MAR ATHANASIUS COLLEGE OF ENGINEERING

(Government Aided and Autonomous)

Kothamangalam-686666

Affiliated to APJ Abdul Kalam Technological University

Thiruvananthapuram

KNOWLEDGE IS POWER

Master of Technology (M. Tech)

Curriculum - 2024

COLLEGE VISION AND MISSION

VISION

Excellence in education through resource integration.

MISSION

The institution is committed to transform itself into a centre of excellence in Technical Education upholding the motto "Knowledge is Power."
This is to be achieved by imparting quality education to mould technically competent professionals with moral integrity, ethical values and social commitment, and by promoting innovative activities in the thrust areas emerging from time to time.

MAR ATHANASIUS COLLEGE OF ENGINEERING

(GOVT. AIDED & AUTONOMOUS)

M.TECH CURRICULUM AND SCHEME-2024

Department of Mechanical Engineering

(Thermal Power Engineering)

PROGRAM OUTCOMES – PO

Outcomes are the attributes that are to be demonstrated by a graduate after completing the programme

PO1: An ability to independently carry out research/investigation and development work in engineering and allied streams

PO2: An ability to communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.

PO3: An ability to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: An ability to apply stream knowledge to design or develop solutions for real world problems by following the standards

PO5: An ability to identify, select and apply appropriate techniques, resources and state-of-the-art tool to model, analyse and solve practical engineering problems.

PO6: An ability to engage in life-long learning for the design and development of the stream related problems taking into consideration sustainability, societal, ethical and environmental aspects. Also to develop cognitive skills for project management and finance which focus on Industry and Entrepreneurship.

The departments conducting the M.Tech programme shall define their own PSOs, if required, and evaluation shall also be done for the same.

SEMESTER I

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
A	M24ME2T101	Numerical Methods for Engineers	40	60	4-0-0-4	4	4
B	M24ME2T102	Advanced Heat Transfer	40	60	4-0-0-4	4	4
C	M24ME2T103	Advanced Fluid Mechanics	40	60	4-0-0-4	4	4
D	M24ME2E104	Programme Elective 1	40	60	3-0-0-3	3	3
E	M24ME2E105	Programme Elective 2	40	60	3-0-0-3	3	3
J	M24ME2R106	Research Methodology & IPR	40	60	2-0-0-2	2	2
G	M24ME2L107	Thermal Power Systems Lab	60	40	0-0-3-3	3	2
Total			300	400		23	22

Teaching Assistance: 7 hours

Self-study- 23 Hrs

Programme Elective 1

Slot	Course Code	Course	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
D	M24ME2E104A	Renewable Energy Systems	40	60	3-0-0-3	3	3
D	M24ME2E104B	Measurement Methods in Thermal Engineering	40	60	3-0-0-3	3	3
D	M24ME2E104C	Energy Management and Audit	40	60	3-0-0-3	3	3

Programme Elective 2

Slot	Course Code	Course	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
E	M24ME2E105A	Industrial Refrigeration	40	60	3-0-0-3	3	3
E	M24ME2E105B	Hydrogen and Fuel Cell Technologies	40	60	3-0-0-3	3	3
E	M24ME2E105C	Advanced Thermodynamics	40	60	3-0-0-3	3	3

SEMESTER II

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
A	M24ME2T201	Computational Fluid Dynamics	40	60	4-0-0-4	4	4
B	M24ME2T202	Gas Turbine and Jet Propulsion	40	60	4-0-0-4	4	4
C	M24ME2E203	Programme Elective 3	40	60	3-0-0-3	3	3
D	M24ME2E204	Programme Elective 4	40	60	3-0-0-3	3	3
E	M24ME2S205	Modelling and simulation of Thermal System.	40	60	3-0-0-3	3	3
G	M24ME2P206	Mini project	60	40	0-0-3-3	3	2
H	M24ME2L207	Computational Fluid Dynamics Lab	60	40	0-0-3-3	3	2
TOTAL			320	380		23	21

Teaching Assistance: 7 hours
Self-study- 23 Hrs

Programme Elective 3

Slot	Course Code	Course	Marks		L-T-P-S	Hours	Credit
			CIA	**ESE**			
C	M24ME2E203A	Alternative Fuels for IC Engines	40	60	3-0-0-3	3	3
C	M24ME2E203B	Thermal Power plant Design	40	60	3-0-0-3	3	3
C	M24ME2E203C	Design of Heat Transfer Equipments	40	60	3-0-0-3	3	3

Programme Elective 4

Slot	**Course Code**	**Course**	**Marks**		**L-T-P-S**	**Hours**	**Credit**
			CIA	**ESE**			
D	M24ME2E204A	Solar Thermal Energy Systems	40	60	3-0-0-3	3	3
D	M24ME2E204B	Combustion and Emissions in IC Engines	40	60	3-0-0-3	3	3
D	M24ME2E204C	HVAC System Design	40	60	3-0-0-3	3	3

SEMESTER III

TRACK 1							
Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
A	M24ME2M301	*MOOC	To be completed successfully		--	--	2
B	M24ME2E302	Programme Elective 5	40	60	3-0-0-3	3	3
K	M24ME2I303	**Internship	50	50	--	--	3
P	M24ME2P304	Dissertation Phase 1	100	--	0-0-16-16	16	11
TOTAL			190	110		19	19
TRACK 2							
A	M24ME2M305	* MOOC 1	To be completed successfully		--	--	2
B	M24ME2M306	* MOOC 2	To be completed successfully		-	-	2
K	M24ME2I307	## Internship	50	50	--	-	4
P	M24ME2P308	###Dissertation Phase 1	100	--	-	-	11
TOTAL			150	50			19

Teaching Assistance:7 hours

Programme Elective 5

Slot	**Course Code**	**Course**	**Marks**		**L-T-P-S**	**Hours**	**Credit**
			CIE	**ESE**			
B	M24ME2E302A	Industrial Safety	40	60	3-0-0-3	3	3
B	M24ME2E302B	Thermal Management in Electric Vehicle Systems	40	60	3-0-0-3	3	3
B	M24ME2E302C	Design and Optimization of Thermal Systems	40	60	3-0-0-3	3	3

*MOOC Course of minimum 8 weeks duration to be successfully completed before the end of

fourth semester (starting from semester 1).

**Internship- mandatory internship of 6 to 8 weeks

Internship - mandatory internship of more than 16 weeks

###Dissertation Phase 1 – Should be done in Industry

TRACK 1 / TRACK 2

In second year, the students can choose either of the two tracks: TRACK 1 or TRACK 2. Track 1 is conventional M.Tech programme in which the dissertation Phase 1 is conducted in college. Track 2 is M.Tech programme designed for students who undergone long term internship (not less than 16 weeks) in industry. An aspirant in track 2 needs to do the dissertation in the industry. The candidates should also be good with performing in-depth research and colluding the conclusions of research led by them. Such students are expected to have the following skills: Technical Skills, Research Skills, Communication Skills, Critical Thinking Skills, and Problem Solving Skills.

The eligibility for Track 2:

Shall have qualified in the GATE or have a SGPA above 8.0 during the first semester, and

Qualify an interview during the end of second semester by an expert committee constituted by the College.

SEMESTER IV

TRACK 1							
Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
P	M24ME2P401	Dissertation Phase II	100	100	0-0-27-24	27	18
TOTAL			**100**	**100**		**27**	**18**
TRACK 2							
P	M24ME2P402	##Dissertation Phase II	100	100			18
TOTAL			**100**	**100**			**18**
Total credits in all four semesters							**80**

##Dissertation Phase II- Should be done in Industry

COURSE NUMBERING SCHEME

The course number consists of digits/alphabets. The pattern to be followed is

The course number consists of digits/alphabets. The pattern to be followed is

For General Courses - MYYBBXCSNN
For Elective Courses - MYYBBXCSNNA

- M: MASTERS
- YY: Last two digits of year of regulation
- BB: DEPARTMENT

Sl.No	Department	Course Prefix
01	Civil Engg	CE
02	Computer Science	CS
03	Electrical & Electronics	EE
04	Electronics & Communication	EC

05	Mechanical Engg	ME
06	Any	GE
07	External (Industry/NPTEL etc)	EX

- X :Specialization number
- C: Course Type

  T- Core Course

  E- Elective Course

  R- Research Methodology & IPR

  L- Laboratory Course

  S- Industry Integrated Course

  I- Internship

  M- MOOC

  P- Project/Dissertation
- S : Semester of Study
  1. Semester 1
  2. Semester 2
  3. Semester 3
  4. Semester 4
- NN: Course sequence number
- A : Elective sequence number - A/B/C/D/E

It is illustrated below: Examples:

M24CE1T202 is a second core course of first specialization offered by the Civil Department in semester 2

M24EC1R106 is Research Methodology & IPR offered in semester 1

M24EC1E104A is the first subject of Elective 1 of first specialization offered by the EC Department in semester 1.

EVALUATION PATTERN

(i) CORE COURSES

Evaluation shall only be based on application, analysis or design based questions(for both internal and end semester examinations).

Continuous Internal Evaluation (CIE) : 40 marks

Micro project/Course based project :10 marks

Course based task/Seminar/Quiz :10 marks

Test paper 1 (Module 1 and Module 2) :10 marks

Test paper 2 (Module 3 and Module 4) :10 marks

The project shall be done individually (Preferable).

End Semester Examination (ESE) : 60marks

The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

(ii) ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design based questions(for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Seminar*	:	10 marks
Course based task/Micro Project//Data collection and interpretation/Case study	:	10 marks
Test paper 1 (Module 1 and Module 2)	:	10 marks
Test paper 2 (Module 3 and Module 4)	:	10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

End Semester Examination: 60 marks

The end semester examination will be conducted by the College. Therewill be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 4 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questionsshall be useful in the testing of overall achievement and maturity of the students in acourse, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one questionfrom each module of which student should answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

(iii) RESEARCH METHODOLOGY & IPR

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications in the relevant discipline (minimum 10 publications shall be referred) : 10 marks

Course based task/Seminar/Quiz : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

End Semester Examination : 60 marks

The end semester examination should be conducted by the college. The time duration will be for 3 Hrs and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

(iv) INTERNSHIP

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined timescales. An internship may be compensated or non-compensated by the organization providing the internship. The internship has to be meaningful and mutually beneficial to the intern and the organization. It is important that the objectives and the activities of the internship program are clearly defined and understood. The internship offers the students an opportunity to gain hands-on industrial or organizational exposure; to integrate the knowledge and skills acquired through the coursework; interact with professionals and other interns; and to improve their presentation, writing, and communication skills. Internship often acts as a gateway for final placement for many students.

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme

Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialization after the second semester for a minimum duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

Objectives

- Exposure to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

Benefits of Internship

Benefits to Students

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- Helps them decide if the industry and the profession is the best career optionto pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an

industrial setup.

- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a full time position.

Benefits to the Institute

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/ students.
- Improvement in teaching learning process.

Benefits to the Industry

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.
- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-

termemployer commitment.

- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

Types of Internships

- Industry Internship with/without Stipend
- Govt / PSU Internship (BARC/Railway/ISRO etc)
- Internship with prominent education/research Institutes
- Internship with Incubation centres /Start-ups

Guidelines

- All the students need to go for internship for minimum duration of 6 to 8 weeks.
- Students can take mini projects, assignments, case studies by discussing itwith concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any otherdocument from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid bythe industry.
- Student should contact his /her Guide/Supervisor from college on weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
    - Report of work done
    - Internship certificate copy

- Feedback from employer / internship mentor
- Stipend proof (in case of paid internship).

Total Marks 100: The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Students diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

Continuous Internal Evaluation: 50 marks

Student's diary	- 25 Marks
Evaluation done by the Industry	- 25 Marks

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

The format of student's diary

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From .... To ....

Brief description about the nature of internship:

Day	Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc.
1	
2	
3	

Signature of Industry Supervisor *Signature of Section Head/HR Manager Office Seal*

Attendance Sheet

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From .... To ....

Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	...
Month & Year																					
Month & Year																					

Signature of Industry Supervisor   *Signature of Section Head/HR Manager*

Office Seal

Note:

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. Absent should be marked as 'A' in red ink.

Evaluation done by the Industry (Marks 25)

Format for Supervisor Evaluation of Intern

Student Name :___________________Date:___________________ Supervisor Name :__________________________Designation:_____________

Company/Organization :____________________________________

Internship Address: ____ Dates of Internship: From__________________To ______________________

Please evaluate intern by indicating the frequency with which you observed the following parameters:

Parameters Marks	Needs improvement (0 – 0.25 mark)	Satisfactory(0.25 – 0.50 mark)	Good (0.75 mark)	Excellent(1 mark)
Behavior				
Performs in a dependable Manner				
Cooperates with coworkers and supervisor				
Shows interest in work				
Learns quickly				
Shows initiative				
Produces high quality work				
Accepts responsibility				
Accepts criticism				
Demonstrates organizational skills				
Uses technical knowledge and expertise				
Shows good judgment				
Demonstrates creativity/originality				
Analyzes problems effectively				
Is self-reliant				

Communicates well				
Writes effectively				
Has a professional attitude				
Gives a professional appearance				
Is punctual				
Uses time effectively				

Overall performance of student

Intern (Tick one) : Needs improvement (0 - 0.50 mark) / Satisfactory (0.50 – 1.0 mark) / Good (1.5 mark) / Excellent (2.0 mark)

Additional comments, if any (2 marks) :

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Office Seal

End Semester Evaluation (External Evaluation): 50 Marks

Internship Report - 25 Marks

Viva Voce - 25 Marks

Internship Report: After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up

- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taughtin the course

Viva Voce (25 Marks) will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

(v) LABORATORY COURSES

Lab work and Viva-voce	: 60 marks
Final evaluation Test and Viva voce	: 40 marks

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final evaluation shall be done by two examiners; one examiner will be a senior faculty from the same department.

(vi) INDUSTRY INTEGRATED COURSE

Engineering students frequently aspire to work in areas and domains that are key topics in the industry. There are concerns by recruiters that skill sets of engineering students did not match with the Industry requirements, especially in the field of latest topics. In response to their desires, the College has incorporated Industry integrated course in the curriculum.

The evaluation pattern for Industry based electives is as follows:

Continuous Internal Evaluation: 40 marks

Seminar	:	10 marks
Course based task/Seminar/Data collection and interpretation/Case study	:	10marks
Test paper 1 (Module 1 and Module 2)	:	10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

End Semester Examination: 60 marks

The examination will be conducted by the College with the question paper provided by the Industry. The examination will be for 3 Hrs and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks. The valuation of the answer scripts shall be done by the expert in the Industry handling the course.

(vii) MOOC COURSES

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semester examination. The students can do the MOOC according to their convenience, but shall complete it before the end of fourth semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/elective course in the concerned discipline or with an open elective.

MOOC Course to be successfully completed before the end of fourth semester (starting from semester 1). A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

(viii) MINIPROJECT

Total marks: 100

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem-solving skills. The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Interim evaluation: 60 (30 marks for each review), final evaluation by a Committee (will be evaluating the level of completion and demonstration of functionality/specifications, clarity of presentation, oral examination, work knowledge and involvement): 25, Report (the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level is not more than 25%): 10, Supervisor/Guide: 5

(ix) DISSERTATION

Dissertation: All Students should carry out the dissertation in the college or can work either in any CSIR/Industrial R&D organization/any other reputed Institute which have facilities for dissertation work in the area proposed.

Dissertation outside the Institute: For doing dissertation outside the Institution, the following conditions are to be met:

- They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
- They should choose Track 2 in semester 3 and 4
- The student has to get prior approval from the DLAC and CLAC.
- Facilities required for doing the dissertation shall be available in the Organization/Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/Industry shall be submitted by the student along with the application).
- They should have an external as well as an internal supervisor. The internal

supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the Institution/Industry/ R&D organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degreein the related area.

- The student has to furnish his /her monthly progress as well as attendance report signed by the external guide and submit the same to the concerned Internal guide.
- The external guide is to be preferably present during all the stages of evaluation of the dissertation.

Note1- Students availing this facility should continue as regular students of the College itself.

Note 2-The course work in the 3rd semester is to be completed as per the curriculum requirements (i) MOOC can be completed as per the norms mentioned earlier

Internship leading to Dissertation: The M. Tech students who after completionof 6 to 8 weeks internship at some reputed organization are allowed to continue theirwork as dissertation for the third and fourth semester after getting approval from theDLAC. Such students shall make a brief presentation regarding the work they propose to carry out before the DLAC for a detailed scrutiny and to resolve its suitability for accepting it as an M.Tech dissertation. These students will be continuing as regular students of the Institute in third semester for carrying out all academic requirements as per the curriculum/regulation. However, they will be permitted to complete their dissertation in the Industry/Organization (where they have successfully completed their internship) during fourth semester.

