| Course Prerequisites | Nil | |
| Objectives | To build a foundation in the fundamentals of cryogenics and to encourage a hands on approach to solving cryogenic problems | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction to cryogenic engineering | 7 |
| Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics- Mechanical, Space, Medicine, Gas industry, High energy physics, Superconductivity | | |
| Unit II | Liquefaction Cycle | 8 |
| Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve- Joule Thomson, Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claude Cycle Dual Pressure Cycle, Ortho-Para hydrogen conversion, Critical Components in Liquefaction Systems | | |
| Unit III | Separation of Cryogenic Gases | 7 |
| Binary Mixtures, T-C and H-C Diagrams , Principle of Rectification, Rectification Column, Analysis-McCabe Thiele Method , Adsorption Systems for purification. | | |
| Unit IV | Cryogenic refrigerants | 7 |
| Joule-Thomson (J.T.) Cryocoolers, Stirling Cycle Refrigerators, Gifford-McMahon (G.M.) Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators | | |
| Unit V | Handling of cryogens | 7 |
| Cryogenic Dewar design, Cryogenic Transfer Lines, Insulations in Cryogenic Systems, Operating principle of different Types of Vacuum Pumps, Instruments to measure Flow, Level and Temperature operating principles. | | |
| Text Books | 1. Randall F. Barron, Cryogenic Systems, McGraw-Hill<br>2. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press New York | |
| Reference Books | 1. Robert W. Vance, Cryogenic Technology, John wiley and Sons<br>2. Mamata Mukhopadhay, Fundamentals of Cryogenic Engineering, PHI Learning<br>3. R.B. Scott, Cryogenic Engineering, Van Nostrand and Co. | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4202**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to understand fundamentals of cryogenic engineering. | 3 | Em |
| CO2 | Students should be able to understand the liquefaction cycles and its related terminologies | 2 | none |
| CO3 | Students should be able to understand the separation storage and transportation of cryogenic liquids | 3 | Em |
| CO4 | Students should be able to understand the different cryogenic refrigerants | 2 | S |
| CO5 | Students should be able to understand the handling of cryogen and its operating principles. | 2 | S |

**CO-PO Mapping for ME4202**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 2 | 2 | 1 | 3 | 0 | 3 | 0 | 2 | 2 | 2 | 3 | 3 | 0 | 1 | 2 | 2 |
| CO 2 | 3 | 2 | 1 | 2 | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 2 | 3 | 1 | 1 | 2 | 3 |
| CO 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 0 | 1 | 0 | 2 | 1 | 3 | 3 | 1 | 2 | 2 |
| CO 4 | 3 | 2 | 3 | 3 | 2 | 1 | 1 | 0 | 1 | 1 | 2 | 1 | 3 | 2 | 1 | 1 | 3 |
| CO 5 | 3 | 2 | 3 | 3 | 2 | 0 | 2 | 0 | 2 | 2 | 0 | 1 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2.2 | 2.2 | 2.2 | 2.2 | 0.6 | 1.8 | 0 | 1.6 | 1.4 | 1.3 | 1.8 | 3 | 2.2 | 1.2 | 2 | 2.6 |

| ME4203 | Title: Transit Refrigeration | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.1 | |
| Course Prerequisites | Nil | |
| Objectives | To present a problem oriented in depth knowledge of Food Preservation and Transport and address the underlying concepts and methods. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 7 |
| Microbiology of Food Products, Mechanism of food spoilage critical microbial growth requirements, Design for control of microorganisms, The role of HACCP, Sanitation, Regulation and standards | | |
| Unit II | Processing | 8 |
| Thermodynamic properties and Transfer properties, Water content, Initial freezing temperature, Ice fraction, Transpiration of fresh fruits and vegetables, Food Processing techniques for Dairy products, Poultry, Meat, Fruits and Vegetables | | |
| Unit III | Freezing and Drying | 7 |
| Pre-cooling, Freeze drying principles, Cold storage and freezers, Freezing drying limitations, Irradiation techniques, Cryofreezing, Numerical and analytical methods in estimating Freezing, Thawing times, Energy conservation in food industry. | | |
| Unit IV | Cold Storage Design and Instrumentation | 7 |
| Initial building consideration, Building design, Specialized storage facility, Construction methods, Refrigeration systems, Insulation techniques, Control and instrumentation, Fire protection, Inspection and maintenance | | |
| Unit V | Transport | 7 |
| Refrigerated transportation, Refrigerated containers and trucks, Design features, Piping and Role of cryogenics in freezing and transport | | |
| Text Books | 1. Alan Rodes, Principles of Industrial Microbiology, Pregmon International Pub.<br>2. Ibraham Dincer, Heat Transfer in Food Cooling Applications, Tailor and Francis Pub. | |
| Reference Books | 1. Clive V.I. Dellino, Cold and Chilled Storage Technology, Van Nostrand Reinhold Pub., New York,<br>2. C.P. Arora, Refrigeration and Air conditioning, McGraw-Hill Pub. | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06-06-2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4203**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to understand the fundamentals of transit refrigeration and identify different areas of Food Processing | 3 | S,Em |
| CO2 | Students should be able to understand the thermodynamic properties and transfer properties related to transit refrigeration. | 3 | S,Em |
| CO3 | Students should be able to understand the methodology of freezing and drying. | 3 | S,Em |
| CO4 | Students should be able to understand the cold storage design and instrumentation. | 2 | S |
| CO5 | Students should be able to understant the preservation and transport and also can find the applications of all the areas in day to day life. | 2 | S,Em |

**CO-PO Mapping for ME4203**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped- 3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 3 | 2 | 1 | 1 | 1 | 3 | 0 | 1 | 1 | 2 | 3 | 3 | 1 | 3 | 2 | 2 |
| CO 2 | 3 | 3 | 1 | 2 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 3 | 2 | 2 | 2 | 3 |
| CO 3 | 3 | 3 | 1 | 2 | 1 | 1 | 2 | 0 | 1 | 0 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| CO 4 | 3 | 2 | 3 | 3 | 1 | 1 | 1 | 0 | 1 | 1 | 2 | 2 | 3 | 2 | 3 | 1 | 3 |
| CO 5 | 3 | 2 | 3 | 3 | 2 | 1 | 2 | 0 | 1 | 1 | 0 | 2 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2.2 | 2.2 | 2.2 | 1.3 | 1 | 1.8 | 0 | 1 | 0.5 | 1.3 | 2.2 | 3 | 2.2 | 2.6 | 2.2 | 2.6 |

| ME4206 | Title: Refrigeration Machinery | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.1 | |
| Course Prerequisites | Nil | |
| Objectives | To master how refrigeration components and systems. To identify and explain various system accessories and controls in refrigeration systems. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Refrigerant compressors | 7 |
| Hermetic compressors - Reciprocating, Rotary, Scroll compressors, Open type compressors - Reciprocating, Centrifugal, Screw Compressors. Semi hermetic compressors - Construction, working and Energy Efficiency aspects. Applications of each type. | | |
| Unit II | Refrigeration system components | 7 |
| Evaporators and condensers-Different types, capacity control, circuitry, Oil return, Oil separators- Different types Refrigerant driers strainers, Receivers, Accumulators, Low pressure receivers, Air Washers, Spray ponds. | | |
| Unit III | Hydronic systems | 8 |
| Water piping in Chilled Water Systems, Multiple Fan Coil Units, Condensers - Multiple Condensers and Cooling Towers. System components , Expansion tank, Balancing valves, Pumping systems, Pump selection, Freeze prevention | | |
| Unit IV | Appliances and accessories | 7 |
| Special components for refrigeration, air Conditioning in Automobiles, Railway Wagons, Marine Vessels, Aircraft and Other Commercial Applications. | | |
| Unit V | System accessories and controls | 7 |
| Refrigerant Pumps, Cooling Tower fans, Compressor Motor protection devices, Oil equalizing in multiple evaporators. Different Defrosting and capacity control methods and their implications. | | |
| Text Books | 1. R.J. Dosset, Principles of Refrigeration, John Wiley and Sons<br>2. Hains, Automatic Control of Heating and Airconditioning, J.B. Mc Graw Hill | |
| Reference Books | 1. Althose, A.D. and Turnquist, C.H, Good Heart, Modern Refrigeration and Airconditioning, Wilcox Co.Inc.<br>2. ASHRAE Hand book - Fundamentals and Equipments | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4206**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to understand basic concepts and working of compressors. | 3 | S,Em |
| CO2 | Students should be able to understand refrigeration system component | 2 | S,Em |
| CO3 | Students should be able to deeply understand various hydraulic system | 3 | S |
| CO4 | Students should be able to understand appliances and accessories | 3 | S |
| CO5 | Students should be able to know about various system accessories and controls. | 3 | S,Em |

**CO-PO Mapping for ME4206**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 3 | 2 | 1 | 1 | 1 | 3 | 0 | 1 | 1 | 2 | 3 | 3 | 1 | 3 | 2 | 2 |
| CO 2 | 3 | 3 | 2 | 2 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 3 | 2 | 2 | 2 | 3 |
| CO 3 | 3 | 3 | 1 | 2 | 1 | 1 | 2 | 0 | 1 | 0 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| CO 4 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 0 | 1 | 1 | 2 | 2 | 3 | 2 | 3 | 1 | 3 |
| CO 5 | 3 | 2 | 2 | 2 | 2 | 1 | 2 | 0 | 1 | 1 | 0 | 2 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2.2 | 1.8 | 1.8 | 1.3 | 1 | 1.8 | 0 | 1 | 0.5 | 1.3 | 2.2 | 3 | 2.2 | 2.6 | 2.2 | 2.6 |

| ME4204 | Title: Finite Element Analysis | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To gain a fundamental understanding of the finite element method for solving boundary value problems and to learn important concepts of variation form, minimum potential energy principles, and method of weighted residuals. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 8 |
| Introduction to FEM: basic concepts, historical back ground, application of FEM, general description, comparison of fem with other methods, variational approach, Co-ordinates, basic element shapes, interpolation function. Rayleigh- Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions. | | |
| Unit II | 1 D Structural Analysis | 8 |
| 1-D structural problems, axial bar element, stiffness matrix, load vector, temperature effects, Quadratic shape function. Analysis of Trusses, Plane Truss and Space Truss elements. Analysis of beams, Hermite shape functions, stiffness matrix, Load vector, Problems analysis. | | |
| Unit III | 2 D Structural Analysis | 7 |
| 2-D problems ,CST, force terms, Stiffness matrix and load vector, boundary conditions, Isoparametric element quadrilateral element, Shape functions , Numerical Integration | | |
| Unit IV | 3 D Structural Analysis | 6 |
| 3-D problems, Tetrahedran element, Jacobian matrix , Stiffness matrix. | | |
| Unit V | Heat Conduction Analysis | 7 |
| Scalar field problems - 1-D Heat conduction , 1-D fin element , 2-D heat conduction Problems, Dynamic considerations, Dynamic equations- consistent mass matrix-Eigen Values, Eigen Vector, Natural frequencies-mode shapes-modal analysis. | | |
| Text Books | 1. J. N. Reddy, An Introduction to Finite Element Methods , McGraw hill<br>2. O.C. Aienkowitz, The Finite Element Method in Engineering Science, McGraw hill | |
| Reference Books | 1. S.S. Rao, The finite element methods in Engineering , Pergamon, New York<br>2. Robert Cook, Concepts and applications of finite element analysis, John Wiley and Sons<br>3. K.J Bathe, Finite Element Procedures in Engineering analysis | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 24.03.2018 | |
| Date of approval by the Academic Council | 11.06.2018 | |

**Course Outcome for ME4204**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to develop the basic understanding of the fem and related concepts. | 3 | S,Em |
| CO2 | Students should be able to apply the concepts to solve structural mechanics problems and to obtain finite element solution and compare with exact solution of simple one-dimensional problems. | 3 | S, |
| CO3 | Students should be able to apply the concepts to solve structural mechanics problems and to obtain finite element solution and compare with exact solution two dimensional problems. | 4 | S |
| CO4 | Students should be able to apply the concepts to solve structural mechanics problems and to obtain finite element solution and compare with exact solution three dimensional problems. | 4 | S |
| CO5 | Students should be able to analyse heat conduction equations. | 3 | S |

**CO-PO Mapping for ME4206**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 3 | 3 | 1 | 3 | 2 | 2 |
| CO 2 | 3 | 3 | 2 | 3 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 3 | 2 | 2 | 2 | 3 |
| CO 3 | 3 | 3 | 1 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| CO 4 | 3 | 2 | 2 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 2 | 3 | 2 | 3 | 1 | 3 |
| CO 5 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 2 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2.2 | 1.8 | 2.6 | 2 | 1 | 0.8 | 0 | 0.2 | 0 | 1.3 | 2.2 | 3 | 2.2 | 2.6 | 2.2 | 2.6 |