Dissertation as part of Employment: Students may be permitted to discontinue the programme and take up a job provided they have completed all the courses till second semester (FE status students are not permitted) prescribed in the approved curriculum. The dissertation work can be done during a later period either in the organization where they work if it has R & D facility, or in the Institute. Such students should submit application with details (copy of employment offer, plan of completion of their project etc.) to the Dean (PG) through HoD. The application shall be vetted by CLAC before granting the approval. When the students are planning to do the dissertation work in the organization with R & D facility where they are employed, they shall submit a separate application having following details:

- Name of R&D Organization/Industry
- Name and designation of an external supervisor from the proposed Organization/Industry (Scientists or Engineers with a minimum post graduate degree in the related area) and his/her profile with consent
- Name and designation of a faculty member of the Institute as internal supervisor with his/her consent
- Letter from the competent authority from the Organization/Industry granting permission to do the dissertation
- Details of the proposed work
- Work plan of completion of project

DLAC will scrutinize the proposal and forward to CLAC for approval.

When students are doing dissertation work along with the job in the organization (with R & D facility) where they are employed, the dissertation work shall be completed in four semesters normally (two semesters of dissertation work along with the job may be considered as equivalent to one semester of dissertation work at the Institute). Extensions may be granted based on requests from the student and recommendation of the supervisors such that he/she will complete the M. Tech programme within four years from the date of admission as per the regulation. Method of evaluation and grading of the dissertation will be the same as in the case of regular students. The course work in the 3rd semester for such students are to be completed as per the curriculum requirements (i) MOOC can be completed as per the norms mentioned earlier. However, for self-learning students, all evaluations shall be carried out in their parent Institution as in the case of regular students.

Mark Distribution:

Phase 1: Total marks: 100, only CIE

Phase 2: Total marks: 200, CIE = 100 and ESE = 100 marks

- Maximum grade (S grade) for the dissertation phase II will be awarded preferably if the student publishes the dissertation work in a peer reviewed journal.
- Final Evaluation (ESE) should be done by a three-member committee comprising of the Department Project coordinator, Guide and an External expert. The external expert shall be an academician or from industry.

(x) TEACHING ASSISTANCESHIP (TA)

All M.Tech students irrespective of their category of admission, shall undertake TA duties for a minimum duration as per the curriculum. Being a TA, the student will get an excellent opportunity to improve their expertise in the technical content of the course, enhance communication skills, obtain a hands-on experience in handling the experiments in the laboratory and improve peer interactions.

The possible TA responsibilities include the following: facilitate a discussion section or tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve as a mentor for students, and act as the course web-master. TAs maybe required to attend the instructor's lecture regularly. A TA shall not be employed asa substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities.

For the tutorial session:

(i) Meet the teacher and understand your responsibilities well in advance, attend the lectures of the course for which you are a tutor, work out the solutions for allthe tutorial problems yourself, approach the teacher if you find any discrepancyor if you need help in solving the tutorial problems, use reference text books, be innovative and express everything in English only.

(ii) Try to lead the students to the correct solutions by providing appropriate hints rather than solving the entire problem yourself, encourage questions from the students, lead the group to a discussion based on their questions, plan to ask them some questions be friendly and open with the students, simultaneously being firm with them.

(iii) Keep track of the progress of each student in your group, give a periodic feedback to the student about his/her progress, issue warnings if the student is consistently under-performing, report to the faculty if you find that a particular student is consistently underperforming, pay special attention to slow-learners and be open to the feedback and comments from the students and faculty.

(iv) After the tutorial session you may be required to grade the tutorials/assignments/tests. Make sure that you work out the solutions to the questions yourself, and compare it with the answer key, think and work out possible alternate solutions to the same question, understand the marking scheme from the teacher. Consult the teacher and make sure that you are not partial to some student/students while grading. Follow basic ethics.

Handling a laboratory Session:

(i) Meet the faculty – in- charge a few days in advance of the actual lab class andget the details of the experiment, get clarifications from him/her regarding all aspects of the experiment and the expectations, prepare by reading about the theoretical background of the experiment, know the physical concepts involved in the experiment, go to the laboratory and check out the condition of the equipment/instrumentation, perform the laboratory experiment at least once oneor two days before the actual laboratory class, familiarize with safety/ security aspects of the experiment / equipment/laboratory, prepare an instruction sheetfor the experiment in consultation with the faculty, and keep sufficient copies ready for distribution to students for their reference.

(ii) Verify condition of the equipment/set up about 30 minutes before the students arrive in the class and be ready with the hand outs, make brief introductory remarks about the experiment, its importance, its relevance to the theory they have studied in the class, ask the students suitable questions to know there level of preparation for the experiment, discuss how to interpret results, ask them comment on the results.

(iii) Correct/evaluate/grade the submitted reports after receiving suitable instructions from the faculty in charge, continue to interact with students if theyhave any clarifications regarding any aspect of the laboratory session, includingof course grading, Carefully observe instrument and human safety in laboratory class, Preparing simple questions for short oral quizzing during explanation of experiments enables active participation of students, facilitate attention, provides feedback and formative evaluation.

POINTS TO REMEMBER

1. Arrange an awareness programme to all M.Tech students on day 1 regarding the curriculum and the regulation.
2. The departments should prepare the list of MOOC courses suitable to their programmes and encourage the students to complete at the earliest.
3. Make a tie up with industries by the middle of semester for Industry Integrated Course. While choosing the course, it should be ensured that the programme is relevant and updated in that discipline. The Industry expert handling the course shall be a postgraduate degree holder. The evaluation procedure shall also be clearly explained to them.
4. Each department offering M.Tech programme should be careful in selecting the mini project in semester 2.
5. The departments should invite the Industries/research organizations during first semester and inform them about the mandatory 6-8 weeks internship that the students should undergo after their second semester. The possibility of doing their dissertation at the Industry shall also be explored. They shouldalso be made aware about the evaluation procedure of the Internships. Theymay also be informed that it is possible to continue internship provided if it leads to their dissertation. Proposals may be collected from them for allotting to students according to their fields of interest.
6. Make sure that all internal evaluations and the end semester examinationsto be conducted by the college are carried out as per the evaluation procedure listed in the curriculum. Any dilution from the prescribed procedure shall be viewed seriously.
7. Teaching assistance shall be assigned to all students as per the curriculum. However, a TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities.
8. The possible TA responsibilities include the following: facilitate a discussion

section or tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve as a mentor for students, and act as the course web-master.

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MAR ATHANASIUS COLLEGE OF ENGINEERING

(Government Aided & Autonomous)

Kothamangalam 686 666

Affiliated to APJ Abdul Kalam Technological University

Thiruvananthapuram

Master of Technology (M. Tech.)

Thermal Power Engineering

Syllabus - 2024

COLLEGE VISION AND MISSION

VISION

Excellence in education through resource integration.

MISSION

The institution is committed to transform itself into a centre of excellence in Technical Education upholding the motto "Knowledge is Power."

This is to be achieved by imparting quality education to mould technically competent professionals with moral integrity, ethical values and social commitment, and by promoting innovative activities in the thrust areas emerging from time to time.

Semester 1

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2T101	Numerical Methods for Engineers	Core	4	0	0	4	4

Preamble: Mechanical engineers rely heavily on numerical simulations as their primary tool for addressing challenges in thermo-fluid systems. The utilization of advanced computational methods is integral to this process. This course aims to familiarize participants with the sophisticated numerical techniques essential for solving problems in mechanical engineering.

Prerequisite: A foundation course in linear algebra, differential equations and computer programming

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Acquire skills necessary for formulating and solving engineering problems through computational methods, illustrated through case studies and computer programming	Apply
CO 2	Proficiently utilize curve fitting techniques for practical situations.	Apply
CO 3	Apply computational techniques of numerical differentiation and integration for real life situations and implement through computer programming	Apply
CO 4	Apply numerical methods for solving ordinary differential equations and Eigen values by practical case studies and implementation through computer programs	Apply
CO 5	Analyze different interpolation techniques, alongside the solution of partial differential equations using difference equations for real life situations and implement through computer programming	Analyse

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2		2	2	2	1
CO 2	1		2	2	2	1
CO 3	1		2	2	2	1
CO 4	1		2	2	2	1
CO 5	1		2	2	2	1

Assessment Pattern

Course name	Numerical Methods for Engineers		
Bloom's Category	**Continuous Assessment Tests**		**End SemesterExamination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	20	20	20
Apply	60	60	60
Analyze	20	20	20
Evaluate	XX	XX	XX
Create	XX	XX	XX

Mark distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project : 10 marks

Course based task/Seminar/Quiz : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (9 Hours)

Introduction to Computational methods, system of equations-Revision - Formulation of engineering problems and solution using computational methods; significant figures, accuracy, precision, round off error, truncation error, Taylor series expansion of a polynomial. Roots of equation - Bisection, Newton-Raphson, and Bairstow methods. Linear algebraic equations - Gauss Elimination method, LU decomposition. Non- linear equation- Gauss-Jordan method, Newton- Raphson for simultaneous equations. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

MODULE 2 (9 Hours)

Curve fitting- Linear regression- linearization of nonlinear relation, linear least squares, multiple linear regression. Nonlinear regression- polynomial regression, Gauss- Newton method. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

MODULE 3 (9 Hours)

Numerical differentiation and integration- Derivatives- Newton's forward, backward, divided difference and Sterling formula. Integration -Trapezoidal rule, Simpsons one third, Simpsons three eighth, Gauss quadrature-two & three points. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

MODULE 4 (9 Hours)

Numerical solutions to ordinary differential equations- Taylor's method, Eulers method, Runge-Kutta method fourth order, simultaneous first order, Milne's predictor corrector. Initial value problem - shooting method, Eigen values - polynomial method, power method. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

MODULE 5 (9 Hours)

Solution of partial differential equation & Interpolation- Interpolation - Newtons forward and backward, divided difference linear & quadratic, Lagrange interpolation, cubic splines, Hermites interpolation. Solution of partial differential equation - Difference equations, Elliptic equation- Laplace equation, Poisson equation, Liebmann's iterative methods, Parabolic equation- Bender-Schmidt method, simple implicit, Crank- Nicolson scheme, Solution of hyperbolic equation. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Reference Books

1. Steven C. Chapra, Raymond P Canale, "Numerical Methods for Engineering", 8e, Mc-Graw Hill Education (2020)
2. Gilbert Strang, "Computational Science and Engineering", Wellesley- Cambridge Press (2007)
3. Joe D Hoffman, "Numerical Methods for Engineers and Scientists", Second Edition, Marcel Dekker (2001)
4. S. P. Venkateshan, Prasanna Swaminathan, "Computational Methods in Engineering", Ane Books (2014)
5. VN Vedamurthy & SN Iyengar, "Numerical Methods", S Chand & Co Ltd (2014)
6. P. Kandasamy, K. Thilagavathy and K. Gunavathy., "Numerical Methods", S Chand & Co Ltd (2016)
7. B.S. Grewal, "Numerical Methods in Engineering Science with Programs in C, C++ and MATLAB", (10th edition) Khanna Publisher (2020)
8. AK Jaiswal and Anju Khandelwal, "Computer Based Numerical and Statistical Techniques", New Age International (2009)

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module -1 (9 Hours)	
1.1	**Introduction to Computational methods, system of equations -** Revision - Formulation of engineering problems and solution using computational methods; significant figures, accuracy, precision, round off error, truncation error, Taylor series expansion of a polynomial	2
1.2	Roots of equation - Bisection, Newton Raphson, and Bairstow methods	2
1.3	Linear algebraic equations - Gauss Elimination method, LU decomposition. Non- linear equation- Gauss-Jordan method, Newton- Raphson for simultaneous equations	3
1.4	Case studies with computer programs (Python/Scilab/ C++/ Fortran/ other) (Not for End Semester Examination)	2
	Module -2 (9 Hours)	

2.1	**Curve Fitting -** Linear regression- linearization of non-linear relation, linear least squares, multiple linear regression	3
2.2	Non-linear regression- polynomial regression, Gauss- Newton method	4
2.3	Case studies with computer programs (Python/Scilab/C++/ Fortran/ other) (Not for End Semester Examination)	2
Module -3 (9 Hours)		
3.1	**Numerical differentiation and integration -** Derivatives - Newton's forward, backward, divided difference and Sterling formula	3
3.2	Integration -Trapezoidal rule, Simpsons one third, Simpsons three eighth, Gauss quadrature-two & three points.	4
3.3	Case studies with computer programs (Python/Scilab/ C++/ Fortran/ other) (Not for End Semester Examination)	2
Module – 4 (9 Hours)		
4.1	**Numerical solutions to ordinary differential equations - Taylor's** method, Eulers method, Runge- Kutta method fourth order, simultaneous first order, Milne's predictor corrector	3
4.2	Initial value problem - shooting method, Eigen values -polynomial method, power method	4
4.3	Case studies with computer programs (Python/Scilab/C++/Fortran/other) (Not for End Semester Examination)	2
Module -5 (9 Hours)		
5.1	**Solution of partial differential equation & Interpolation - Interpolation** - Newtons forward and backward, divided difference linear & quadratic, Lagrange interpolation, cubic splines, Hermites interpolation	3
5.2	Solution of partial differential equation - Difference equations, Elliptic equation- Laplace equation, Poisson equation, Liebmann's iterative methods, Parabolic equation- Bender-Schmidt method, simple implicit, Crank-Nicolson scheme, Solution of hyperbolic equation	4
5.3	Case studies with computer programs (Python/Scilab/C++/ Fortran/other) (Not for End Semester Examination)	2

Model Question Paper

QP CODE: A Pages: 2

Reg No.:________________________

Name:__________________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2T101

Course Name: Numerical Methods for Engineers

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. Explain significant figures and truncation error. An approximate value of π is given by 3.1428571 and its true value is 3.1415926. Find the absolute and relative errors.

2. By the method of Least squares, find the straight line that best fit the following data

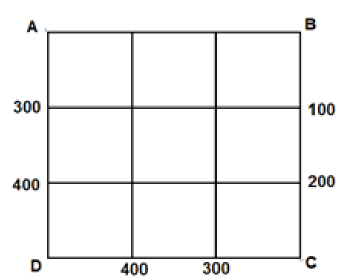
x	1	2	3	4	5
y = f(x)	14	27	40	55	64

3. A function *y = f(x)* is given by the following table. Find *f(0.2)* by a suitable formula.

x	0	1	2	3	4	5	6
y = f(x)	176	185	194	203	212	220	229

4. Solve $dy/dx = x + y$, $y(0) = 1$ with $h = 0.2$ at $x = 1$ by Euler's method

5. Solve the elliptic equation $U_{xx} + U_{yy} = 0$ for the following square mesh with boundary values as shown below using Liebmann method



PART B

Answer any five questions. Each question carries 8 marks.

6. Find a real root of the equation $x^3 - x - 11 = 0$ using Newton Raphson method.

7. Fit a straight line to the following data and estimate the value of *y* corresponding to *x =6.*

x	0	5	10	15	20	25
y	12	15	17	22	24	30

8. Evaluate the following integral:

$$\int_0^{\pi/2} (6 + 3\cos x)\, dx$$

(a) single application of Simpson's 1/3 rule
(b) multiple-application Simpson's 1/3 rule, with n = 4.

9. Evaluate

$$\int_0^1 \frac{dx}{1 + x^2}$$

by two-point and three-point Gassian quadrature formula.

10. Solve the following initial value problem over the interval from t = 0 to 2 where y (0) = 1. Display all your results on the same graph.

$$\frac{dy}{dx} = yt^2 - 1.1y$$

(a) Euler's method with h = 0.5 and 0.25.
(b) Fourth-order RK method with h = 0.5.