| ME4205 | Title: Computational Fluid Dynamics | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To develop an understanding for the major theories, approaches and methodologies used in CFD. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 7 |
| Introduction: Computational Fluid Dynamics as a Research and Design Tool, Applications of Computational Fluid Dynamics. Governing Equations of Fluid Dynamics: Introduction, Control Volume, Substantial Derivative, Divergence of Velocity, Continuity Equation, Momentum Equation and Energy Equation | | |
| Unit II | Partial Differential Equations | 7 |
| Introduction, Classification of Quasi-Linear Partial Differential Equations, Eigen Value Method, Hyperbolic Equations, Parabolic Equations, Elliptic Equations | | |
| Unit III | Discretization | 8 |
| Introduction of Finite Differences, Difference Equations, Explicit and Implicit Approaches, Errors and Stability Analysis, Grid Generation, Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test. | | |
| Unit IV | Finite Volume Method | 7 |
| Introduction, Implicit Crank-Nicholson Technique, Pressure Correction Method, SIMPLE and SIMPLER algorithms, Computation of Boundary Layer Flow | | |
| Unit V | Turbulence and its modeling | 7 |
| Description of turbulent flow, free turbulent flows, flat plate boundary layer and pipe flow. Algebraic Models, One equation model | | |
| Text Books | 1. J D Anderson Jr., Computational Fluid Dynamics: The Basics With Applications McGraw Hill, Inc.<br>2. S.P. Patankar, Numerical Heat Transfer and Fluid flow, CRC Press | |
| Reference Books | 1. K Murlidhar and T Sundara Rajan, Computational fluid flow and heat transfer, Narosa Publishing House.<br>2. D.A. Anderson, J.I. Tannehill and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation<br>3. T.K. Bose, Numerical Fluid Dynamics, Narosa Publishing House.<br>4. C.A.J. Fletcher, Computational Techniques for Fluid Dynamics 1, Springer<br>5. C.A.J. Fletcher, Computational Techniques for fluid Dynamics 2, Springer | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 24.03.2018 | |
| Date of approval by the Academic Council | 11.06.2018 | |

**Course Outcome For ME4205**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to develop an understanding for the major theories, approaches and methodologies used in CFD. | 3 | S,Em |
| CO2 | Students should be able to analyse the partial differential equation | 4 | S, |
| CO3 | Students should be able to analyse discrete structures. | 4 | S |
| CO4 | Students should be able to numerically solve the governing equations for fluid flow problems | 4 | S |
| CO5 | Students should be able to analyse fluid flow and also able to do its modeling. | 3 | S |

**CO-PO Mapping for ME4205**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped- 3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 3 | 3 | 1 | 3 | 2 | 2 |
| CO 2 | 3 | 3 | 2 | 3 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 3 | 2 | 2 | 2 | 3 |
| CO 3 | 3 | 3 | 1 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| CO 4 | 3 | 2 | 2 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 2 | 3 | 2 | 3 | 1 | 3 |
| CO 5 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 2 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2.2 | 1.8 | 2.6 | 2 | 1 | 0.8 | 0 | 0.2 | 0 | 1.3 | 2.2 | 3 | 2.2 | 2.6 | 2.2 | 2.6 |

| ME4210 | Title: Design of Heat Exchangers | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To learn the thermal and stress analysis on various parts of the heat exchangers and to analyze the sizing and rating of the heat exchangers for various applications | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Fundamentals of Heat Exchanger | 7 |
| Temperature distribution and its implications types, shell and tube heat exchangers, regenerators and recuperators, analysis of heat exchangers, LMTD and effectiveness method. | | |
| Unit II | Flow And Stress Analysis | 8 |
| Effect of turbulence, friction factor, pressure loss, stress in tubes, header sheets and pressure vessels, thermal stresses, shear stresses, types of failures. | | |
| Unit III | Design Aspects | 8 |
| Comparison of air standard and fuel air cycles, effect of operating variables, comparison of air standard and actual cycles, effect of time loss, heat loss and exhaust loss in Petrol and Diesel engines, valve and port timing diagrams | | |
| Unit IV | Compact And Plate Heat Exchangers | 7 |
| Types, merits and demerits, design of compact heat exchangers, plate heat exchangers, performance influencing parameters, limitations. | | |
| Unit V | Condensers And Cooling Towers | 6 |
| Design of surface and evaporative condensers, cooling tower, performance characteristics. | | |
| Text Books | 1. Sadik Kakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press<br>2. Arthur P Frass, Heat Exchanger Design, John Wiley and Sons | |
| Reference Books | 1. Taborek.T, Hewitt.G.F and Afgan.N, Heat Exchangers-Theory and Practice, McGraw-Hill Book Co.<br>2. G.F. Hewitt, G.L. Shires and T.R. Bott, Process Heat Transfer, CRC Press | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 24.03.2018 | |
| Date of approval by the Academic Council | 11.06.2018 | |

**Course Outcome For ME4210**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should able to develop good understanding of the intricacies of heat exchanger design. | 2 | S,Em |
| CO2 | Students should learn about the flow and stresses in heat exchanger | 2 | None |
| CO3 | Students should aware about different design aspacts of heat exchangers | 2 | Em |
| CO4 | Students should gain knowledge of different heat exchanger in thermal power plant. | 2 | Em |
| CO5 | Students should able to know the designing of condenser using the knowledge of heat exchanger. | 2 | S |

**CO-PO Mapping for ME4210**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PE O 2 | PE O 3 |
| CO 1 | 2 | 1 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 2 | 3 |
| CO 2 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 1 | 0 | 2 | 3 |
| CO 3 | 1 | 2 | 3 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 3 | 3 | 3 | 0 | 2 | 2 |
| CO 4 | 2 | 2 | 3 | 3 | 2 | 1 | 0 | 1 | 0 | 1 | 2 | 3 | 2 | 2 | 1 | 1 | 3 |
| CO 5 | 2 | 2 | 3 | 3 | 2 | 1 | 0 | 1 | 0 | 2 | 0 | 2 | 3 | 2 | 2 | 3 | 3 |
| Avg | 1.8 | 1.8 | 2.6 | 2.3 | 1.6 | 0.8 | 0 | .3 | 0 | .6 | 0.3 | 2.6 | 2.6 | 1.6 | 0.6 | 2 | 2.6 |

| ME4207 | Title: Jet & Rocket Propulsion Systems | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.1 | |
| Course Prerequisites | Nil | |
| Objectives | To develop an understanding of how air-breathing engines and chemical rockets produce thrust. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Turbo Jet Propulsion System | 6 |
| Turbo Jet Propulsion System: Gas turbine cycle analysis, layout of turbo jet engine. Turbo machinery- compressors and turbines, Combustor, blade aerodynamics, engine off design performance analysis.<br>Flight Performance: Forces acting on vehicle, Basic relations of motion , multi stage vehicles. | | |
| Unit II | Principles | 8 |
| Principles of Jet Propulsion and Rocketry: Fundamentals of jet propulsion, Rockets and air breathing jet engines, Classification , turbo jet , turbo fan, turbo prop, rocket (Solid and Liquid propellant rockets) and Ramjet engines.<br>Nozzle Theory and Characteristics Parameters: Theory of one dimensional convergent , divergent nozzles, aerodynamic choking of nozzles and mass flow through a nozzle , nozzle exhaust velocity , thrust, thrust coefficient, Supersonic nozzle shape, non-adapted nozzles, summer field criteria, departure from simple analysis ,characteristic parameters , relationship between the characteristic parameters | | |
| Unit III | Solid Propulsion System | 8 |
| Review of properties of mixture of gases , Gibbs , Dalton laws , Equivalent ratio, enthalpy changes in reactions, heat of reaction and heat of formation<br>Solid Propulsion System: Solid propellants, classification, homogeneous and heterogeneous propellants, double base propellant compositions and manufacturing methods. Composite propellant oxidizers and binders. Burning rate and burning rate laws, factors influencing the burning rate, methods of determining burning rates. Solid propellant rocket engine, Heat transfer considerations in solid rocket motor design. Ignition system, simple pyro devices. | | |
| Unit IV | Liquid Rocket Propulsion System | 7 |
| Liquid propellants, classification, Mono and Bi propellants, Cryogenic and storage propellants. Liquid propellant rocket engine, system layout, pump and pressure feed systems, feed system components. Design of combustion chamber, characteristic length, constructional features, and chamber wall stresses. Heat transfer and cooling aspects. Uncooled engines, injectors, various types, injection patterns, injector characteristics, and atomization and drop size distribution, propellant tank design. | | |
| Unit V | Ramjet Propulsion System | 7 |
| Fuel rich solid propellants, gross thrust, gross thrust coefficient, combustion efficiency of ramjet engine, air intakes and their classification , critical, super critical and sub-critical operation of air intakes, engine intake matching, classification and comparison of IIRR propulsion systems. | | |
| Text Books | 1. M.L. Mathur, Gas Turbine and Jet Rocket Propulsion, ST and ARD Publishers<br>2. H.I.H. Saravana Muttoo, G.F.C. Rogers, H. Cohen, Gas Turbine Theory, Pearson Publication | |
| Reference Books | 1. Ganesan, Gas Turbines, TMH<br>2. Khajuria and Dubey, Gas Turbines and Propulsive Systems, Dhanpatrai | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4207**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to understand working of various propulsion systems. | 2 | S,Em |
| CO2 | Students should be able to understand the principles of jet propulsion and rocketry. | 2 | S |
| CO3 | Students should be able to review the properties of mixture of gases and understand the solid propulsion system. | 3 | S |
| CO4 | Students should be able to understand the liquid rocket propulsion system. | 2 | None |
| CO5 | Students should be able to understand the ramjet propulsion system | 2 | none |

**CO-PO Mapping for ME4207**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped- 3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 2 | 2 | 1 | 3 | 0 | 3 | 0 | 2 | 2 | 2 | 3 | 3 | 0 | 3 | 2 | 2 |
| CO 2 | 3 | 2 | 1 | 1 | `1 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 3 | 1 | 2 | 2 | 3 |
| CO 3 | 2 | 3 | 2 | 1 | 2 | 0 | 2 | 0 | 1 | 0 | 2 | 2 | 3 | 3 | 2 | 2 | 2 |
| CO 4 | 3 | 2 | 3 | 3 | 2 | 0 | 1 | 0 | 1 | 1 | 2 | 2 | 3 | 2 | 2 | 1 | 3 |
| CO 5 | 3 | 2 | 3 | 3 | 2 | 0 | 2 | 0 | 2 | 2 | 0 | 2 | 3 | 2 | 2 | 3 | 3 |
| Avg | 2.8 | 2.2 | 2.2 | 1.8 | 2 | 0 | 1.8 | 0 | 1.6 | 1.4 | 1.3 | 2.2 | 3 | 2.2 | 2.2 | 2 | 2.6 |

| ME4208 | Title: Gas Turbine and Compressors | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | The course is intended to impart knowledge on theory and practice of gas turbines and compressors | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 6 |
| Gas turbines -Open and closed cycles -Requirements of working medium -Applications. Ideal cycles and their analysis - Simple cycle and its modifications with reheat, regeneration and inter cooling -Ericsson cycle. | | |
| Unit II | Design Cycles | 8 |
| Real cycles -Compressor and turbine efficiencies -Heat exchanger effectiveness -Flow losses - Incomplete combustion - Cycle efficiency -Performance prediction of simple gas turbines -Off Design operations -Methods of improving part load operations -Transient behavior Performance deterioration. | | |
| Unit III | Axial Flow Gas Turbines | 8 |
| Work done. Velocity triangle and efficiencies, Thermodynamic flow analysis, Degree of reaction, Design cascade analysis, Blade assembling, Material and cooling of blades, Performances, Matching of compressors and turbines, off design Performance. | | |
| Unit IV | Centrifugal Compressor | 7 |
| Types, Velocity triangles and efficiencies, Blade passage design, Diffuser and pressure recovery. Slip factor, Stanitz and Stodolas formula's, Effect of inlet mach numbers, Pre whirl, Performance. | | |
| Unit V | Axial Flow Compressors | 7 |
| Flow Analysis, Work and velocity triangles, Efficiencies, Thermodynamic analysis. Stage pressure rise, Degree of reaction, Stage Loading, General design, Effect of velocity, Incidence, Performance. Cascade Analysis: Geometrical and terminology. Blade force, Efficiencies, Losses, Free end force, Vortex Blades. | | |
| Text Books | 1. Yahya, Elements of Gas Dynamics, New Age Publication<br>2. V Ganesan, Gas Turbines, Tata McGraw-Hill Pub. | |
| Reference Books | 1. D.G. Shepherd, Principles of Turbo Machinery, The Macmillan Company<br>2. Dixon, Fluid Mechanics, Thermodynamics of Turbo Machinery, Pergamon Press | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 24.03.2018 | |
| Date of approval by the Academic Council | 11.06.2018 | |

**Course Outcome For ME4208**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to develop Basic understanding of gas turbine and related working cycles | 2 | S,Em |
| CO2 | Students should be able to understand designing concepts of gas turbines | 3 | S |
| CO3 | Students should be able to understand velocity triangle and axial flow turbine | 3 | S |
| CO4 | Students should be able to understand centrifugal compressor basics and their performance evaluation | 3 | S |
| CO5 | Students should be able to understand the concept of degree of reaction for axial flow compressors. | 2 | S,Em |