11. Determine the largest eigen value and the corresponding eigen vector of the matrix using power method.

$$\begin{bmatrix} 1 & 3 & -1 \\ 3 & 2 & 4 \\ -1 & 4 & 10 \end{bmatrix}$$

12. Solve by Schimidth's method *Ut = 5Uxx* with conditions *U(0,t) 0 , U(5,t) = 60* and *U(x,0) = 20x* for $0 < x \le 3$, *U(x,0) = 60* for $3 < x \le 5$ for 5 time steps having *h = 1.*

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2T102	**Advanced Heat Transfer**	**Core**	**4**	**0**	**0**	**4**	**4**

Preamble: Students are empowered to model complex heat transfer phenomena by seamlessly integrating fundamental heat transfer physics with mathematical tools. It equips students with the theoretical foundations necessary to analyze and solve intricate heat transfer problems but also cultivates critical thinking and problem-solving skills essential for addressing real-world engineering challenges

Prerequisite: A foundation course in Heat Transfer

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statement	Cognitive Knowledge Level
CO 1	Design fins that are used for enhancing the heat transfer from surfaces and solve 2D heat transfer problems, apply the lumped capacitance method and analytical solutions to one-dimensional transient heat transfer problems	Apply
CO 2	Analyze and solve convection heat transfer problems using appropriate mathematical models, similarity solutions, and analytical techniques	Analyze
CO 3	Apply fundamental heat transfer principles to analyze and solve problems related to natural convection	Apply
CO 4	Evaluate different modes of boiling and solve heat transfer problems associated with condensation over flat and curved surfaces	Evaluate
CO 5	Apply advanced analytical skills, demonstrated through the evaluation of radiation heat transfer phenomena, to solve complex engineering problems	Apply

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	1	3	1	3	2
CO 2	1	1	3		3	2
CO 3	1	1	3		3	2
CO 4		1	2		1	2
CO 5	1	1	2		2	2

Assessment Pattern

Course name	**Advanced Heat Transfer**		
Bloom's Category	**Continuous Assessment Tests**		**End SemesterExamination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	20	20	20
Apply	40	40	40
Analyse	30	30	30
Evaluate	10	10	10
Create	XX	XX	XX

Mark Distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project : 10 marks

Course based task/Seminar/Quiz : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (11 Hours)

Introduction to Heat Transfer: Fundamental concepts of Conduction, Convection and Radiation – Heat diffusion equation in cartesian, cylindrical, spherical coordinates – variable thermal conductivity – boundary conditions and initial conditions

Solution to heat conduction problems: conduction with energy generation - heat transfer through extended surfaces – two-dimensional heat conduction – method of separation of variables – finite difference method – energy balance method

Transient conduction: Lumped capacitance method, validity, Biot number, Fourier Number, Lumped capacitance Analysis – One dimensional transient problem, analytical solutions, Unsteady conduction from a semi-infinite solid

MODULE 2 (11 Hours)

Fundamental concepts of convection: continuity, momentum, energy equations – use of energy integral equation – non-dimensional numbers in convection heat transfer

Forced Convection: flat plate – similarity solution – isothermal and constant heat flux surfaces - unheated starting length – liquid metal heat transfer over a flat plate – 2d laminar couette flow - cylinder and sphere in cross flow – flow across tube banks – pipes – hydrodynamic and thermal boundary layer development - constant heat flux and constant wall temperature – fully developed flow – flow through non-circular tubes - concentric tube annulus – Reynold's-Colburn analogy

MODULE 3 (6 Hours)

Natural convection: flat plate – laminar free convection over vertical and inclined plates – isothermal and constant heat flux – horizontal and vertical cylinder and sphere – free convection between vertical and inclined parallel channels - natural convection through pipes – combined forced and natural convection

MODULE 4 (7 Hours)

Boiling and Condensation: Boiling – modes – pool boiling – curves, modes, correlations - Maximum heat flux - flow boiling - Condensation – film condensation - heat transfer correlations for film condensation – condensation over flat vertical plate, horizontal and vertical tube - dropwise condensation

MODULE 5 (10 Hours)

Radiation: fundamental concepts – radiation intensity (spectral and total) – black body radiation – Planck's law, Stefan Boltzman law, Wien's Displacement law, Kirchoff's law – Radiosity, Irradiation – real surface radiation – view factor – black body radiation exchange – radiation exchange between opaque, diffuse, grey surfaces – radiation shields – Multimode heat transfer – Radiation exchange in participating media.

Reference Books

1. Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, Adrienne S. Lavine, "Principles of Heat and Mass Transfer", 8th Edition, 2017
2. Yunus, A. Cengel, "Heat Transfer –A Practical Approach, Second Edition" ,Tata Mc Graw Hill, 2010
3. Alan Chapman, "Heat Transfer", Pearson Education India4th Edition, 2016
4. John H. Lienhard IV, John H. Lienhard V, "A Heat Transfer Textbook", 4th edition, 2018
5. Siegel, R. and Howell, J.R, "Thermal Radiation Heat Transfer", Taylor and Francis, 2002.
6. Mayers, G.E., "Analytical methods in Conduction Heat Transfer", McGraw Hill, 1971.
7. Kays, W.M. and Crawford, M.E., "Convective Heat and Mass Transfer", McGraw Hill Int. Edition, 3rd edition, 1993
8. Siegel, R. and Howell, J.R, "Thermal Radiation Heat Transfer", Taylor and Francis, 2002.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (11 Hours)	
1.1	Fundamental concepts of Conduction, Convection and Radiation heat transfer	1
1.2	Heat diffusion equation in cartesian, cylindrical, and spherical coordinates	1
1.3	Variable thermal conductivity, Boundary and initial conditions	1
1.4	Conduction with energy generation, Heat transfer through extended surfaces, Fin efficiency & effectiveness	3
1.5	Two-dimensional heat conduction – solution using method of separation of variables - Finite difference method – energy balance method	3
1.6	Transient conduction: Lumped capacitance method, validity, Biot number, Fourier Number	1
1.7	Semi-infinite solid	1
	Module 2 (11 Hours)	
2.1	Fundamental concepts of convection heat transfer	1
2.2	Discuss continuity, momentum, and energy equations - non-dimensional numbers in convection heat transfer	2
2.3	Forced convection over flat plate, similarity solution	1
2.4	Isothermal and constant heat flux surfaces, surfaces with unheated starting length - heat transfer in case of liquid metal flowing over a flat plate - energy integral equation	2
2.5	2D laminar Couette flow - Cylinder and sphere in cross flow – flow across tube banks	2
2.6	Flow through pipes - hydrodynamic and thermal boundary layer development - fully developed flow - flow through non-circular tubes - concentric tube annulus	2
2.7	Reynold's –Colburn analogy	1
	Module 3 (6 Hours)	
3.1	Fundamentals of Natural convection – laminar free convection over vertical and inclined plates	1
3.2	Horizontal and vertical cylinder and sphere isothermal and constant heat flux	1
3.3	Free convection between vertical and inclined parallel channels	1
3.4	Natural convection through pipes	2

3.5	Combined forced and natural convection	1
	Module 4 (7 Hours)	
4.1	Boiling – modes – pool boiling – curves, modes, correlations – Max heat flux - flow boiling	3
4.2	Condensation – film condensation – over flat vertical plate, horizontal and vertical tube	2
4.3	Dropwise condensation	2
	Module 5 (10 Hours)	
5.1	Radiation – fundamental concepts – radiation intensity: spectral and total	2
5.2	Black body radiation –– Planck's law, Stefan Boltzman law, Wien's Displacement law, Kirchoff's law - – Radiosity, Irradiation - Real surface radiation	2
5.3	View factor – radiation exchange between opaque, diffuse, grey surfaces – black body radiation exchange	3
5.4	Radiation shields	1
5.5	Multimode heat transfer – Radiation exchange in participating media	2

Model Question Paper

QP CODE: B Pages: 2

Reg No.:___________________

Name:_____________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2T102

Course Name: Advanced Heat Transfer

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. Hot water is to be cooled as it flows through the tubes exposed to atmospheric air. Fins are to be attached to enhance heat transfer. Would you recommend attaching the fins inside or outside the tubes? Why?
2. Explain Reynold's –Colburn analogy.
3. Justify the statement "natural convection plays a significant role in the cooling of computers".
4. Draw the boiling curve and identify the different boiling regimes. Also, explain the characteristics of each regime.
5. What is a graybody? How does it differ from a blackbody? What is a diffuse grey surface?

PART B

Answer any five questions. Each question carries 8 marks.

6. Consider steady one-dimensional heat conduction in a large plane wall of thickness L and constant thermal conductivity k with no heat generation. Obtain an expression for the variation of temperature within the wall for the following boundary conditions
7. The temperature of a gas stream is to be measured by a thermocouple whose junction can be approximated as 1.2 mm- diameter sphere. The properties of the junction are thermal conductivity = 35 W/mK, density = 8500 kg/m3, and specific heat = 320 J/kgK, and the heat transfer coefficient between the junction and the gas is 65 W/m^{2}K. Determine how long it will take for the thermocouple to read 99 percent of the initial temperature difference.

8. Using integral method, obtain an expression for Nusselt number when a liquid metal flows over a flat plate assuming the flow is to be laminar.
9. Water is to be heated from 15°C to 65°C as it flows through a 3-cm- internal diameter 5-m-long tube. The tube is equipped with an electric resistance heater that provides uniform heating throughout the surface of the tube. The outer surface of the heater is well insulated, so that in steady operation all the heat generated in the heater is transferred to the water in the tube. If the system is to provide hot water at a rate of 10 L/min, determine the power rating of the resistance heater. Also, estimate the inner surface temperature of the pipe at the exit.
10. Write down the continuity, momentum and energy equation for a natural convection boundary layer on a vertical heated plate. Non- dimensionalise the governing equations and identify the non-dimensional numbers. Explain the significance of each dimensionless numbers.
11. The condenser of a steam power plant operates at a pressure of 7.38 kPa. Steam at this pressure condenses on the outer surfaces of horizontal pipes through which cooling water circulates. The outer diameter of the pipes is 3 cm, and the outer surfaces of the pipes are maintained at 30°C. Determine (a) the rate of heat transfer to the cooling water circulating in the pipes and (b) the rate of condensation of steam per unit length of a horizontal pipe.
12. Two parallel plates of size 0.5m by 1m spaced 0.5m apart are located in a very large room, the walls of which are maintained at a temperature of 27°C. One plate is maintained at a temperature of 1000°C and the other at 500°C. Their emissivities are 0.2 and 0.5 respectively. If the plates exchange heat between themselves and surroundings, find the net heat transfer to each plate and to the room. Consider only the plate surfaces facing each other.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2T103	Advanced Fluid Mechanics	Core	4	0	0	4	4

Preamble: The core ideas and techniques of compressible and incompressible flows are covered in this course. With its broad application, fluid mechanics is a vital subject in many scientific and engineering domains. The emphasis of the current course is on applying the fundamental concepts of fluid mechanics to solve practical situations. Students will graduate from this course with a solid foundational grasp of incompressible and compressible flow dynamics and the ability to apply those concepts to the analysis of fluid mechanical systems.

Prerequisite: A foundational course in fluid mechanics and Differential equations is preferable.

Course Outcomes: After the completion of the course the student will be able to

CO No.	CO Statements	Cognitive Knowledge Level
CO 1	Model physical fluid dynamics systems using application of proper governing equations with suitable boundary conditions.	Apply
CO 2	Apply conservation equations to analytically solve simple fluid dynamics problems on the broad area of potential flows, vortex flows and laminar flows	Analyse
CO 3	Understand boundary layer theory and instability theory and to apply these in real fluid flow systems	Apply
CO 4	Categorize compressible flows and apply suitable governing equation for isentropic flows.	Evaluate
CO 5	Examine shock waves and its consequences in physical systems.	Analyse

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	1	2	1	3	1
CO 2	1		3	1	2	1
CO 3	2	2	2	1	1	2
CO 4	1		1		3	1
CO 5	3		3	2	2	1

Assessment Pattern

Course name	Advanced Fluid Mechanics		
Bloom's Category	**Continuous Assessment Tests**		**End SemesterExamination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	10	10	10
Apply	40	40	40
Analyse	30	30	30
Evaluate	20	20	20
Create	XX	XX	XX

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project : 10 marks

Course based task/Seminar/Quiz : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (10 Hours)

Introduction to Cartesian Tensors - index notation and Einstein summation convention; Brief recapitulation of some preliminary concepts of Fluid Mechanics.

Fluid Kinematics: Lagrangian and Eulerian Approach- Acceleration of fluid flows- Reynolds Transport Theorem- Linear and angular Deformation-Concept of Vorticity, Potential Function and Stream function

Governing Equations: Derivation of general form of conservation of mass- Navier Stokes Equation- Energy Equation in differential and integral forms.

MODULE 2 (11 Hours)

Vorticity Dynamics: Vortex lines and tubes, Role of viscosity in rotational and irrotational vortices- Kelvin's circulation theorem-Interaction of vortices.

Irrotational Flow Theory: Application of complex variables- Source, Sink, Doublet- Flow at a wall angle- Flow past a half body- Flow past a circular cylinder with circulation- Forces on 2D body- Method of Images- Conformal Mapping.

Exact Solutions of N-S equations: Steady flow in pipes. Steady flow between parallel plates and concentric cylinders- Axi-symmetric flows; Impulsively started plates: Similarity solutions.

MODULE 3 (9 Hours)

Boundary Layer Theory: Boundary Layer approximations- Measures of boundary layer thickness- Blasius Solution- Momentum Integral Equation- effect of pressure gradient-Separation- Flow past a circular cylinder and sphere- Dynamics of sports balls.

Flow Instabilities (Theory only): Introduction- Method of normal modes- Thermal instability- K-H instability.

MODULE 4 (**8 Hours)**

Introduction to Compressible flows- Speed of Sound- Basic equation for 1 D flow.

Isentropic flow with variable area: Stagnation and Critical conditions, Mass flow rate, Geometric chocking, Isentropic flow through C-D nozzle.

Fanno flow: Adiabatic flow in constant area duct with friction, Fanno line, Friction choking and its consequences.

MODULE 5 (7 Hours)

Rayleigh flow: Frictionless flow in constant area duct with heat transfer, Rayleigh line, Thermal choking and its consequences.

Standing normal shocks-– Fundamental relations-R-H equations- Stationary normal shock waves in C-D Nozzles; Oblique **Shocks**: Fundamental relations, property relationships, θ-β-M diagram. Shock Reflection and Intersections- shock tube.

Reference Books

1. Pijush K. Kundu, and Ira M. Cohen. “Fluid Mechanics”. 4th ed. Academic Press, 2008.
2. James John & Theo Keith, “Gas Dynamics”, Pearson Education, 2006.
3. White F. M., “Viscous Fluid Flow”, Mc Graw Hill Pub., 2006
4. Schlichting, H., and K. Gersten. “Boundary Layer Theory”. Springer, 2000.
5. John D Anderson, “Modern Compressible Flow”, McGraw Hill, 2003
6. Shapiro A. H., “The Dynamics and Thermodynamics of Compressible Flow; Vol 1”, 1953.
7. Annual Review of Fluid Mechanics

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (10 Hours)	
1.1	Introduction to Cartesian Tensors - index notation and Einstein's summation convention- Mathematical Operators – Stokes theorem- Divergence Theorem	2
1.2	Brief recapitulation of some preliminary concepts of Fluid Mechanics	1
1.3	Lagrangian and Eulerian Approach- Acceleration of fluid flows- Stream line, Path line and Streak line	1
1.4	Fluid deformation, Reynolds Transport Theorem	1
1.5	Concept of Vorticity, Potential Function, and Stream Function	1
1.6	Conservation of mass	1
1.7	Conservation of momentum, Navier- Stokes equation	2
1.8	Conservation of energy; Numerical Problems	1
	Module 2 (11 Hours)	
2.1	Vorticity Dynamics: Vortex lines and tubes, Role of viscosity in rotational and irrotational vortices	1
2.2	Kelvin's circulation theorem-Interaction of vortices	1
2.3	Irrotational Flow Theory: Application of complex variables	1
2.4	Source, Sink, Doublet- Flow at a wall angle	1
2.5	Flow past a circular cylinder with circulation- Forces on 2D body	1
2.6	Method of Images- Conformal Mapping- Numerical Problems	2
2.7	Exact Solutions of N-S equations: Plane Couette flow and Poiseuille flow-; Hagen -Poiseuille flow	2
2.8	Exact Solutions of N-S equations: Steady flow between concentric cylinders, axi-symmetric flows	1
2.9	Impulsively started plates: Similarity solutions; Numerical problems	1
	Module 3 (9 Hours)	
3.1	Boundary Layer Approximations-Measures of boundary layer thickness- displacement and momentum thickness	2
3.2	Blasius Solution, Falkner Skan Solution	2
3.3	Momentum Integral equations, Effect of Pressure gradient	1
3.4	Separation, Sport ball dynamics; Numerical Problems	1
3.5	Theory of Instability: method of normal modes, Orr-Sommerfield equation (Theory only)	2
3.6	Types of Instability: Benard Cells, K-H instability	1
	Module 4 (8 Hours)	
4.1	Introduction to Compressible flows- Speed of Sound- Basic equation for 1 D flow	2
4.2	Stagnation and static properties, Area-Velocity relationship in	2

	Isentropic flows	
4.3	Nozzles: mass flow rate, compressible flows in C-D nozzles Geometric choking.	2
4.4	Fanno flow: Effect of friction in constant area ducts- property relationships; Friction choking	2
Module 5 (7 Hours)		
5.1	Frictionless flow in constant area duct with heat transfer, Rayleigh line, Thermal chocking and its consequences	2
5.2	Standing normal shocks-– Fundamental relations-R-H equations-Stationary normal shock waves in C-D Nozzles; Numerical problems	2
5.3	Oblique Shocks: Fundamental relations, θ-β-M diagram.	2
5.4	Shock Reflection and Intersections- Shock tube	1

Model Question Paper

QP CODE: C Pages: 3

Reg No.:___________________

Name:_____________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2T103
Course Name: Advanced Fluid Mechanics

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. The velocity field in a flow field is given by $\boldsymbol{V} = 3xy^2\,\hat{\imath} + 2x\,\hat{j} + (2zy + 3t)\boldsymbol{k}$. Find the magnitude and directions of (i) translational velocity, (ii) Rotational Velocity and (iii) vorticity of the fluid element at position (*1,2,1*) and time *t =3*.

2. Water of kinematic viscosity $\upsilon = 1 \times 10^{-6}\, m^2/s$ is flowing steadily over a smooth flat plate at zero angle of attack with a velocity 1.6 m/s. The length of the plate is 0.3 m. Calculate (a) the thickness of boundary layer at 15 cm from the leading edge (b) the rate of growth of boundary layer at 15 cm from leading edge of the plate. Assume a parabolic velocity profile.

3. Explain how bowlers are employing separation phenomena in a cricket game and how trajectories of sports balls are determined by boundary layer separation. How the same separation phenomena are detrimental in rocket propulsion systems?

4. There is no friction in the system shown in Figure 1 except in the constant-area ducts from sections 3 to 4 and from 6 to 7. Sketch the T –s diagram for the entire system. Assume adiabatic flow throughout the system.

5. Write down jump conditions (that is property relations) across a normal shock by simplifying equations of conservation of mass, momentum and energy in one dimensional flows.

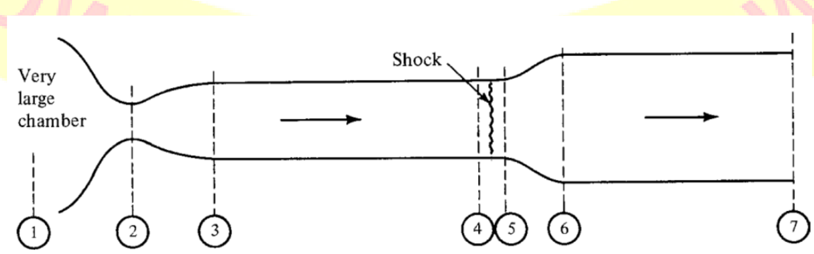


Figure 1

PART B

Answer any five questions. Each question carries 8 marks.

6. a. Write down general form of Navier-Stokes equation for a three-dimensional unsteady viscous compressible flow in a gravitational field. Simplify the equation for steady incompressible irrotational flows. (6 marks)

   b. Define compressible form of stream function. Give its importance. (2 marks)

7. Oil flows between two parallel plates, one of which is at rest and other moves with a velocity ***U***. (a) If the pressure is decreasing in the flow direction at a rate of 10 Pa/m, the dynamic viscosity is 0.05 kg/m s, the spacing of the horizontal plate is 0.04 m and the volumetric flow (Q) per unit width is 0.03 m^2/s, what is the velocity ***U***? (b) Calculate ***U*** if the pressure is increasing at a rate of 5 Pa/, in the direction of flow.

8. a. Derive non-dimensional form of Prandtl boundary layer equations for 2D steady laminar flow over a flat surface in the absence of body forces. Justify your assumptions. (4 marks)

   b. Describe any two types of instability encountered in fluid flows with typical examples. Explain how instabilities in a laminar flow lead to turbulent flows. (4 marks)

9. a. Compressed air is discharged through the converging nozzle as shown in figure 2. The tank pressure is 500 kPa and local atmospheric pressure is 101 kPa. The inlet area of nozzle is 100 cm^2; the exit area is 34 cm^2. Find the force of the air on the nozzle, assuming the air to behave as a perfect gas with constant γ=1.4. Take the temperature in the tank to be 300 K. You may assume that nozzle is choked and isentropic flow. (6 marks)

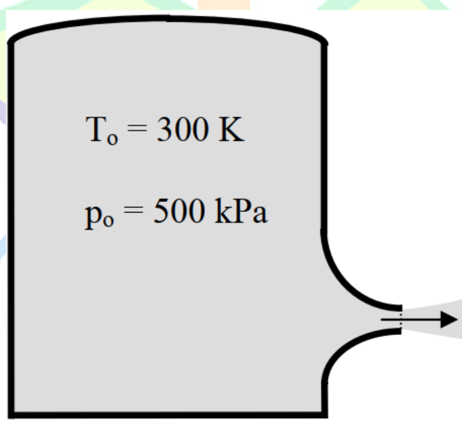


Figure 2

   b. Mach number play an important role in design and working of machines working on higher molecular weight fluids". Evaluate the above statement? (2 marks)

10. a. Explain how thermal chocking happens in flow through varying area duct with the support of property diagrams. (2 marks)

    b. Derive Rankine -Hugoniot equations for a normal shock. (6 marks)

11. a. The pressure, temperature and Mach number of air at entry to a flow passage are 0.25 MPa, 27°C, and 1.4 resp. If exit Mach number is 2 determine stagnation and static temperature of air and flow rate per unit area at inlet and exit. Assume isentropic flow throughout the passage. (4marks)

b. For a straight oblique shock situation, draw a diagram showing relationship between shock angle vs deflection angle for specific upstream Mach number. Illustrate salient features of the diagram.

(4 marks)

12. a. A hurricane is blowing over a long "Quonset hut," that is, a long half-circular cylindrical cross-section building, 6 m in diameter. If the velocity far upstream is U_∞ = 40 m/s and P_∞= 1 atm, ρ_∞= 1.23 kg/m³, find the force per unit depth on the building, assuming the pressure inside is P_∞.

(4 marks)

b. Explain the principle of shock tube with a neat sketch. What are the common applications of a shock tube?

(4 marks)

Programme Elective 1

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E104A	**Renewable Energy Systems**	**Elective**	**3**	**0**	**0**	**3**	**3**

Preamble: This course aims for the students to know the renewable energy scenario in India, their reserves, potentials, applications, and environmental aspects. and enables them to select the proper renewable energy system.

Prerequisite: A background in engineering and environmental science may provide a foundation for understanding the technical aspects of renewable energy technologies.

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Identify various renewable energy sources and conversion technologies along with environmental aspects of energy utilization	Understand
CO 2	Apply principles of solar energy to design and implement basic renewable energy systems.	Apply
CO 3	Apply fundamental concepts of wind, tidal, and geothermal energies to develop and evaluate basic renewable energy solutions and their environmental impact.	Apply
CO 4	Apply various methods and technologies to utilize biomass as a fuel with reduced environmental impact.	Apply
CO 5	Analyze hydrogen energy and fuel cells, evaluating their performance, potential, safety, and environmental aspects.	Analyse

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	2	2	2	1	1
CO 2	1	2	2	2	2	1
CO 3	1	2	2	2	2	1
CO 4	1	2	2	2	1	1
CO 5	1	2	2	2	1	1

Assessment Pattern

Course name	**Renewable Energy Systems**		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	20	20	20
Apply	60	60	60
Analyze	20	20	20
Evaluate	XX	XX	XX
Create	XX	XX	XX

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contains 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation, and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving, and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. The total duration of the examination will be 3 Hrs.

SYLLABUS

MODULE 1 (7 Hours)

Introduction to Renewable Energy: Global and Indian energy scenario – reserves of energy resources. Fossil fuels and environmental issues, impact of emission on environment & climate, sources of emission, types of emissions from various sectors (industry, power, human and agricultural activities etc.), environmental aspects of energy utilization. Renewable energy scenario & policies in India – potentials, achievements and applications.

MODULE 2 (7 Hours)

Solar Energy: Energy from Sun, solar constant, Sun-earth angles. Collection of Solar energy - flat plate and concentrating collectors. Solar thermal systems - Solar heating and cooling techniques, Solar desalination, Solar Pond, Solar cooker, solar thermal power plant. Solar photo voltaic conversion, Solar cells, PV applications.

MODULE 3 (7 Hours)

Energy from biomass: Bio-Energy Scenario - Potential, benefits & limitations, Biomass resources. Biomass conversion: Thermochemical energy processes - Direct combustion, torrefaction, Pyrolysis, and gasification, applications. Biomass conversion: Biochemical processes- bio methanation, anaerobic digesters, fermentation, ethanol production, biodiesel, applications.

MODULE 4 (7 Hours)

Wind, Ocean, and Geothermal energy: Basics – Wind energy data and energy estimation, types of wind energy systems, performance of wind turbine generators, safety and environmental aspects. Ocean energy - Resources & routes - OTEC - tidal energy – wave energy. Geothermal energy – Origin, types of geothermal energy sites, geothermal power plants.

MODULE 5 (8 Hours)

Introduction to hydrogen energy: Hydrogen as a source of energy –potential, benefits, and limitations. Hydrogen production, Storage and transportation, applications. Fuel Cells: Working principle – Basic thermodynamic and electrochemical principles – Classifications – Applications for power generation energy integrated FC systems.

Reference Books

1. B Godfrey, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press, 2012.
2. JW Twidell and A Weir, “Renewable Energy Resources”, EFN Spon Ltd., 2015.
3. M Kanoglu, “Fundamentals and Applications of Renewable Energy”, Indian edition McGraw Hill Publication, Hardcover/Paperback-2020.
4. S P Sukhatme, “Solar Energy: Principles of Thermal Collection and Storage”, Tata McGraw Hill Publishing Company Ltd., New Delhi,2009.
5. P Basu, “Biomass Gasification, Pyrolysis, and Torrefaction: Practical Design and Theory”, Academic Press (2013), Second edition.
6. L L Freris, “Wind energy conversion system”, Prentice Hall U K.
7. Fuel cell handbook, Seventh edition, EG&G Technical Services, Inc.
8. MK G Babu and B Subramanian “Alternative Transportation Fuels: Utilization in Combustion Engines”, CRC Press (2013).

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
Module 1 (7 Hours)		
1.1	Introduction to Renewable Energy: Global and Indian energy scenario – Reserves of energy resources, Fossil fuels, and environmental issues.	2
1.2	Impact of Emission on Environment & Climate, Sources of emission, Types of Emissions from various sectors (industry, power, human activities, agricultural activities). – Environmental aspects of energy utilization	2
1.3	Renewable energy scenario & policies in India – Potentials – Achievements – Applications.	3
Module 2 (7 Hours)		
2.1	Solar Energy: Energy from Sun, Solar constant, Sun-earth angles.	1
2.2	Collection of Solar energy - flat plate and concentrating collectors.	2
2.3	Solar thermal systems - Solar heating and cooling techniques, Solar desalination, Solar Pond, Solar cooker, solar thermal power plant. Solar photo voltaic conversion, Solar cells, PV applications.	4
Module 3 (7 Hours)		
3.1	Energy from biomass: Bio-Energy Scenario - Potential, benefits & limitations, Biomass resources.	1
3.2	Biomass conversion: Thermochemical energy processes - Direct combustion, torrefaction, Pyrolysis, and gasification, applications.	3
3.3	Biomass conversion: Biochemical processes- bio methanation, anaerobic digesters, fermentation, ethanol production, biodiesel, applications.	3
Module 4(7 Hours)		
4.1	Wind, Ocean, and Geothermal energy: Basics Wind energy data and energy estimation	1
4.2	Types of wind energy systems, performance of wind turbine generators, safety and environmental aspects.	2
4.3	Ocean energy - Resources & routes - OTEC - tidal energy – wave energy.	2
4.4	Geothermal energy – Origin, types of geothermal energy sites, geothermal power plants.	2

Module 5 (8 Hours)		
5.1	Hydrogen and Fuel Cells: Hydrogen as a source of energy – potential, benefits, and limitations	1
5.2	Hydrogen production, storage and transportation, applications	3
5.3	Fuel Cells: Working principle – Basic thermodynamic and electrochemical principles – Classifications – Applications for power generation energy integrated FC systems.	4

Model Question Paper

QP CODE:D **Pages: 2**

Reg No.:_________________

Name:___________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: **M24ME2E104A**

Course Name: Renewable Energy Systems

Max. Marks:60 **Duration: 3 hours**

PART A

Answer all questions. Each question carries 4 marks.

1. Explain the benefits of renewable energy over conventional fossil fuel
2. Comment on the superior thermal efficiency of evacuated tube collectors over normal FPC.
3. What do you mean by biomass conversion? What are the different types of conversions?
4. With the help of a T-S diagram explain vapor dominated geothermal system.
5. State whether SOFCs are suitable for short-distance automotive (car) applications. Give reasons if your answer is yes. Otherwise, suggest a suitable type of fuel cell for such applications.

PART B

Answer any five questions. Each question carries 8 marks.

6. Write in detail about the Renewable energy scenario of India with a special focus on solar, wind, and biomass energy.
7. Explain in detail about any two solar desalination techniques which use flashing.
8. With a neat sketch explain the principle and working of a solar pond. Explain how the different layers with different concentrations are maintained.
9. Derive betz limit for a horizontal axis wind turbine.
10. A 2m wave has a 6s period and occurs at the surface of water 100m deep. Find the wavelength, wave velocity, and horizontal and vertical semi-axes for water motion at the surface. Also, find the energy and power density. The density of water is 1025 kg/m3.

11. Differentiate between torrefaction, pyrolysis, and gasification. Based on what criteria will you decide which method to choose among these three for biomass conversion?

12 What are the major losses associated with the operation of a fuel cell? Discuss its I-V characteristics.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E104B	Measurement Methods in Thermal Engineering	Elective	3	0	0	3	3

Preamble: In the dynamic realm of Thermal Engineering accurate measurement methods stand as the cornerstone of innovation and progress. As we delve into the intricate processes governing heat transfer, fluid flow, and energy conversion, it becomes evident that precise measurements are paramount for understanding, analysing, and optimizing thermal systems.

Prerequisite: A foundation course in metrology, mechanical measurement and electronics

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Understand advanced measurement techniques and to apply the various steps involved in error analysis and uncertainty analysis.	Apply
CO 2	Understand principles and applications of various pressure measuring instruments and the calibration procedures.	Apply
CO 3	Apply the temperature measurement techniques alongside the principles and calibration of different thermocouples	Apply
CO 4	Understand the application and implementation of measurement science and engineering in gas flow	Analyze
CO 5	To effectively utilize microprocessors and computers in measurement systems, including data logging and data acquisition (DAQ) along with, the evaluation of analog to digital (A-D) and digital to analog conversion (DAC).	Evaluate

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1		3	1	1	1
CO 2	1		3	1	1	1
CO 3	1		3	1	1	1
CO 4	1		3	1	1	1
CO 5	1		3	1	1	1

Assessment Pattern

Course name	**Measurement Methods in Thermal Engineering**		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	20	20	20
Apply	50	50	50
Analyse	20	20	20
Evaluate	10	10	10
Create	XX	XX	XX

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project : 10 marks

Course based task/Seminar/Quiz : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (7 Hours)

Measurement characteristics, Measurement and Instrument Classifications. Characteristics of Instruments – Static and dynamic Measurements. Errors in Measurements, Systematic and Random errors, Uncertainty, Selection of measuring instruments. Reliability of Measuring instruments.

MODULE 2 (7 Hours)

Measurement of Pressure, Various Pressure sensing elements. Bellows Inductance, Resistance types, Capacitive Pressure Transducers, Piezoelectric and Potentiometric Pressure Transducers, Strain gauge pressure sensors. Bridgeman Gauge for Very High-Pressure Measurement. Vacuum Measurement and McLeod gauge for very Low-Pressure Measurement. Pirani Gauge. Calibration Process, Dead weight Tester.

MODULE 3 (7 Hours)

Measurement of Temperature, Thermometers, Thermometers Thermocouple. Resistance Temperature Detector (RTD), Thermistor, Bi-metallic Thermometers. Thermo-electric Pyrometers, Total radiation Pyrometers. Optical Pyrometers Pressure Thermometers, Infrared Thermometers, Temperature Calibration RTD and Thermocouple calibration.

MODULE 4 **(8 Hours)**

Advance Measurement Techniques- Shadowgraph, Schlieren imaging, Interferometer, Laser Doppler Anemometer, Particle Image Velocimetry Hot Wire Anemometer, Turbine Flow Meters, Telemetry, Orsat apparatus, 5 Gas Analysers, Smoke meters, Gas Chromatography.

MODULE 5 (7 Hours)

Microprocessors and Computers in measurement, Data logging and data acquisition (DAQ) system. Analog to Digital (A-D) and Digital to Analog Conversion (DAC). Pulse Code Modulation (PCM), 4-bit DAC convertor, R- 2R Ladder DAC.