**CO-PO Mapping for ME4208**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped- 3, Moderate- 2, Low-1, Not related- 0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PEO1 | PEO2 | PEO 3 |
| CO 1 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 1 |
| CO 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | 2 |
| CO 3 | 3 | 3 | 2 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 3 | 3 | 1 | 2 | 2 |
| CO 4 | 3 | 2 | 3 | 3 | 2 | 0 | 1 | 0 | 0 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| CO 5 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 3 | 3 | 2 | 2 | 2 |
| Avg | 2.8 | 2.2 | 2.2 | 2 | 1.9 | 0.4 | 1.8 | 0.2 | 0.2 | 1.2 | 1.8 | 2.2 | 2.8 | 2.2 | 2.2 | 2 | 2 |

| ME4209 | Title: Fire Dynamics Engineering | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.1 | |
| Course Prerequisites | Nil | |
| Objectives | To understand initiation and propagation of a Fire along with techniques of fire detection and suppression. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Combustion Fundamentals | 6 |
| Fuels - Types and Characteristics of Fuels, Fuels Analysis - Proximate and Ultimate Analysis - Moisture Determination - Calorific Value, Gross and Net Calorific Values - Calorimetry - DuLong's Formula for CV Estimation | | |
| Unit II | Combustion Stoichiometry | 8 |
| Stoichiometry– Mass Basis and Volume Basis – Excess Air Calculation – Fuel and Flue Gas Compositions - Calculations – Rapid Methods – Combustion Processes – Stationary Flame – Surface or Flameless Combustion – Submerged Combustion – Pulsating and Slow Combustion Explosive Combustion. | | |
| Unit III | Mechanism of Combustion | 8 |
| Mechanism of Combustion – Ignition and Ignition Energy – Spontaneous Combustion – Flame Propagation – Solid, Liquid and Gaseous Fuels Combustion – Flame Temperature – Theoretical, Adiabatic and Actual – Ignition Limits – Limits of Inflammability. Thermo Chemistry - Equilibrium combustion products. Low temperature combustion products – High temperature combustion products | | |
| Unit IV | Fire Dynamics | 7 |
| Flames and fire spread theory, buoyant plumes, interactions with surfaces, smoke spread, turbulent diffusion flames, soot formation and radiation effects, toxic products; feedback to fuel; fire chemistry, nitrogen and halogen thermochemistry. | | |
| Unit V | Fire Detection and Suppression | 7 |
| Instruments and sensors, monitoring systems, halogen and water mist suppression. Automatic sprinkler systems and prediction of actuating time. Codes, standards and laws; case studies of real fires – buildings, factories and godowns, automobiles, buses, trains and aircraft, oil spills, forest fires, tents, slums, residential spaces. | | |
| Text Books | 1. D.D. Drysdale, An Introduction to Fire Dynamics, Wiley, New York | |
| Reference Books | 1. J.W. Lyons, Fire, Scientific American Books<br>2. B. Karlsson, and J.G. Quintiere, Enclosure Fire Dynamics, CRC Press<br>3. G. Cox, Combustion Fundamentals of Fire, Academic Press, London | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4209**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to basic knowledge of Combustion Fundamentals of Fire Dynamics Engineering. | 2 | Em |
| CO2 | Students should be able to understand the Combustion Stoichiometry, Combustion Processes, Surface or Flameless Combustion. | 2 | None |
| CO3 | Students should be able to basic knowledge of Mechanism of Combustion and Thermo Chemistry. | 3 | None |
| CO4 | Students should be able to basic principle Fire Dynamics Flames and fire spread theory. | 2 | None |
| CO5 | Students should be able to acquired knowledge on real life problems and importance of life safety in building fire and method of evacuation. | 2 | S |

**CO-PO Mapping for ME4209**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PE O 2 | PE O 3 |
| CO 1 | 3 | 2 | 2 | 1 | 3 | 0 | 3 | 0 | 2 | 2 | 2 | 3 | 3 | 1 | 3 | 2 | 2 |
| CO 2 | 3 | 2 | 1 | 1 | `1 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 2 | 1 | 2 | 2 | 3 |
| CO 3 | 2 | 3 | 2 | 1 | 2 | 0 | 2 | 0 | 1 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO 4 | 3 | 2 | 2 | 2 | 2 | 0 | 1 | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2 |
| CO 5 | 3 | 2 | 2 | 2 | 2 | 0 | 2 | 0 | 2 | 2 | 0 | 2 | 3 | 2 | 2 | 3 | 2 |
| Avg | 2.8 | 2.2 | 1.8 | 1.4 | 2 | 0 | 1.8 | 0 | 1.6 | 1.4 | 1.3 | 2.2 | 2.2 | 1.6 | 2.2 | 2 | 2.2 |

| ME4301 | Title: Alternative Fuels | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To know about the types of alternative fuels and energy sources for IC engines. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 7 |
| Working process of I.C. Engine. Study of various parameters related to properties of different types of fuel (Rating of fuel, Ignition quality, volatility, calculations of Air-Fuel ratio, Calorific Value) as input and output in terms of results (Fuel efficiency, Fuel requirement, Engine efficiency and Engine life). Sources of fossil fuel, scope of availability of fossil fuel in future. | | |
| Unit II | Need for Alternative Fuels | 7 |
| Effects of constituents of Exhaust gas emission on environmental condition of earth, Pollution created by Exhaust gas emission in atmosphere. Greenhouse effect, Factors affecting greenhouse effect. Study of Global Carbon Budget, Carbon foot print and Carbon credit calculations. Emission norms as per Bharat Standard up to BS - VI and procedures for confirmation on production. | | |
| Unit III | Alcohol and Bio Diesel | 7 |
| Sources of Methanol and Ethanol, methods of its production. Properties of methanol and ethanol as engine fuels, Use of alcohols in S.I. and C.I. engines, performance of blending methanol with gasoline. Emulsification of alcohol and diesel. Dual fuel systems. Base materials used for production of Bio Diesel, Process of separation of Bio Diesel. Properties Diesel blended with vegetable oil, and difference in performance of Engine. | | |
| Unit IV | Hydrogen and Biogas | 8 |
| Hydrogen as a substitute fuel. Study Properties, Sources and methods of Production of Hydrogen, Storage and Transportation of hydrogen. Advantages of hydrogen (Liquid hydrogen) as fuel, Cost estimation. Layout of a hydrogen car. Fuel Cells: Concept of fuel cells based on usage of Hydrogen and Methanol. Power rating and performance.<br>Introduction to Biogas system, Factors affecting biogas formation. Usage of Biogas in SI engine and CI engine. | | |
| Unit V | Vegetable Oils, LPG and CNG | 7 |
| Vegetable oils for Engines, Esterification, Performance and emission characteristics. Synthetic Alternative Fuels: Di-Methyl Ether (DME), P-Series, Eco Friendly Plastic fuels (EPF).<br>LPG and CNG: Properties of LPG and CNG as engine fuels, fuel metering systems, combustion characteristics, effect on performance, emission, cost and safety. | | |
| Text Books | 1. S.S. Thipse, Alternative Fuels: Concepts, Technologies and Developments, Jaico Publishing House<br>2. Zainul, Abdul, Alternative Fuels for CI Engines, Springer Publications | |
| Reference Books | 1. Dr. G. Devaradjane, Dr. M. Kumaresan, Automobile Engineering, AMK Publishers.<br>2. Richard L Bechtold P.E., Alternative Fuels Guide Book, Society of Automotive Engineers<br>3. Gerhard Knothe, Jon Van Gerpen, Jargon Krahl, The Biodiesel Handbook, AOCS Press Champaign, Illinois | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4301**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should able to understand the basic concepts of IC engine | 2 | S,Em |
| CO2 | Students should aware about the need of alternative fuel in different fields | 2 | S,Em |
| CO3 | Students should able to understand and analyze the application of alcohol and biodiesel in IC engine | 3 | S |
| CO4 | Students should able to understand the application Hydrogen and biogas | 2 | None |
| CO5 | Students should able to apply the basics of chemistry in the preparation of biodiesel | 2 | S |