Reference Books

1. Holman, J.P., “Experimental methods for engineers”, McGraw-Hill, 1988.
2. Alan S Morris, Reza Langari, “Measurement and Instrumentation Theory and Application”, Academic Press 2016.
3. Raman, C.S. Sharma, G.R., Mani, V.S.V., “Instrumentation Devices and Systems”, Tata McGraw-Hill, New Delhi, 1983.
4. Doeblin, “Measurement System Application and Design”, McGraw-Hill, 1978.
5. Morris. A.S, “Principles of Measurements and Instrumentation” Prentice Hall of india.
6. Raghavendra N.V., Krishnamurthy L., “Engineering Metrology and Measurements”, Oxford University Press 2013.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
	Module 1 (7 Hours)	
1.1	Measurement characteristics, Measurement and Instrument Classifications	3
1.2	Characteristics of Instruments – Static and dynamic Measurements	2
1.3	Errors in Measurements, Systematic and Random errors, Uncertainty, Selection of measuring instruments	1
1.4	Reliability of Measuring instruments	1
	Module 2 (7 Hours)	
2.1	Measurement of Pressure, Various Pressure sensing elements	1
2.2	Bellows Inductance, Resistance types, Capacitive Pressure Transducers, Piezoelectric and Potentiometric Pressure Transducers, Strain gauge pressure sensors.	2
2.3	Bridgeman Gauge for Very High-Pressure Measurement. Vacuum Measurement and McLeod gauge for very Low-Pressure Measurement	2
2.4	Pirani Gauge. Calibration Process, Dead weight Tester	2
	Module 3 (7 Hours)	
3.1	Measurement of Temperature, Thermometers, Thermometers Thermocouple	2
3.2	Resistance Temperature Detector (RTD), Thermistor, Bi-metallic Thermometers. Thermo-electric Pyrometers, Total radiation Pyrometers	2
3.3	Optical Pyrometers Pressure Thermometers, Infrared Thermometers, Temperature Calibration RTD and Thermocouple calibration	3
	Module 4 (8 Hours)	
4.1	Advance Measurement Techniques- Shadowgraph, Schlieren imaging, Interferometer, Laser Doppler Anemometer,	4

4.2	Particle Image Velocimetry Hot Wire Anemometer, Turbine Flow Meters, Rotameters, Telemetry, Orsat apparatus, 5 Gas Analysers, Smoke meters, Gas Chromatography	4
	Module 5 (7 Hours)	
5.1	Microprocessors and Computers in measurement,	2
5.2	Data logging and data acquisition (DAQ) system	2
5.3	Analog to Digital (A-D) and Digital to Analog Conversion (DAC).	2
5.4	Pulse Code Modulation (PCM), 4-bit DAC convertor, R- 2R Ladder DAC.	1

Model Question Paper

QP CODE: **D** Pages: 2

Reg No.:___________________

Name:_____________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2E104B

Course Name: Measurement Methods in Thermal Engineering

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. What is measurement? Mention the uses of gauges, micrometers and dial gauge indicators in measurement system
2. Explain the working of Carbon pile pressure transducer
3. Discuss the working of Pirani gauge with suitable sketches
4. Discuss the principle of turbine flow meter
5. Why are digital display units more preferred by researchers in measurement?

PART B

Answer any five questions. Each question carries 8 marks.

6. Discuss the principle of any two-pressure sensing instrument
7. Explain the working of strain gauge pressure sensor instrument
8. With neat sketches explain the working of Bridgman gauge and Mcleod gauge in measurement
9. Explain the working of Flat Top and Natural top type of A/D convertors

10. With neat sketch explain Particle Image Velocimetry technique. Mention its advantages and disadvantages

11. Explain the working of five gas analyzer and the working of a smoke meter. Mention its advantages and disadvantages

12. With neat sketch explain Schlieren interferometer and shadowgraph. Mention its advantages and disadvantages

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E104C	**Energy Management and Audit**	**Elective**	**3**	**0**	**0**	**3**	**3**

Preamble: This course is designed to aware the students concerning various energy intensive process in different industries and to find out the energy conservation opportunities. The course envisaged that students will have the capability to prepare energy auditing and managing the energy demand.

Prerequisite: Basic information about thermal and electrical energy and awareness of energy policy and regulations.

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Understand energy management principles, objectives of energy surveying and auditing, and the use of energy indices and load profiles.	Understand
CO 2	Analyzing instrument characteristics such as sensitivity, accuracy, and precision, as well as the ability to calibrate instruments and analyze measurement errors.	Analyse
CO 3	Analyse supply and demand side management, economic operation strategies, and the importance of power factor correction and capacitor sizing.	Analyse
CO 4	Optimize thermal energy management systems in industrial facilities.	Apply
CO 5	Apply economic analysis methods to evaluate energy management proposals and investment decisions.	Apply

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1		1	2			2
CO 2	1		2		1	2
CO 3		1	2			2
CO 4			2			2
CO 5		2	1			2

Assessment Pattern

Course name	**Energy Management and Audit**		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (Marks)**
	Test 1 (Marks)	**Test 2 (Marks)**	
Remember	XX	XX	XX
Understand	20	20	20
Apply	40	40	40
Analyse	40	40	40
Evaluate	XX	XX	XX
Create	XX	XX	XX

Mark Distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 Hrs.

SYLLABUS

MODULE 1 (7 Hours)

Energy Management and Audit. Scope of energy management, general principles of energy management, Energy surveying and auditing, objectives, energy index, cost index, pie charts, Sankey diagrams, CUSUM chart, load profiles (histograms), types of energy audits-preliminary energy audit – detailed energy audit, questionnaire, energy audit instruments and tools.

Type of industrial loads, maximum demand controls, Methodologies, Optimum load scheduling-Case studies.

MODULE 2 (5 Hours)

Instruments for Energy Auditing. Instrument characteristics-Sensitivity, readability, accuracy, precision, hysteriss, Error and calibration, Measurement of flow, velocity, temperature, speed, Lux, power and humidity. Analysis of stack, power and fuel quality

MODULE 3 (8 Hours)

Electrical energy management. overall structure of electrical systems, supply and demand side management, economic operation; reactive power, power factor correction and capacitor sizing, Numerical problems.; transformer loading and efficiency analysis; feeder loss evaluation; energy efficient lighting schemes; types and operating characteristics of electric motors: energy efficient control and starting, load matching, motor selection, Rewinding effects on energy efficiency,; Industrial drives and control schemes, variable speed drives and energy conservation schemes; energy conservation in pumps and fans; case studies.

MODULE 4 (8 Hours)

Thermal energy management. Factors affecting boiler performance, Steam distribution losses- Steam pipe sizing, selection of steam traps, optimum insulation, steam utilization, energy saving opportunities. Heat Recovery Systems- Sources and grading of waste heat, feasibility study of waste heat recovery, gas to gas, gas to liquid heat recovery, waste heat boilers. performance evaluation of a typical furnace, energy conservation in furnaces, excess air control. Performance and energy savings in HVAC system

MODULE 5 (8 Hours)

Economic analysis methods-cash flow model, time value of money, evaluation of proposals, pay-back method, average rate of return method, internal rate of return method, present value method, life cycle costing approach, Case studies

References:

1. General Aspects of Energy Management & Energy Audit, http://www.em-ea.org/gbook11.asp, National Certificate Examination for Energy Managers and Energy Auditors, National Productivity Council of India
2. Energy Performance Assessment for Equipment and Utility systems, http://www.em-ea.org/gbook14.asp, National Certificate Examination for Energy Managers and Energy Auditors, National Productivity Council of India
3. John.C. Andreas, "Energy efficient electric motors", Marcel Dekker Inc Ltd., 2e, 1995.
4. Murphy, W.R., Mckay, G. "Energy Management", London: Butterworth-Heinemann, 1982.
5. Smith, C.B., "Energy Management Principles : applications, benefits, savings", Amsterdam : Pergamon Press, 4E, 1981.
6. Witte, L. C. (1988), "Industrial energy management and utilization", Springer Berlin Heidelberg, 1988
7. Sonal Desai, "Handbook of Energy Audit", Mcgraw Hill Education Private Ltd.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (7 Hours)	
1.1	**Energy Management and Audit** - Scope of energy management, general principles of energy management	2
1.2	Energy surveying and auditing, objectives, energy index, cost index, pie charts, Sankey diagrams, CUSUM chart, load profiles (histograms),	2
1.3	Types of energy audits-preliminary energy audit – detailed energy audit, questionnaire, energy audit instruments and tools.	1
1.4	Type of industrial loads, maximum demand controls, Methodologies, Optimum load scheduling-Case studies	2
	Module 2 (5 Hours)	
2.1	**Instruments for Energy Auditing -** Instrument characteristics- Sensitivity, readability, accuracy, precision, hysteriss, Error and calibration	2
2.2	Measurement of flow, velocity, temperature.	1
2.3	Measurement of speed, Lux, power and humidity.	1
2.4	Analysis of stack, power and fuel quality	1
	Module 3 (8 Hours)	
3.1	**Electrical energy management** - Overall structure of electrical systems, supply and demand side management, economic operation; reactive power, power factor correction and capacitor sizing, Numerical problems.	2
3.2	Transformer loading and efficiency analysis; feeder loss evaluation; energy efficient lighting schemes.	2
3.3	Types and operating characteristics of electric motors: energy efficient control and starting, load matching, motor selection, Rewinding effects on energy efficiency,	2
3.4	Industrial drives and control schemes, variable speed drives and energy conservation schemes; energy conservation in pumps and fans; case studies.	2
	Module 4 (8 Hours)	
4.1	**Thermal energy management -** Factors affecting boiler performance, Steam distribution losses- Steam pipe sizing, selection of steam traps, Numerical problems.	2
4.2	Optimum insulation, steam utilization, energy saving opportunities.	2

4.3	Heat Recovery Systems- Sources and grading of waste heat, feasibility study of waste heat recovery, gas to gas, gas to liquid heat recovery, waste heat boilers.	2
4.4	Performance evaluation of a typical furnace, energy conservation in furnaces, excess air control. Performance and energy savings in HVAC system.	2
Module 5 (8 Hours)		
5.1	**Economic analysis methods** - Cash flow model, time value of money.	2
5.2	Evaluation of proposals, pay-back method, average rate of return method.	2
5.3	Internal rate of return method, present value method, life cycle costing approach.	2
5.4	Case studies.	2

Model Question Paper

QP CODE: D Pages: 2

Reg No.:___________________

Name:_____________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

***Course Code:* M24ME2E104C**

Course Name: Energy Management and Audit

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. Evaluate the significance of energy index and cost index in energy management. How are these indices calculated, and what insights do they provide into energy consumption and cost patterns?
2. Assess the effectiveness of calibration procedures in ensuring the accuracy and reliability of energy audit measurements. How often should instruments be calibrated, and what challenges may arise during the calibration process?
3. Evaluate the importance of reactive power in electrical systems and its impact on overall system efficiency. How can power factor correction and capacitor sizing techniques be used to improve power quality and reduce energy losses?
4. Analyze the different sources and grading of waste heat in industrial settings. How can this analysis inform the design and implementation of effective waste heat recovery systems?
5. Evaluate the factors that should be considered when conducting a life cycle costing analysis for investment projects. How does this approach account for total cost of ownership over the project's lifespan?

PART B

Answer any five questions. Each question carries 8 marks.

6. Evaluate the role of industrial drives and control schemes in optimizing energy consumption in manufacturing processes. How do variable speed drives and energy conservation schemes contribute to energy savings?

7. Assess the effectiveness of load profiling techniques in analyzing energy consumption patterns. How can load profiles help organizations identify opportunities for load optimization and demand-side management?
8. Evaluate the significance of hysteresis in energy auditing instruments. How does hysteresis affect the repeatability and consistency of measurement results, and what measures can be taken to minimize its impact?
9. Create a proposal for implementing variable speed drives in an industrial facility to improve energy efficiency and reduce operating costs. Include a cost-benefit analysis, implementation plan, and projected savings to support the proposal.
10. Design an innovative solution for optimizing excess air control in industrial furnaces to improve combustion efficiency and reduce energy waste. Consider factors such as airflow regulation, burner design, and control system integration in your design.
11. Analyze the factors that can affect boiler performance in thermal energy management. How do variations in these factors impact overall efficiency and productivity?
12. Critically evaluate the strengths and weaknesses of using the internal rate of return method as a decision criterion for investment projects. What factors could lead to misleading results when using this method?

Programme Elective 2

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E105A	**Industrial Refrigeration**	**Elective**	**3**	**0**	**0**	**3**	**3**

Preamble: Students learn about basics of refrigeration, the introduction to industrial refrigeration, the operations of compressors in industrial systems, the operational features of evaporators & condensers in industrial refrigeration systems, vessels in industrial refrigeration systems, and the energy conservation aspects of industrial refrigeration systems

Prerequisite: Knowledge in the basics of refrigeration

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Apply the principles of thermodynamics to analyse refrigeration systems	Apply
CO 2	Apply industrial refrigeration concepts to differentiate from conventional systems and analyse their applications, including multistage reciprocating and screw compressors.	Analyse
CO 3	Apply knowledge of evaporators, liquid circulation methods, industrial condensers, and refrigerant piping design, including lubricating oil types and properties.	Apply
CO 4	Analyse the function and design of various vessels in industrial refrigeration systems	Analyse
CO 5	Evaluate the impact of recent trends in the refrigeration industry on efficiency and sustainability.	Evaluate

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	3	1	2	1	
CO 2		2	1	1	2	
CO 3	2	1	1		1	
CO 4	2	1		1	1	
CO 5	2	1	2	2	2	1

Assessment Pattern

Course name	**Industrial Refrigeration**		
Bloom's Category	**Continuous Assessment Tests**		**End SemesterExamination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	20	20	20
Apply	40	40	40
Analyse	30	30	30
Evaluate	10	10	10
Create	XX	XX	XX

Mark Distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (8 Hours)

Thermodynamics of refrigeration- reversed Carnot cycle- heat pump and refrigeration machines. Unit of refrigeration. Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams. Vapour absorption systems - Ammonia – water system - simple system - Electrolux system. Properties of moist air - Psychrometry, Psychrometric Processes, sensible heat ratio; sensible heating and cooling, Humidification and dehumidification devices.

MODULE 2 (7 Hours)

Introduction to industrial refrigeration - difference from conventional system - applications – industrial and comfort air - conditioning systems, various applications of industrial refrigeration: milk and dairy products preservation, storage and transport, Reciprocating and screw compressors, Effect of evaporator and condenser temperature on volumetric efficiency, Refrigerating Effects and COP, Variable speed drive of screw compressors, Variable volume ratio, Cooling methods – Water, oil and refrigerant methods, Capacity regulations – Economizers-side port options.

MODULE 3 (9 Hours)

Types of Evaporators, Liquid circulation: Mechanical pumping and gas pumping - advantage and disadvantage of liquid re-circulation - circulation ratio - top feed and bottom feed refrigerant – Net Positive Suction Head (NPSH) - two pumping vessel system - suction risers – design piping loses. Different Industrial Condensers arrangement, Evaporators-Types and arrangement, liquid circulation, type of feed, refrigerant piping design, functional aspects. Lubricating oil: types - physical properties, types of circulation and oil separator

MODULE 4 (5 Hours)

Vessels in industrial refrigeration: High-pressure receiver - flash tank - liquid and vapour separators - separation enhancers - low-pressure receivers - surge drum - surge line accumulator, thermosyphon receiver - oil pots.

MODULE 5 (7 Hours)

Energy conservation and design considerations - source of losses - energy efficient components -heat reclaim - thermal storage: ice builder and ice harvester. Insulation: critical thickness – insulation cost and energy cost - vapour barriers - construction methods of refrigerated spaces. Recent trends in the refrigeration industry-desiccant-based cooling, magneto calorific effect.

Reference Books

1. Wilbert F.Stoecker, "Industrial Refrigeration Hand Book", McGraw-Hill, 1998.
2. Koelet, Pieter, "Industrial Refrigeration: Principles, Design and Applications", Macmillan,1992
3. ASHRAE Hand Book: Refrigeration Fundamentals, 2023.
4. ASHRAE Hand Book: HVAC Systems and Equipment, 2023.
5. Transport properties of SUVA Refrigerants, Du-Pont Chemicals, 1993.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
	MODULE: 1 (8 Hours)	
1.1	Thermodynamics of refrigeration- reversed Carnot cycle- heat pump and refrigeration machines.	1
1.2	Unit of refrigeration. Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams.	2
1.3	Vapour absorption systems - Ammonia – water system - simple system - Electrolux system.	2
1.4	Properties of moist air - Psychrometry, Psychrometric Processes	2
1.5	Sensible heat ratio; sensible heating and cooling, Humidification and dehumidification devices.	1

MODULE 2 (7 Hours)		
2.1	Introduction to industrial refrigeration - difference from conventional system - applications – industrial and comfort air - conditioning systems, various applications of industrial refrigeration: milk and dairy products preservation, storage and transport	2
2.2	Reciprocating and screw compressors, Effect of evaporator and condenser temperature on volumetric efficiency.	2
2.3	Refrigerating Effects and COP, Variable speed drive of screw compressors, Variable volume ratio.	1
2.4	Cooling methods – Water, oil and refrigerant methods	1
2.5	Capacity regulations – Economizers-side port options.	1
Module 3 (9 Hours)		
3.1	Liquid circulation: Mechanical pumping and gas pumping, Advantage and disadvantage of liquid re-circulation	2
3.2	Circulation ratio - top feed and bottom feed refrigerant	1
3.3	Net Positive Suction Head (NPSH) - two pumping vessel system - suction risers	1
3.4	Different Industrial Condensers arrangement.	1
3.5	Liquid circulation and type of feed	1
3.6	Refrigerant piping design, functional aspects.	2
3.7	Lubricating oil: types - physical properties, types of circulation and oil separator.	1
MODULE 4 (5 Hours)		
4.1	Vessels in industrial refrigeration: High-pressure receiver -	1
4.2	Flash tank - liquid and vapour separators	1
4.3	Separation enhancers - low-pressure receivers - surge drum - surge line accumulator	2
4.4	Thermosyphon receiver - oil pots.	1
MODULE 5 (7 Hours)		
5.1	Energy conservation and design considerations - source of losses	1
5.2	Eenergy efficient components -heat reclaim	1
5.3	thermal storage: ice builder and ice harvester	1
5.4	Insulation: critical thickness – insulation cost and energy cost - vapour barriers	2
5.5	construction methods of refrigerated spaces. Recent trends in the refrigeration industry- desiccant-based cooling, magneto calorific effect	2

Model Question Paper

QP CODE: E Pages: 1

Reg No.:___________________
Name:_____________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2E105A

Course Name: Industrial Refrigeration

Max. Marks:60 Duration: 3 hours

PART A (5 x 4 = 20 Marks)

Answer all questions. Each question carries 4 marks.