**CO-PO Mapping for ME4301**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PE O 2 | PE O 3 |
| CO 1 | 3 | 1 | 0 | 0 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 2 | 3 |
| CO 2 | 3 | 2 | 1 | 2 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 3 | 1 | 0 | 2 | 3 |
| CO 3 | 3 | 3 | 2 | 2 | 0 | 1 | 2 | 0 | 0 | 0 | 2 | 1 | 3 | 3 | 0 | 2 | 2 |
| CO 4 | 3 | 2 | 3 | 3 | 2 | 1 | 1 | 0 | 0 | 1 | 2 | 1 | 3 | 2 | 1 | 1 | 3 |
| CO 5 | 3 | 2 | 3 | 3 | 2 | 1 | 2 | 0 | 0 | 2 | 0 | 1 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2 | 1.8 | 2 | 1.6 | 1 | 1.8 | 0 | 0 | 0.6 | 0. | 1.8 | 3 | 2.2 | 1.2 | 2 | 2.6 |

| ME4302 | Title: Solar Energy Technology | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | The course will deliver fundamental knowledge of the solar energy technologies, both, thermal and photovoltaic. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 8 |
| Solar angles, day length, angle of incidence on tilted surface; Sunpath diagrams; Shadow determination; Extraterrestrial characteristics; Effect of earth atmosphere; Measurement and estimation on horizontal and tilted surfaces; Analysis of Indian solar radiation data and applications.<br>Flat-plate Collectors - Effective energy losses; Thermal analysis; Heat capacity effect; Testing methods; Evacuated tubular collectors; Air flat-plate Collectors: types; Thermal analysis; Thermal drying. Selective Surfaces - Ideal coating characteristics; Types and applications; Anti-reflective coating; Preparation and characterization. | | |
| Unit II | Concentrating Collector Designs | 6 |
| Concentrating Collector Designs - Classification, design and performance parameters; Tracking systems; Compound parabolic concentrators; Parabolic trough concentrators; Concentrators with point focus; Heliostats; Comparison of various designs: Central receiver systems, parabolic trough systems; Solar power plant; Solar furnaces | | |
| Unit III | Solar Heating and Cooling and Energy Storage | 8 |
| Solar Heating and Cooling System - Liquid based solar heating system; Natural, forced and gravity flow, mathematical modeling, Vapour absorption refrigeration cycle; Water, ammonia and lithium bromide-water absorption refrigeration systems; Solar operated refrigeration systems; Solar desiccant cooling. -Solar Thermal Energy Storage - Sensible storage; Latent heat storage; Thermo-chemical storage. Solar still; Solar cooker: Solar pond; Solar passive heating and cooling systems: Trombe wall; Greenhouse technology: Fundamentals, design, modeling and applications. | | |
| Unit IV | Solar Cell Physics | 7 |
| Solar Cell Physics , P-N junction: homo and hetro junctions, Metal-semiconductor interface; Dark and illumination characteristics; Figure of merits of solar cell; Efficiency limits; Variation of efficiency with band-gap and temperature; Efficiency measurements; High efficiency cells, Tandem structure. | | |
| Unit V | SPV systems | 7 |
| SPV Applications - Centralized and decentralized SPV systems; Stand alone, hybrid and, grid connected system, System installation, operation and maintenances; Field experience; PV market analysis and economics of SPV systems , Government Schemes and Polices | | |
| Text Books | 1. H.P. Garg, J. Prakash, Solar Energy: Fundamentals and Applications, Tata McGraw Hill,<br>2. S P Sukhatme, Solar Energy, Tata McGraw Hill | |
| Reference Books | 1. J.F. Kreider and Frank Kreith,Solar Energy Handbook, McGraw Hill<br>2. D.Y. Goswami, Frank Kreith and J F Kreider, Principles of Solar Engineering, Taylor and Francis | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4302**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to conceptual knowledge of the solar energy technology, economics and regulation related issues associated with solar power development and management. | 2 | Em |
| CO2 | Students should be able to concentrating collector designs of solar energy technology, solar power plant; solar furnaces. | 2 | Em |
| CO3 | Students should be able to solar heating and cooling system – of solar energy system. | 2 | S |
| CO4 | Students should be able to solar cell physics variation of efficiency with band-; high efficiency cells, tandem structure of the solar . | 2 | S |
| CO5 | Students should be able to develop a comprehensive technological understanding in solar pv system components. | 2 | S |

**CO-PO Mapping for ME4302**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PE O 2 | PE O 3 |
| CO 1 | 3 | 2 | 2 | 1 | 3 | 0 | 3 | 0 | 2 | 2 | 2 | 3 | 3 | 0 | 1 | 2 | 2 |
| CO 2 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 3 | 1 | 1 | 2 | 3 |
| CO 3 | 3 | 3 | 2 | 2 | 2 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 3 | 3 | 1 | 2 | 2 |
| CO 4 | 3 | 2 | 3 | 3 | 2 | 0 | 1 | 0 | 1 | 1 | 2 | 0 | 3 | 2 | 1 | 1 | 3 |
| CO 5 | 3 | 2 | 3 | 3 | 2 | 0 | 2 | 0 | 2 | 2 | 0 | 0 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2.2 | 2.2 | 2.2 | 2.2 | 0 | 1.8 | 0 | 1.6 | 1.4 | 1.3 | 1 | 3 | 2.2 | 1.2 | 2 | 2.6 |

| ME4304 | Title: Nuclear Engineering | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To learn nuclear fuel cycles, characteristics, principles governing nuclear fission chain reaction and fusion | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Nuclear reactions | 7 |
| Mechanism of nuclear fission - nuclides - radioactivity – decay chains - neutron reactions - the fission process - reactors - types of fast breeding reactor - design and construction of nuclear reactors - heat transfer techniques in nuclear reactors - reactor shielding | | |
| Unit II | Reactor Materials | 8 |
| Nuclear Fuel Cycles - characteristics of nuclear fuels - Uranium - production and purification of Uranium - conversion to UF4 and UF6 - other fuels like Zirconium, Thorium – Berylium. | | |
| Unit III | Reprocessing | 8 |
| Nuclear fuel cycles - spent fuel characteristics - role of solvent extraction in reprocessing - solvent extraction equipment. | | |
| Unit IV | Separation of reactor products | 7 |
| Processes to be considered - 'Fuel Element' dissolution - precipitation process – ion exchange - redox - purex - TTA - chelation -U235 - Hexone - TBP and thorax Processes - oxidative slaging and electro - refinng - Isotopes - principles of Isotope separation | | |
| Unit V | Waste disposal and radiation protection | 6 |
| Types of nuclear wastes - safety control and pollution control and abatement - international convention on safety aspects - radiation hazards prevention | | |
| Text Books | 1. Cacuci, Dan Gabriel, Nuclear Engineering Fundamentals , Springer<br>2. Collier J.G. and G.F. Hewitt, Introduction to Nuclear Power, Hemisphere Pub. | |
| Reference Books | 1. S. Glasstone and A. Sesonske, Nuclear Reactor Engineering, Von Nostrand<br>2. Kenneth D. Kok, Nuclear Engineering, CRC Press.<br>3. J. Kenneth Shultis, Richard E. Faw, Fundamentals of Nuclear Science and Engineering, CRC Press<br>4. Lamarsh J.R., Wesley, Introduction to Nuclear Reactor Theory, Amer Nuclear Society | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4304**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to mechanism of nuclear fission, - design and construction of nuclear reactors. | 2 | Em |
| CO2 | Students should be able basic knowledge of nuclear fuel cycles and reactor materials. | 2 | Em |
| CO3 | Students should be able to nuclear fuel cycles - spent fuel characteristics - solvent extraction equipment. | 2 | None |
| CO4 | Students should be able to basic knowledge of separation of reactor products, - principles of isotope- separation. | 2 | None |
| CO5 | Students should be able to understand the waste disposal and radiation protection, radiation hazards prevention | 2 | Em |

**CO-PO Mapping for ME4304**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 2 | 2 | 1 | 1 | 1 | 2 | 0 | 1 | 0 | 2 | 3 | 3 | 0 | 2 | 2 | 2 |
| CO 2 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 0 | 1 | 0 | 0 | 2 | 2 | 1 | 2 | 2 | 3 |
| CO 3 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 0 | 1 | 0 | 2 | 0 | 3 | 3 | 2 | 2 | 2 |
| CO 4 | 2 | 2 | 3 | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 2 | 0 | 2 | 2 | 2 | 1 | 3 |
| CO 5 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 3 | 2 | 2 | 3 | 3 |
| Avg | 2.6 | 2.2 | 2.3 | 1.8 | 1.6 | 1.2 | 1.8 | 0 | 1 | 0 | 1.3 | 1 | 2.6 | 2.2 | 2 | 2 | 2.6 |

| ME4303 | Title: Energy Storage Techniques | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | The objective of this course is to learn fundamentals of energy storage methods | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 7 |
| Introduction to energy storage, Need of Energy storage, Different modes of energy storage, Technology Types. Mechanical energy storage: flywheels, compressed air and pumped hydro electric storage- advantages and application | | |
| Unit II | Battery storage | 7 |
| Principle of operation Battery components and design Electrode, cell and battery fabrications Building block cells, battery modules and packs Li-polymer batteries, Li-ion batteries ,Advance Ni-MH batteries for transportation Future prospects of Ni-MH batteries vs. lithium ion batteries, Lead-acid battery | | |
| Unit III | Magnetic and Electric Storage | 7 |
| Supercapacitor energy storage, Advance battery-supercap hybrids for auto, space and marine applications Superconducting Magnetic Energy Storage-Advantages, disadvantages, applications | | |
| Unit IV | Fuel Cell and Hydrogen Storage | 7 |
| Advance fuel cells Introduction to fuel cells PEM and alkaline fuel cells for transportation Solid oxide fuel cells Hydrogen storage systems Solid state hydrogen storage tanks Gas phase hydrogen storage tanks Cryogenic hydrogen storage tanks Liquid phase hydrogen storage tanks Fuel reformers Advanced fuel reformers | | |
| Unit V | Thermal Storage | 8 |
| Thermal storage in buildings, Earth storage, Aquifers storage. Basics of Latent heat storage, Phase change materials (PCM) | | |
| Text Books | 1. Pendse, Energy Storage Science and Technology, SBS Publishers<br>2. Mullick, Garg and Vijay Bhargava, Solar Thermal Energy Storage, Springer | |
| Reference Books | 1. Detlef Stolten, Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications, Wiley<br>2. Jiujun Zhang, Lei Zhang, Electrochemical Technologies for Energy Storage and Conversion, John Wiley and Sons.<br>3. Batteries for Renewable Energy Storage, The Electrochemical Society, New Jersy<br>4. H.A Kiehne, Battery Technology Handbook, CRC Press book | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4303**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should able to understand the energy storage systems | 2 | S,Em |
| CO2 | Students should able to understand the working of battery storage systems | 2 | S |
| CO3 | Students should able to understand the working of magnetic and electric storage systems | 2 | S |
| CO4 | Students should able to understand the working of fuel cell and hydrogen storage systems | 2 | S |
| CO5 | Students should able to understand the thermal storage systems | 2 | S,Em |

**CO-PO Mapping for ME4303**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PE O 2 | PE O 3 |
| CO 1 | 3 | 2 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 2 | 2 | 1 |
| CO 2 | 3 | 2 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 3 | 1 | 1 |
| CO 3 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 2 | 2 | 1 |
| CO 4 | 3 | 2 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 2 | 1 | 1 |
| CO 5 | 3 | 2 | 1 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 2 | 1 | 1 |
| Avg | 3 | 2 | 1 | 1 | 1 | 0.8 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 2.2 | 1.4 | 1 |

| ME4305 | Title: Energy Management in Thermal System | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To learn the instruments suitable for energy auditing and to study the various measures for energy conservation and financial implications for various thermal utilities. | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Introduction | 8 |
| Energy Scenario, world and India. Energy Resources Availability in India. Energy consumption pattern. Energy conservation potential in various Industries and commercial establishments. Energy intensive industries, an overview. Energy conservation and energy efficiency, needs and advantages. Energy auditing, types, methodologies, barriers. Role of energy manager, Energy audit questionnaire, energy Conservation Act 2003. | | |
| Unit II | Instruments for Energy Auditing | 8 |
| Instrument characteristics, sensitivity, readability, accuracy, precision, hystersis. Error and calibration. Measurement of flow, velocity, pressure, temperature, speed, Lux, power and humidity. Analysis of stack, water quality, power and fuel quality. | | |
| Unit III | Thermal Utilities: Operation and Energy Conservation | 6 |
| Boilers, Thermic Fluid Heaters, Furnaces, Waste Heat Recovery Systems, Thermal Storage. | | |
| Unit IV | Thermal Energy Transmission | 6 |
| Steam traps, refractories, optimum insulation thickness, Insulation , piping design. | | |
| Unit V | Financial Management | 8 |
| Investment , need, appraisal and criteria, financial analysis techniques , break even analysis , simple pay back period, return on investment, net present value, internal rate of return, cash flows, DSCR, financing options, ESCO concept. | | |
| Text Books | 1. C.B. Smith, Energy Management Principles, Pergamon Press, NewYork, | |
| Reference Books | 1. PR Trivedi, KR Jolka, Energy Management, Commonwealth Publication<br>2. Write, Larry C, Industrial Energy Management and Utilization, Hemisphere Publishers, Washington<br>3. Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case Study, Washington | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4305**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to the course is intended to introduce principles of energy auditing and to provide measures for energy conservation in thermal applications | 2 | S,Em |
| CO2 | Students should be able to design suitable energy monitoring system to analyz and optimize the energy consumption in an organization. | 3 | S |
| CO3 | Students should be able to improve the thermal efficieny by designing suitable systems for heat recovery and co-generation. | 3 | S |
| CO4 | Students should be able to guide the employees of the organization about the need and the methods of energy conservation. | 2 | S |
| CO5 | Students will be able to carry out the cost- benefit analysis of various investment alternatives for meeting the energy needs of the organization. | 3 | S,Em |