1. Explain the significance of reversed Carnot cycle.
2. Discuss the effect of evaporating temperature and condensing temperature on volumetric efficiency, refrigerating effect and COP of a refrigeration system.
3. Explain net positive suction head.
4. Elucidate the application of flash tank and surge drum.
5. Make a note on critical thickness of insulation and vapour barriers.

Part B (5 x 8 = 40 Marks)
Answer any five questions. Each question carries 8 marks

6. With a neat sketch explain the working of simple vapour compression refrigeration system.
7. Explain the refrigeration methods adopted in preservation, storage and transport of milk and dairy products.
8. Narrate the function of evaporator in a refrigeration system. Describe any Two types of evaporators.
9. What are the required properties of lubricants? Explain the types of circulation.
10. Discuss the energy conservation opportunities of a refrigeration system
11. Indicate the need of cold storage. Explain how it's constructed.
12. Evaluate the use of thermal storage systems like ice builders and ice harvesters in refrigeration applications. What are the criteria for selecting the most suitable thermal storage solution, and how do these systems contribute to energy savings?

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E105B	**Hydrogen and Fuel Cell Technologies**	Elective	3	0	0	3	3

Preamble: A comprehensive course on Hydrogen and Fuel Cell Technology that delves into the forefront of sustainable energy solutions. Throughout this course, we will explore the principles, applications, and advancements in hydrogen-based technologies, including fuel cells. This course enables the students to understand the pivotal role of hydrogen in transitioning towards a cleaner and more sustainable energy future.

Prerequisite: A foundational understanding of chemistry and familiarity with basic concepts in physics, such as energy conversion and thermodynamics and a background knowledge in the technical aspects of hydrogen and fuel cell technologies.

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Understand the relevance of hydrogen energy in sustainable clean power applications.	Understand
CO 2	Apply knowledge of hydrogen production methods to design and evaluate efficient and sustainable systems for generating hydrogen fuel.	Apply
CO 3	Design and develop a suitable hydrogen storage system.	Apply
CO 4	Apply fundamental concepts of fuel cell technology to analyze and troubleshoot basic fuel cell systems.	Apply
CO 5	Analyze and compare different types of fuel cells to determine their suitability for various applications based on performance characteristics and operational requirements.	Analyse

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	2	2	2		
CO 2	1	2	2	2		1
CO 3	1	2	2	2	1	1
CO 4	1	2	2	2	1	2
CO 5	1	2	2	2	1	2

Assessment Pattern

Course name	**Hydrogen and Fuel Cell Technologies**		
Bloom's Category	**Continuous Assessment Tests**		**End SemesterExamination (Marks)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	xx	xx	xx
Understand	20	20	20
Apply	60	60	60
Analyse	20	20	20
Evaluate	xx	xx	xx
Create	xx	xx	xx

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contains 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation, and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving, and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. The total duration of the examination will be 3 Hrs.

SYLLABUS

MODULE 1 (6 hours)

Introduction to Hydrogen Energy: Introduction to hydrogen economy - Hydrogen as a source of energy, physical and chemical properties, salient characteristics, relevant issues, and concerns, fundamentals, and classification of fuel cells.

MODULE 2 (7 hours)

Hydrogen Energy Production: Thermal steam reformation, Thermochemical water splitting, gasification, pyrolysis, electrolysis, photoelectrochemical, anaerobic digestion, fermentation, PEM-based electrolysis.

MODULE 3 (8 hours)

Hydrogen storage, applications, and safety: Hydrogen storage options, compressed gas, liquid hydrogen, hydride, chemical storage, safety and management of hydrogen, applications of hydrogen, hydrogen transportation, and hydrogen refueling methods.

MODULE 4 (8 hours)

Fuel Cells - Fuel cell definition, difference between batteries and fuel cells, fuel cell history, components of fuel cells, principle of working of fuel cell, thermodynamics and kinetics of fuel cell process, performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack, fuel cell power plant: fuel processor, fuel cell power section, power conditioner, Advantages and disadvantages of fuel cell power plant.

MODULE 5 (7 hours)

Types of Fuel Cells -Types of fuel cells; AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits, performance evaluation of fuel cell. Fuel cell usage for power generation, automobile, space applications, economic and environmental analysis on usage of fuel cells, future trends of fuel cells.

Reference Books

1. B Sorenson, "Hydrogen and fuel cells- emerging technologies and applications", Academic Press.
2. B Viswanathan, and M A Scibioh, "Fuel Cells – Principles and Applications", Universities Press.
3. L Rebecca and Busby, "Hydrogen and Fuel Cells: A Comprehensive Guide", Penn Well Corporation, Oklahoma.
4. M F Hordeski, "Hydrogen and fuel cells- Advances in transportation and power", The Fairmount press.
5. K Kordesch, and G Simader, "Fuel Cell and Their Applications", Wiley-Vch, Germany.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (6 hours)	
1.1	Hydrogen – Fundamentals: Introduction to hydrogen economy - Hydrogen as a source of energy	2
1.2	Physical and chemical properties, salient characteristics, relevant issues, and concerns, Introduction to hydrogen economy	2
1.3	Fundamentals and classification of fuel cells	2
	Module 2 (7 hours)	
2.1	Thermal steam reformation, Thermochemical water splitting,	2
2.2	Gasification, pyrolysis, electrolysis, photoelectrochemical Process	3
2.3	Anaerobic digestion, fermentation, PEM-based electrolysis.	2

Module 3 (8 hours)		
3.1	Hydrogen storage options, compressed gas, liquid hydrogen, hydride	2
3.2	Hydride, chemical storage, safety, and management of hydrogen	3
3.3	Applications of hydrogen, hydrogen transportation, and hydrogen refueling methods.	3
Module 4 (8 hours)		
4.1	Fuel cell definition, difference between batteries and fuel cells, fuel cell history, components of fuel cells	2
4.2	Principle of working of a fuel cell, thermodynamics and kinetics of fuel cell process, performance characteristics of fuel cells, the efficiency of fuel cell, fuel cell stack	3
4.3	Fuel cell power plant: fuel processor, fuel cell power section, power conditioner, Advantages and disadvantages of fuel cell power plant	3
Module 5 (7 hours)		
5.1	Types of fuel cells; AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits, performance evaluation of fuel cell	4
5.2	Fuel cell usage for power generation, automobile, space applications, economic and environmental analysis on usage of fuel cells	2
5.3	Future trends of fuel cells	1

Model Question Paper

QP CODE: E Pages: 1

Reg No.:___________________

Name:_____________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

***Course Code:* M24ME2E105B**

Course Name: Hydrogen and Fuel Cell Technologies

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. Describe the merit of hydrogen as a fuel.
2. How is hydrogen typically generated through the process of pyrolysis
3. What is cryogenic liquid hydrogen?
4. Write a note on the ideal and real efficiencies of fuel cells.
5. Describe the concept of stack clamping.

PART B

Answer any five questions. Each question carries 8 marks.

6. What are the potential benefits and challenges associated with transitioning to a hydrogen economy, and how might this transition impact various sectors such as transportation, industry, and energy production?
7. Discuss in detail any three technologies for hydrogen production.
8. With a neat sketch explain the hydrogen production using PEM-based electrolysis.
9. Explain the working principles and elaborate on the components involved in a fuel cell power plant, detailing how it generates electricity and its key components' roles in the process.
10. What are the operational principles and distinguishing features of a Molten Carbonate Fuel Cell (MCFC), and how do its components contribute to electricity generation within the cell?
11. Compare the operational capabilities of Alkaline (AFC) and Phosphoric Acid fuel cells (PAFC), analyzing their merits and drawbacks in terms of performance and practicality
12. a. What are the primary criteria for selecting an optimal electrolyte for fuel cell applications?

    b. Explore the different strategies for enhancing the kinetic performance of a fuel cell.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E105C	Advanced Thermodynamics	Elective	3	0	0	3	3

Preamble: The course intends to empower students with application-level understanding in the field of Thermodynamics**.**

Prerequisite: Foundation course in engineering thermodynamics

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Apply his knowledge to analyze systems using the first and second laws of thermodynamics	Apply
CO 2	Differentiate between energy and exergy while elucidating the significance of computing the exergy of a system	Analyze
CO 3	Analyze systems with gas mixtures	Analyze
CO 4	Demonstrate proficiency in analyzing combustion processes	Apply
CO 5	Proficiently comprehend statistical thermodynamics	Apply

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1		1	2	1	2	2
CO 2		1	2	1	1	2
CO 3		1	3	1	1	2
CO 4		2	3	1	2	2
CO 5		1	3	1	1	2

Assessment Pattern

Course name	Advanced Thermodynamics		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	20	20	20
Apply	40	40	40
Analyse	40	40	40
Evaluate	XX	XX	XX
Create	XX	XX	XX

Mark Distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (7 Hours)

Fundamentals of Thermodynamics – Work Transfer, Heat Transfer- First Law for Closed Systems and Open System - The Second Law for Closed System and Open System - Local Equilibrium - Entropy Maximum and Energy Minimum - Carathéodory's Two Axioms.

MODULE 2 (7 Hours)

Availability and Exergy – Irreversibility - Graphical Representation of Available Energy and Irreversibility - Availability Balance for a Closed System - Availability Balance for an Open System – ideal reversible heat transfer – irreversible heat transfer

MODULE 3 (6 Hours)

Uses of the Thermodynamic Relationships: Maxwells Relations for Single Component System – Clausius-Clapeyron equation - Equations of State- Mixtures of Ideal Gases: Gibbs– Dalton Law, Mixture Relationships, Specific Heats of Mixtures, Entropy of Mixtures - Developing tables of Thermodynamic properties from Experimental Data.

MODULE 4 (8 Hours)

Combustion: Combustion Equations - Theoretical & Excess Air - Stoichiometric Air Fuel Ratio (A/F) - Air Fuel Ratio from Analysis of Products - Heat of Formation and Heat of Reaction – Adiabatic flame Temperature - Gibbs Energy - Chemical Potential – calculation of chemical equilibrium – Equilibrium Constant - Vant Hoff's Equation

MODULE 5 (8 Hours)

Statistical Thermodynamics - Quantization of Energy - The Entropy Function - Entropy and the most Probable state - Microscopic Implications of work and heat - Entropy changes in term of macroscopic variables - the Statistical interpretation of second and third laws of thermodynamics - Elements of non-equilibrium thermodynamics: Thermodynamic Forces and Thermodynamic Velocities.

Reference Books

1. Desmond E. Winterbone & Ali Turan, "Advanced Thermodynamics for Engineers", Butterworth-Heinemann Ltd, 1996
2. Adrian Bejan, "Advanced Engineering Thermodynamics", Wiley; 4th edition, 2016
3. Michael J Moran, Howard N Shapiro, "Fundamentals of Engineering Thermodynamics", Wiley; 8th edition, 2014
4. Kenneth K Kuo, "Principles of Combustion", Wiley India Pvt Ltd; 2e, 2012
5. T D Eastop & Mcconkey, "Applied Thermodynamics for Engineering Technologists", Longman; 5e, 1993
6. Mark W. Zemansky & Richard H. Dittman, "Heat and Thermodynamics", McGraw-Hill Higher Education; 7e, 1997

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
Module 1 (7 Hours)		
1.1	Fundamentals of Thermodynamics – Work Transfer, Heat Transfer	1
1.2	First Law for Closed Systems and Open System	2
1.3	The Second Law for Closed System and Open System	2
1.4	Entropy Maximum and Energy Minimum - Carathéodory's Two Axioms	2
Module 2 (7 Hours)		
2.1	Availability and Exergy	1
2.2	Irreversibility - Graphical Representation of Available Energy and Irreversibility	3
2.3	Availability Balance for a Closed System & Open System	3

Module 3 (6 Hours)		
3.1	Maxwells Relations for Single Component System	1
3.2	Clausius-Clapeyron equation - Equations of State	2
3.3	Mixtures of Ideal Gases: Gibbs– Dalton Law, Mixture Relationships, Specific Heats of Mixtures, Entropy of Mixtures	2
3.4	Developing tables of Thermodynamic properties from Experimental Data	1
Module 4 (8 Hours)		
4.1	Combustion Equations - Theoretical & Excess Air - Stoichiometric Air Fuel Ratio (A/F)	1
4.2	Air Fuel Ratio from Analysis of Products	2
4.3	Heat of Formation and Heat of Reaction – Adiabatic flame Temperature	2
4.4	Gibbs Energy - Chemical Potential – calculation of chemical equilibrium – Equilibrium Constant - Vant Hoff's Equation	3
Module 5 (8 Hours)		
5.1	Statistical Thermodynamics	1
5.2	Quantization of Energy - The Entropy Function - Entropy and the most Probable state	2
	Microscopic Implications of work and heat - Entropy changes in term of macroscopic variables - the Statistical interpretation of second and third laws of thermodynamic	3
5.3	Elements of non-equilibrium thermodynamics: Thermodynamic Forces and Thermodynamic Velocities	2

M Tech in Thermal Power Engineering

Model Question Paper

QP CODE: E Pages: 2

Reg No.:______________________

Name:________________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

***Course Code:* M24ME2E105C**

Course Name: Advanced Thermodynamics

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. How changes in the inlet steam properties, such as pressure, temperature, and mass flow rate, impact the performance of the turbine according to the Steady Flow Energy Equation?
2. Compare and contrast the concepts of energy and exergy in the context of thermodynamics.
3. A dealer advertises that he has just received a shipment of electric resistance heaters for residential buildings that have an efficiency of 100%. Assuming an indoor temperature of 21°C and outdoor temperature of 10°C, determine the second law efficiency of these heaters.
4. What is the importance of the Van't Hoff equation? Explain in detail.
5. Describe the entropy function and its role in Statistical Thermodynamics

PART B

Answer any five questions. Each question carries 8 marks.

6. a. Differentiate between work and heat. (3 marks)

   b. Air is contained in a vertical piston–cylinder assembly fitted with an electrical resistor. The atmosphere exerts a pressure of 1 bar on the top of the piston, which has a mass of 45 kg and a face area of 0.09 m^2. Electric current passes through the resistor, and the volume of the air slowly increases by 0.045 m^3 while its pressure remains constant. The mass of the air is 0.27 kg, and its specific internal energy increases by 42 kJ/kg. The air and piston are at rest initially and finally. The piston–cylinder material is a ceramic composite and thus a good insulator. Friction between the piston and cylinder wall can be ignored, and the local acceleration of gravity is g = 9.81 m/s^2. Determine the heat transfer from the resistor to the air, in kJ, for a system consisting of (a) the air alone, (b) the air and the piston. (5 marks)

7. a. What is the first law applied to an open system? (3 marks)

b. Air at 200 kPa and 950 K enters an adiabatic nozzle at low velocity and is discharged at a pressure of 80 kPa. If the isentropic efficiency of the nozzle is 92 percent, determine (*a*) the maximum possible exit velocity, (*b*) the exit temperature, and (*c*) the actual velocity of the air. Assume constant specific heats for air.
(5 marks)

8. a. Explain the Exergy of a system (3 marks)

b. A cylinder of an internal combustion engine contains 2450 cm^3 of gaseous combustion products at a pressure of 7 bar and a temperature of 867°C just before the exhaust valve opens. Determine the specific exergy of the gas, in kJ/kg. Ignore the effects of motion and gravity, and model the combustion products as air as an ideal gas. Take T_o = 300 K (27°C) and p_o=1.013 bar.
(5 marks)

9. a. Explain various terms in Van der Waals equation of state. (3 marks)

b. Determine the specific volume of refrigerant-134a vapor at 1.4 MPa and 140°C based on (*a*) the ideal-gas equation, (*b*) the generalized compressibility chart, and (*c*) the experimental data from tables. Also, determine the error involved in the first two cases. (5 marks)

10 a. What is the application of determining adiabatic flame temperature? (3 marks)

b. Liquid octane at 25°C, 1 atm enters a well-insulated reactor and reacts with air entering at the same temperature and pressure. For steady-state operation and negligible effects of kinetic and potential energy, determine the temperature of the combustion products for complete combustion with (a) the theoretical amount of air, (b) 400% theoretical air. (5 marks)

11 a. What are the factors affecting equilibrium constant of a reaction? (3 marks)

b. One kilomole of carbon monoxide, CO, reacts with ½ kmol of oxygen, O_2, to form an equilibrium mixture of CO_2, CO, and O_2 at 2500 K and (a) 1 atm, (b) 10 atm. Determine the equilibrium composition in terms of mol e fractions.
(5 marks)

12 a. Classical thermodynamics is sufficient for most practical matters. Why is it required to study statistical thermodynamics? Discuss with examples.
(3 marks)

b. Discuss the statistical interpretation of second law. (5 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2R106	**Research Methodology & IPR**	**Theory**	**2**	**0**	**0**	**2**	**2**

Preamble: This course introduces the strategies and methods related to scientific research. It covers salient aspects of publication and patenting along with the crucial role of ethics in research. This course will equip students to define research problem and to adopt suitable methodologies for the solution of problem. The students are trained in the oral presentation with visual aids and writing technical thesis/reports/research papers.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO No.	CO Statement	Cognitive Knowledge Level
CO 1	Approach research projects with enthusiasm and creativity.	Apply
CO 2	Conduct literature survey and define research problem.	Apply
CO 3	Adopt suitable methodologies for solution of the problem.	Analyze
CO 4	Deliver well-structured technical presentations and write technical reports.	Apply
CO 5	Publish/Patent research outcome.	Apply

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	3	1		1	3
CO 2	2	3	1		1	3
CO 3	2	3	1		1	3
CO 4	2	3	1		1	3
CO 5	2	3	1		1	3

Assessment Pattern

Course name	**Research Methodology & IPR**		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (%Marks)**
	Test 1 (% Marks)	**Test 2 (% Marks)**	
Remember	XX	XX	XX
Understand	20	20	20
Apply	60	60	60
Analyse	20	20	20
Evaluate	XX	XX	XX
Create	XX	XX	XX

Mark Distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications in the relevant discipline (minimum 10 publications shall be referred) : 10 marks

Course based task/Seminar/Quiz : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

End Semester Examination Pattern: The end semester examination should be conducted by the college. The time duration will be for 3 hrs and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

SYLLABUS

MODULE 1 (5 Hours)

Meaning, and objective of research, Motivation for research

Types of research, Research Approaches, significance of research, Characteristics of good research, Research process.

Thinking skills: Types and Levels of thinking - common-sense, scientific thinking, and logical thinking.

Creativity: Some definitions, illustrations from day-to-day life, intelligence versus creativity, creative process, requirements for creativity.

MODULE 2 (4 Hours)

Literature survey and Problem definition

Information gathering – reading, searching and documentation, Types of literature.

Integration of research literature and identification of research gaps, Attributes and sources of research problems, problem formulation, Research question, multiple approaches to a problem, Problem solving strategies – reformulation or rephrasing, techniques of representation, Importance of graphical representation, examples.

MODULE 3 (6 Hours)

Experimental and modelling skills

Scientific method, role of hypothesis in experiment, dependent and independent variables, control in experiment, precision and accuracy, need for precision, definition, detection, estimation and reduction of random errors, statistical treatment of data, definition, detection and elimination of systematic errors.

Design of experiments, experimental logic and documentation.

Types of models, stages in modelling, curve fitting, the role of approximations, problem representation, logical reasoning, mathematical skills.

Continuum/meso/micro scale approaches for numerical simulation, Case studies illustrating experimental and modelling skills.

MODULE 4 (5 Hours)

Effective communication - oral and written

Examples illustrating the importance of effective communication, stages and dimensions of a communication process.

Oral communication –verbal and non-verbal, casual, formal and informal communication, interactive communication, listening, form, content and delivery, various contexts for speaking- conference, seminar etc.

Guidelines for preparation of good presentation slides.

Written communication – Rules of scientific writing, form, content and language, layout, typography and illustrations, nomenclature, reference and citation styles, contexts for writing – paper, thesis, reports etc. Tools for document preparation-LaTeX.

Common errors in typing and documentation.

MODULE 5 (5 Hours)

Publication and Patents

Relative importance of various forms of publication, Choice of journal and reviewing process, Stages in the realization of a paper.

Research metrics-Journal level, Article level and Author level, Plagiarism and research ethics.

Introduction to IPR, Concepts of IPR, Types of IPR, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark.

Patents- Concept, Objectives and benefits, features, Patent process – steps and procedures.

References

1. Panneerselvam, "Research Methodology", Prentice Hall of India, New Delhi, 2012.
2. C. R. Kothari, "Research Methodology", New Age International, 2004
3. E. M. Phillips and D. S. Pugh, "How to get a PhD - a handbook for PhD students and their supervisors", Viva books Pvt Ltd.
4. G. L. Squires, "Practical physics", Cambridge University Press
5. Antony Wilson, Jane Gregory, Steve Miller, Shirley Earl, "Handbook of Science Communication", Overseas Press India Pvt Ltd, New Delhi, 1st edition 2005
6. Leedy P. D., "Practical Research: Planning and Design", McMillan Publishing Co.
7. Day R. A., "How to Write and Publish a Scientific Paper", Cambridge University Press, 1989.
8. William Strunk Jr., "Elements of Style", Fingerprint Publishing, 2020

9. Peter Medawar, “Advice to Young Scientist”, Alfred P. Sloan Foundation Series, 1979.

10. E. O. Wilson, “Letters to a Young Scientist”, Liveright, 2014.

11. R. Hamming, “You and Your Research”, 1986 Talk at Bell Labs.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (5 Hours)	
1.1	Meaning, and objective of research, Motivation for research: Motivational talks on research: "You and Your Research"- Richard Hamming.	1
1.2	Types of research, Research Approaches.	1
1.3	Significance of research, Characteristics of good research, Research process.	1
1.4	Thinking skills: Types and Levels of thinking - common-sense, scientific thinking, and logical thinking.	1
1.5	Creativity: Some definitions, illustrations from day to day life, intelligence versus creativity, creative process, requirements for creativity.	1
	Module 2 (4 Hours)	
2.1	Information gathering – reading, searching and documentation, types of literature	1
2.2	Integration of research literature and identification of research gaps	1
2.3	Attributes and sources of research problems, problem formulation, Research question, multiple approaches to a problem	1
2.4	Problem solving strategies – reformulation or rephrasing, techniques of representation, Importance of graphical representation, examples	1
	Module 3 (6 Hours)	
3.1	Scientific method, role of hypothesis in experiment, dependent and independent variables, control in experiment	1
3.2	Precision and accuracy, need for precision, definition, detection, estimation and reduction of random errors, statistical treatment of data, definition, detection and elimination of systematic errors	1

3.3	Design of experiments, experimental logic and documentation	1
3.4	Types of models, stages in modelling, curve fitting, the role of approximations, problem representation, logical reasoning, mathematical skills	1
3.5	Continuum/meso/micro scale approaches for numerical simulation, Case studies illustrating experimental and modelling skills.	2
Module 4 (5 Hours)		
4.1	Examples illustrating the importance of effective communication, stages and dimensions of a communication process	1
4.2	Oral communication –verbal and non-verbal, casual, formal and informal communication, interactive communication, listening, form, content and delivery, various contexts for speaking- conference, seminar etc.	1
4.3	Guidelines for preparation of good presentation slides.	1
4.4	Written communication – Rules of scientific writing, form, content and language, layout, typography and illustrations, nomenclature, reference and citation styles, contexts for writing – paper, thesis, reports etc. Tools for document preparation-LaTeX.	1
4.5	Common errors in typing and documentation	1
Module 5 (5 Hours)		
5.1	Relative importance of various forms of publication, Choice of journal and reviewing process, Stages in the realization of a paper.	1
5.2	Research metrics-Journal level, Article level and Author level, Plagiarism and research ethics	1
5.3	Introduction to IPR, Concepts of IPR, Types of IPR	1
5.4	Common rules of IPR practices, Types and Features of IPR Agreement, Trademark	1
5.5	Patents- Concept, Objectives and benefits, features, Patent process – steps and procedures	1

M Tech in Thermal Power Engineering

Model Question Paper

QP CODE: J Pages: 1

Reg No.:____________________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2R106

Course Name: Research Methodology & IPR

Max. Marks:60 Duration: 3 hours

Answer any five questions. Each question carries 12 marks.

1. (a) Discuss the salient recommendations for great research recommended by Richard Hamming in his famous talk "You and Your Research". (4 marks)

   (b) Classify different types of researches. (8 marks)
2. (a) List out the different steps for identification of research gaps. (6 marks)

   (b) Classify various types of literature. (6 marks)
3. (a) Distinguish between continuum, meso-scale and micro scale approaches for numerical simulation. (6 marks)

   (b) Illustrate the role of approximations in research. (6 marks)
4. (a) Discuss any four rules of scientific writing. (4 marks)

   (b) List out the Guidelines for preparation of good presentation slides. (8 marks)
5. (a) Examine the requirements for patentability? (6 marks)

   (b) Contrast between copyright and trademark protection. (6 marks)
6. (a) What are the characteristics of a good research question? Discuss with an example. (6 marks)

   (b) Explain the various sources of research problem. (6 marks)
7. (a)Discuss the various stages and dimensions of communication process. (6 marks)

   (b) Compare Journal level, Article level and Author level research metrics. (6 marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2L107	**Thermal Power Systems Lab**	**Laboratory**	**0**	**0**	**3**	**3**	**2**

Preamble: This lab is focused to develop a platform where the students can master their engineering knowledge on various thermal and energy conversion equipment.

Prerequisite: Basic knowledge in thermal engineering

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO1	Analyze and interpret data to understand the principles of heat transfer mechanisms.	Analyse
CO2	Compare the performance characteristics of different thermal systems	Apply
CO3	Evaluate the efficiency and suggest improvements for energy conservation in thermal systems.	Evaluate
C04	Evaluate the efficiency and emissions of the engine using different fuel combinations.	Evaluate
CO5	Measure different parameters with precision and accuracy	Apply

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	3	1	1	3
CO 2	2	2	3	1	1	3
CO 3	3	2	3	1	1	3
CO 4	2	2	3	1	1	3
CO 5	2		3	1		3

Mark distribution

Total Marks	CIE Marks	ESE Marks
100	60	40

Continuous Internal Evaluation Pattern:

Lab work and Viva-voce : 60 marks
Final assessment Test and Viva voce : 40 marks

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

SYLLABUS

LIST OF EXPERIMENTS

1	Basic heat transfer experiments such as determining thermal conductivity/heat transfer coefficient/emissivity etc.
2	Experimental study on film and drop wise condensation
3	Critical Heat Flux
4	Performance monitoring and analysis of refrigeration plant
5	Performance monitoring and analysis of air conditioning systems
6	Test on rotary and reciprocating compressors
7	Test on computerized engine testing rig
8	Performance test on Variable Compression Ratio Engine.
9	Test on a CRDI Engine
10	Test on dual fuelled engine
11	Performance analysis of a slow speed diesel engines
12	Investigation on the effect of Volumetric Efficiency and Cooling Water Temperature on engine performance.
13	Test on engine emission levels using smoke analyzers
14	Performance evaluation and Emission studies of alternative fuels in SI and CI engines.
15	Calibration of Pressure Gauge, RTD and Thermocouples
16	Test on Thermal power plant (Steam Power Plant)

References:

1. Wilbert F. Stoecker, “Refrigeration and Air conditioning”, Mc Graw Hill, Inc 1982.
2. Frank P Incropera and David P Dewitt, “Fundamentals of Heat and Mass Transfer”, 6th Edition
3. Roger F. Haycock and John E. Hillier, “Automotive Lubricants Reference Book”, 2nd Edition, SAE International Publications, 2004.
4. Pundir B.P, “Engine Emissions: Pollutant Formation and Advances in Control Technology”, Narosa, Publishing House Pvt. Ltd., Delhi, 2007.
5. Keith Owen and Trevor Eoley, “Automotive Fuels Handbook”, SAE Publications,1990
6. Sorensen, H. A., “Energy Conversion Systems”, J. Wiley, 1983
7. Morse, T. F., “Power Plant Engineering”, Affiliated East West Press,

Semester 2

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2T201	**Computational Fluid Dynamics**	**Core**	**4**	**0**	**0**	**4**	**4**

Preamble: The Course aims to enable students to solve the governing equations of fluid flow using various numerical techniques. This learning may be used to solve practical fluid flow problems in engineering applications.

Prerequisite: Basic understanding of differential equations and numerical methods is assumed.

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Derive the governing equations of fluid flow.	Understand
CO 2	Apply finite volume methods to solve convection diffusion transport problems.	Apply
CO 3	Solve flow fields for steady and unsteady flows	Apply
CO 4	Conduct practical CFD simulations.	Analyse
CO 5	Choose appropriate turbulence models	Apply

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	1	3	1	2	1
CO 2	1	1	3	1	2	1
CO 3	1	1	3	1	2	1
CO 4	1	1	3	1	2	1
CO 5	1	1	3	2	2	1

Assessment Pattern

Course name	**Computational Fluid Dynamics**		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember	xx	xx	xx
Understand	20	20	20
Apply	50	50	50
Analyse	30	30	30
Evaluate	xx	xx	xx
Create	xx	xx	xx

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project :10 marks

Course based task/Seminar/Quiz :10 marks

Test paper 1 (Module 1 and Module 2) :10 marks

Test paper 2 (Module 3 and Module 4) :10 marks

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

Module 1: (9 Hours)

Governing equations of fluid flow and heat transfer, Equations of state, Navier–Stokes equations for a Newtonian fluid, Conservative form of the governing equations of fluid flow, differential and integral forms of the general transport equations, classification of physical behaviours, the role of characteristics in hyperbolic equations, classification method for simple PDE's, classification of fluid flow equations

Module 2: (10 Hours)

Finite volume method for convection-diffusion problems, Steady one-dimensional convection and diffusion, Steady two-dimensional convection and diffusion, properties of discretisation schemes, the upwind differencing scheme, the hybrid differencing scheme, the power-law scheme, higher-order differencing schemes, TVD schemes

Module 3: (9 Hours)

Solution algorithms for pressure-velocity coupling in steady flows, the staggered grid, the momentum equations, the SIMPLE algorithm, the PISO algorithm, worked examples of the SIMPLE algorithm solution of discretised equations using TDMA, point-iterative methods, the finite volume method for unsteady flows: explicit scheme, Crank–Nicolson scheme & fully implicit scheme.

Module 4: (7 Hours)

Implementation of boundary conditions, inlet boundary conditions, outlet boundary conditions, wall boundary conditions, the constant pressure boundary condition, symmetry boundary condition, periodic boundary condition, errors and uncertainty in CFD, numerical errors, input uncertainty, physical model uncertainty, verification and validation, guidelines for best practice in CFD

Module 5: (10 Hours)

Turbulence and its modelling, descriptors of turbulent flow, turbulent flow calculations, Reynolds-averaged Navier–Stokes equations and classical turbulence models: mixing length model, the k–ε model, Reynolds stress equation models, advanced turbulence models, guidelines for choice of turbulence models

Reference Books

1. H K Versteeg & W Malalasekera , “An Introduction To Computational Fluid Dynamics”, Pearson, 2008
2. Suhas V Patankar , “Numerical Heat Transfer And Fluid Flow”, CRC Press, 2017
3. T. J. Chung , “Computational Fluid Dynamics” , Cambridge University Press, 2014

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (9 Hours)	
1.1	Governing equations of fluid flow and heat transfer, Equations of state	1
1.2	Navier–Stokes equations for a Newtonian fluid	2
1.3	Conservative form of the governing equations of fluid flow	1
1.4	differential and integral forms of the general transport equations	1
1.5	Classification of physical behaviors	2
1.6	The role of characteristics in hyperbolic equations,	1

1.7	Classification method for simple PDE's, classification of fluid flow equations	1
Module 2 (10 Hours)		
2.1	Finite volume method for convection-diffusion problems, Schemes for Steady one-dimensional convection and diffusion	1
2.2	Schemes for Steady two-dimensional convection and diffusion	1
2.3	Properties of discretisation schemes	1
2.4	The upwind differencing scheme	1
2.5	The hybrid differencing scheme	1
2.6	The power-law scheme	1
2.7	Higher-order differencing schemes	1
2.8	TVD schemes	1
2.9	Problems	2
Module 3 (9 Hours)		
3.1	Solution algorithms for pressure-velocity coupling in steady flows	1
3.2	The staggered grid, the momentum equations	1
3.3	SIMPLE algorithm	1
3.4	PISO algorithm	1
3.5	TDMA	2
3.6	Worked out examples of the SIMPLE algorithm solution of discretised equations using TDMA	1
3.7	Point-iterative methods	1
3.8	Finite volume method for unsteady flows: explicit scheme, Crank–Nicolson scheme & fully implicit scheme.	1
Module 4 (7 Hours)		
4.1	Implementation of boundary conditions, inlet boundary conditions, outlet boundary conditions, wall boundary conditions	1

4.2	Constant pressure boundary condition, symmetry boundary condition, periodic boundary condition	1
4.3	Errors and uncertainty in CFD	2
4.4	Numerical errors, input uncertainty, physical model uncertainty, verification and validation	1
4.5	Guidelines for best practice in CFD	2
Module 5 (10 Hours)		
5.1	Turbulence and its modelling, descriptors of turbulent flow	1
5.2	Turbulent flow calculations, Reynolds-averaged Navier–Stokes equations	2
5.3	Classical turbulence models: mixing length model	1
5.4	The k–ε model	2
5.5	Reynolds stress equation models	1
5.6	Advanced turbulence models	2
5.7	Guidelines for choice of turbulence models	1

Model Question Paper

QP CODE: A Pages: 1

Reg No.:____________________

Name:______________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

Second SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: **M24ME2T201**
Course Name: Computational Fluid Dynamics

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. Write the governing equations of fluid flow
2. Using Taylor's series, derive second order difference expression for ∂u/∂y
3. Define Peclet number. How does it influence the choice of convection diffusion schemes?
4 What is the utility of y+ value?
5 Define Kolmogorov scale. How is it influenced by Reynolds number?