**CO-PO Mapping for ME4305**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PE O 2 | PE O 3 |
| CO 1 | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 0 | 2 | 2 | 2 | 3 | 3 | 1 | 2 | 2 | 2 |
| CO 2 | 3 | 2 | 1 | 2 | 0 | 2 | 0 | 0 | 1 | 2 | 0 | 2 | 3 | 1 | 1 | 2 | 3 |
| CO 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 0 | 2 | 1 | 3 | 3 | 2 | 2 | 2 |
| CO 4 | 3 | 2 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 2 | 1 | 3 |
| CO 5 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 0 | 1 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2.2 | 2.2 | 2.2 | 2.2 | 1.8 | 1.8 | 0.6 | 1.6 | 1.4 | 1.3 | 1.6 | 3 | 1.8 | 1.8 | 2 | 2.4 |

| ME 4309 | Title: Air-Conditioning System Design | L T P C<br>3 0 0 3 |
|---|---|---|
| Version No. | 1.0 | |
| Course Prerequisites | Nil | |
| Objectives | To provide the concepts of thermal distribution technique through a air conditioning system and its various types and advantages | |
| Unit No. | Unit Title | No. of hours (per Unit) |
| Unit I | Estimation of Solar Radiation | 6 |
| Cooling And Heating Load Calculation – I: Introduction, solar radiation, constant and irradiation geometry and various related basic and derived angle ,angle of incident for horizontal, vertical and tilted surfaces, calculation of direct, diffuse and reflected radiation using ASHRAE solar radiation model including effect of clouds. | | |
| Unit II | Solar Radiation fenestration, ventilation and infiltration | 8 |
| Cooling And Heating Load Calculation – II: Fenestration, need, effect on air conditioning systems, estimation, concepts, SHGF, shading coefficient, external shading, calculation of shaded area, windows with overhang, infiltration and ventilation, causes, estimation of heat transfer rate. | | |
| Unit III | Heat Transfer through building, fabric heat gain/loss | 8 |
| Cooling And Heating Load Calculation – III: Heat transfer through buildings, 1-D, steady state and unsteady state heat transfer through homogeneous, non homogeneous walls, air spaces, composite walls, opaque walls, roofs. The analytical and in brief numerical methods used to solve the 1-D transient heat transfer problem, semi-emperical methods, physical significance of decrement and time lag factor, typical tables of CLTD for walls and roofs. | | |
| Unit IV | Selection Of Air Conditioning Systems | 6 |
| Introduction to thermal distribution systems, there functions, selection criteria and there classification of air conditioning systems, working principal, advantages, disadvantages and its application for various air/water flow systems. | | |
| Unit V | Transmission of Air in Air Conditioning Ducts | 8 |
| Describe an air handling unit(AHU) its functions, need for studying transmission , air flow through ducts, Bernoulli and modified Bernoulli equation, static, dynamic, datum and total head, fan total pressure(FTP) and power input to fan, estimation of pressure loss through ducts, estimation of dynamic pressure drop in various types of heatings. | | |
| Text Books | 1. Stoecker W.F ,Refrigeration and air conditioning, McGraw Hill<br>2. C.P. Arora ,Refrigeration and air conditioning, Tata McGraw Hill. | |
| Reference Books | 1. Ahmad ul Ameen ,Refrigeration and air conditioning, PHI publication.<br>2. Shan K. Wang ,Handbook of air conditioning and Refrigeration,Tata McGraw Hill | |
| Mode of Evaluation | Internal and External Examinations | |
| Recommendation by Board of Studies on | 06.06.2019 | |
| Date of approval by the Academic Council | 13.07.2019 | |

**Course Outcome For ME4309**

| Unit-wise Course Outcome | Descriptions | BL Level | Employability (Em)/ Skill(S)/ Entrepreneurship (En)/ None (*Use , for more than One*) |
|---|---|---|---|
| CO1 | Students should be able to estimate the solar radiation. | 3 | S |
| CO2 | Students should be able to learn about the Solar Radiation fenestration, ventilation and infiltration. | 2 | S |
| CO3 | Students should be able to learn about the Heat Transfer through building, fabric heat gain/loss. | 3 | S |
| CO4 | Students should be able to sense about the Selection of Air Conditioning Systems | 2 | S |
| CO5 | Students should be able to differentiate about the Transmission of Air in Air Conditioning Ducts | 2 | S,Em |

**CO-PO Mapping for ME4309**

| Course Outcomes | Program Outcomes (Course Articulation Matrix (Highly Mapped-3, Moderate- 2, Low-1, Not related-0 ) | | | | | | | | | | | | Program Specific Outcomes | | Program Educational Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PEO 1 | PEO 2 | PEO 3 |
| CO 1 | 3 | 2 | 2 | 1 | 3 | 0 | 3 | 0 | 2 | 2 | 2 | 2 | 3 | 0 | 1 | 2 | 2 |
| CO 2 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 3 | 1 | 1 | 2 | 3 |
| CO 3 | 3 | 3 | 2 | 2 | 2 | 0 | 2 | 0 | 1 | 0 | 2 | 1 | 3 | 3 | 1 | 2 | 2 |
| CO 4 | 3 | 2 | 3 | 3 | 2 | 0 | 1 | 0 | 1 | 1 | 2 | 1 | 3 | 2 | 1 | 1 | 3 |
| CO 5 | 3 | 2 | 3 | 3 | 2 | 0 | 2 | 0 | 2 | 2 | 0 | 1 | 3 | 2 | 2 | 3 | 3 |
| Avg | 3 | 2.2 | 2.2 | 2.2 | 2.2 | 0 | 1.8 | 0 | 1.6 | 1.4 | 1.3 | 1.4 | 3 | 2.2 | 1.2 | 2 | 2.6 |