PART B

Answer any five questions. Each question carries 8 marks.

6. From the governing equations of fluid flow, arrive at the general transport equation. Write the physical significance of each of the terms.
7. Explain TDMA algorithm. How is it significant to CFD algorithm?
8. Explain how the Navier Stokes equations are solved in the PISO method.
9. Assess the desirability of Central difference scheme for convection-diffusion problems against criteria of conservativeness, accuracy, transportiveness and boundedness.
10. Explain k-ω turbulence model.
11. Explain SIMPLE algorithm with a neat flowchart.
12. Derive the RANS equation. Explain why modeling is required in solving turbulent flows.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2T202	Gas Turbines and Jet Propulsion	Core	4	0	0	4	4

Preamble: This course is designed to provide a comprehensive understanding of the principles, operation, and applications of gas turbines and jet propulsion systems. Gas turbines and jet propulsion are fundamental technologies that play pivotal roles in various industries including aviation, power generation, marine propulsion, and automotive engineering.

Prerequisite: A foundation course in Thermodynamics and Fluid mechanics.

Course Outcomes: After the completion of the course the student will be able to

CO No.	CO Statements	Cognitive knowledge level
CO 1	Explore Simple Gas Turbine System, thermodynamic analyses, and cycle modifications, which will equip them with a skill set for comprehending, analyzing, and optimizing gas turbine performance in diverse applications.	Understand
CO 2	Analyze jet propulsion cycles for various engines including turbojet, turboprop, ramjet and turbofan with essential skills for improving propulsion systems.	Analyze
CO 3	Comprehend centrifugal and axial flow compressors, including the components, operating principles, and performance characteristics, which qualifies for compressor analysis and problem-solving.	Apply
CO 4	Analyze turbine performance, losses, efficiencies, and cooling strategies by learning the different combustion systems, turbine configurations, and cooling methods	Analyze
CO 5	Perform system matching and analysis, including compressor, combustor, turbine, and nozzle matching, along with general procedures and environmental impact assessment, which enhances the knowledge of gas turbine engine operation and optimization.	Evaluate

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	2		3	1
CO 2	2	1	2		3	1
CO 3	2	1	2		3	1
CO 4	2	1	2		3	1
CO 5	2	1	2	1	2	1

Assessment Pattern

Course name	Gas Turbines and Jet Propulsion		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	10	10	10
Apply	30	30	30
Analyse	40	40	40
Evaluate	20	20	20
Create	XX	XX	XX

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (10 Hours)

Simple Gas turbine system - major components, working. Brayton cycle-open cycle and closed cycle. Ideal cycle- Cycle analysis, T-s, P-V diagrams, Net work done, Cycle efficiency. Real cycle-pressure drop at combustion, compressor efficiency and turbine efficiency. Modifications of Brayton cycle- Regeneration, Compressor intercooling, Turbine reheat, Water/Steam injection.

MODULE 2 (9 Hours)

Jet propulsion cycles and thermodynamic analysis- Turbojet, Turboprop, Turbofan, Ramjet. Basic working principle. Thrust equation. Efficiencies. Thrust augmentation. Numerical problems on cycle analysis.

MODULE 3 (9 Hours)

Centrifugal compressor-components and operating principle. Analysis of flow-velocity triangles. Compressor characteristics-slip factor, surging, chocking, losses and efficiency. Simple numerical problems.

Axial flow compressor-working principle, velocity triangle. Performance characteristics-surging and stalling. Stage efficiency, losses. Simple numerical problems.

MODULE 4 (8 Hours)

Combustion systems-process of combustion, combustion chamber geometry and arrangements. Coolong systems. Impulse and Reaction turbines- velocity triangles. Losses and efficiencies. Turbine blade cooling. Inlets and Nozzles.

MODULE 5 (9 Hours)

System matching and Analysis- Compressor matching, Combustor matching, Turbine matching, Nozzle matching. Operating line. General matching procedures. Simple problems. Environmental impact of gas turbine engines.

Reference Books

1. V. Ganesan, “Gas Turbines”, Tata McGraw Hill, 2010.
2. Henry Cohen, G. F. C. Rogers, H. I. H. Saravanamuttoo, “Gas Turbine theory”, Addison Wesley Longman, 1996.
3. Ronald D. Flack, “Fundamentals of Jet propulsion with applications”, Cambridge University press, 2005.
4. William W. Bathie, “Fundamentals of Gas Turbines”, Wiley, 1996.
5. M.M. El Wakil, “Power Plant Technology”, McGraw Hill, 1984.
6. Philip Walsh, Paul Fletcher, “Gas turbine performance”, Blackwell Science, 2004.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (10 Hours)	
1.1	Simple Gas turbine system – Compressor, Combustor/Heat exchanger, Turbine. Brayton cycle-open cycle and closed cycle (only mention the difference). Ideal cycle- Cycle analysis, T-s, P-V diagrams, Net work done, Cycle efficiency.	3
1.2	Real cycle-pressure drop at combustion, compressor efficiency and turbine efficiency (not in detail). Numerical problems.	3
1.3	Modifications of Brayton cycle- Exhaust gas recovery-Regenerative cycles, Compressor intercooling, Turbine reheat, Water/Steam injection.	4
	Module 2 (9 Hours)	

2.1	Jet propulsion cycles and thermodynamic analysis- Thrust equation. Performance parameters. Efficiencies. Ideal and real cycle.	3
2.2	Turbojet-inlet diffuser, compressor, combustor, turbine, nozzle. Turboprop-theory of propulsion. Turbofan- bypass ratio, Ramjet-flame stabilizers.	3
2.3	Thrust augmentation methods-. Numerical problems on cycle analysis	3
	Module 3 (9 Hours)	
3.1	Centrifugal compressor-components and operating principle. Impeller type. Analysis of flow-velocity triangles.	3
3.2	Compressor characteristics-slip factor, surging, chocking, losses and efficiency. Simple numerical problems.	3
3.3	Axial flow compressor-working principle, velocity triangle. Performance characteristics-surging and stalling. Stage efficiency, losses. Simple numerical problems	3
	Module 4 (8 Hours)	
4.1	Combustion systems-process of combustion, combustion chamber geometry and arrangements. Coolong systems.	2
4.2	Impulse and Reaction turbines- velocity triangles. Losses and efficiencies.	3
4.3	Turbine blade cooling- Internal air cooling, Impingement cooling, Film cooling, Transpiration cooling. Inlets- subsonic and supersonic inlets and Nozzles-thrust vectoring.	3
	Module 5 (9 Hours)	
5.1	System matching and Analysis- Compressor matching, Combustor matching.	3
5.2	Turbine matching, Nozzle matching. Operating line.	3
5.3	General matching procedures. Simple problems. Environmental impact of gas turbine engines.	3

Model Question Paper

QP CODE: B Pages: 2

Reg No.:___________________

Name:_____________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2T202

Course Name: Gas Turbines and Jet propulsion

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. With a neat sketch explain the working principle of an ideal Gas turbine cycle with intercooling, regeneration and reheat. Also draw the T-s diagram.
2. Derive the thrust equation for a general propulsion system.
3. Describe the phenomenon of surge and chocking in centrifugal compressors.
4. Discuss any two turbine blade cooling techniques.
5. Enumerate the reasons for “matching of components” in a Gas turbine engine.

PART B

Answer any five questions. Each question carries 8 marks.

6. A Brayton cycle works between 1 bar and 300 K and 5 bar, 1250 K. There are two stages of compression with perfect intercooling and two stages of expansion. The work output of the first expansion stage being used to drive the two compressors, where the interstage pressure is optimized for the compressor. The air from the first stage turbine is again heated to 1250 K and expanded. Calculate the power output of free power turbine and cycle efficiency without and with a perfect heat exchanger and compare them. Also calculate the percentage improvement in the efficiency because of the addition of heat exchangers.
7. The following data apply to a turbojet aircraft flying at an altitude of 6.1 km where the ambient conditions are 0.458 bar and 248 K

Speed of Aircraft	:	805km/h.
Pressure ratio of compressor	:	4:1

Combustion chamber pressure loss	:	0.21 bar
Turbine inlet temperature	:	1100 K
Intake duct Efficiency	:	95%
Isentropic Efficiency of compressor	:	0.85
Isentropic Efficiency of turbine	:	0.90
Mechanical Efficiency of transmission	:	99%
Nozzle Efficiency	:	95%
Nozzle outlet area	:	0.0935 m^2
L.C.V of fuel	:	43 MJ/kg

Find the thrust and SFC in kg/Nh of thrust. Assume convergent Nozzle. Take specific heat capacity of air and gas as 1.005 kJ/kgK and 1.147 kJ/kgK respectively and corresponding ϒ value as 1.4 and 1.33 respectively.

8. Air at 1.0132 bar and 288 K enters an axial flow compressor stage with an axial velocity 150 m/s. There are no inlet guide vanes. The rotor stage has a tip diameter of 60 cm and a hub diameter of 50 cm and rotates at 100 rps. The air enters the rotor and leaves the stator in axial direction with no change in velocity or radius. The air is turned to 30.2^0 as it passes through the rotor. Assume a stage pressure ratio of 1:2. Assuming constant specific heats and that air enters and leaves the blade at the blade angles,

    1. Construct the velocity diagram at mean diameter for this stage.
    2. Mass flow rate
    3. Power required and
    4. Degree of reaction.

9. a. Describe briefly the factors affecting combustion chamber design

    b. Discuss the combustion chamber geometry with a neat sketch, bringing out the various zones that play a part in the process of combustion.

10. Gas at 7 bar and 300^0C expands to 3 bar in an impulse turbine stage. The nozzle angle is 70^0 with reference to the exit direction. The rotor blades have equal inlet and outlet angles, and the stage operates with optimum blade speed ratio. Assuming that the isentropic efficiency of the nozzle is 0.9, and that the velocity at the entry to the stage is negligible, deduce the blade angle used and the mass flow required for this stage to produce 75 kW. Take C_p = 1.15 kJ/kgK.

11. Discuss the general matching procedure for a single-spool turbojet engine by clearly stating the assumptions taken.

12. Derive an expression for specific work output and the efficiency of a simple cycle with reheat. Explain through the derivations that how do the efficiency change when a regenerator is installed in the cycle.

Programme Elective 3

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E203A	**Alternative Fuels for IC Engine**	**Elective**	**3**	**0**	**0**	**3**	**3**

Preamble: Comprehending the engineering challenges and perspectives that impact alternative fuels compared to conventional fuels examining future trends and development, including hydrogen as an internal combustion engine fuel. Also exploring development of upcoming technologies in the domain of electric vehicles**.**

Prerequisite: A foundational understanding of thermodynamics, combustion chemistry, mechanical engineering principles, environmental science, energy systems, automotive engineering basics

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Understand potential alternative fuel and their characteristics.	Understand
CO 2	Select suitable substitute liquid fuels for SI engines in order to improve emission and combustion characteristics.	Apply
CO 3	Elaborate on the utilisation of Bio-Diesel and its types as a suitable fuel in CI engines	Appy
CO 4	Utilise different gaseous fuels and predict their performance and combustion characteristics in both SI and CI engines.	Analyse
CO 5	Select suitable substitute among the different EV technologies considering the environmental and societal needs.	Analyse

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1		1	3			1
CO 2	2	1	3	1		1
CO 3	2	1	3	1		1
CO 4	2	1	3	1		1
CO 5	1	1	3	1		1

Assessment Pattern

Course name	**Alternative Fuels for IC Engine**		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	20	20	20
Apply	40	40	40
Analyse	40	40	40
Evaluate	XX	XX	XX
Create	XX	XX	XX

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (7 Hours)

Overview. Availability, Suitability and properties of potential alternative Fuels – Ethanol, Methanol, DEE, DME, Hydrogen, LPG, Natural Gas, Producer Gas, Bio gas and Bio-diesel, Properties, Merits and Demerits.

MODULE 2 (7 Hours)

Alternate Liquid Fuels for SI Engines. Requirements of alternative fuels for SI engines- Utilization of alternative liquid fuels in SI engine in neat and blend form – Manufacturing methods - Engine modifications – Engine Performance and Emission Characteristics of alternative liquid fuels.

MODULE 3 (7 Hours)

Alternate Liquid Fuels for CI Engines. Requirements of alternative fuels for CI engines- Manufacturing of biodiesel – Blends and fuel modifications to suit CI engines, Emulsions, Dual fueling, Ignition accelerators and other additives– Engine Performance and emission characteristics.

MODULE 4 **(8 Hours)**

Alternate Gaseous Fuels for SI and CI Engines. Production of hydrogen from natural gas and producer gas from biomass.

Use of Hydrogen, CNG, LPG, Natural Gas, and Bio gas in SI engines– Safety Precautions – Engine performance and emission characteristics.

Use of Hydrogen, Producer Gas, Biogas, LPG, CNG in CI engines. Engine performance and emission characteristics.

MODULE 5 (7 Hours)

Electric Vehicle Technology. Societal requirements for a sustainable electric vehicle transport system – Battery Electric vehicles (BEVs), Hybrid electric vehicles (HEVs), Hydrogen powered fuel cell electric vehicles (FCEVs) – Challenges of BEVs and FCEVs – Environmental impacts of BEVs and FCEVs.

Reference Books

1. S.S. Thipse, “Alternative Fuels”, Jaico Publishing House, 2010
2. Desai Ashok V, “Alternative Liquid Fuels”, New Age International publisher, 2008
3. Keith Owen, Trevor Eoley, “Automotive Fuels Handbook”, SAE Publications, 1990
4. C.E (Sandy) Thomas, “Sustainable Transport Options for 21st Century and Beyond”, Springer, 2015
5. B. P. Pundir, “Engine Emissions: Pollutant formation and Advances in Control Technology”, Narosa Publishing House, 2007

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (7 Hours)	
1.1	**Overview-** Availability and Suitability of potential alternative Fuels	2
1.2	Properties of potential alternative Fuels - Methanol, Ethanol, DEE and DME	2
1.3	Properties of potential alternative Fuels - Hydrogen, LPG, Natural Gas, Producer Gas, Bio gas and Bio-diesel	2

1.4	Merits and Demerits.	1
	Module 2 (7 Hours)	
2.1	**Alternate Liquid Fuels for SI Engines** - Requirements of alternative fuels for SI engines-	1
2.2	Utilization of alternative liquid fuels in SI engine in neat and blend form	1
2.3	Manufacturing methods	2
2.4	Engine modifications	2
2.5	Engine Performance and Emission Characteristics of alternative liquid fuels	1
	Module 3 (7 Hours)	
3.1	**Alternate Liquid Fuels for CI Engines** - Requirements of alternative fuels for SI engines	1
3.2	Utilization of alternative liquid fuels in SI engine in neat and blend form	1
3.3	Manufacturing methods	2
3.4	Engine modifications	2
3.5	Engine Performance and Emission Characteristics of alternative liquid fuels.	1
	Module 4 (8 Hours)	
4.1	**Alternate Gaseous Fuels for SI and CI Engines -** Production of hydrogen from natural gas and producer gas from biomass.	2
4.2	Use of Hydrogen, CNG, LPG, Natural Gas, and Bio gas in SI engines– Safety Precautions	2
4.3	Engine performance and emission characteristics.	2
4.4	Use of Hydrogen, Producer Gas, Biogas, LPG, CNG in CI engines. Engine performance and emission characteristics	2
	Module 5 (7 Hours)	
5.1	**Electric Vehicle Technology -** Societal requirements for a sustainable electric vehicle transport system	1
5.2	Battery Electric vehicles (BEVs), Hybrid electric vehicles (HEVs),	2
5.3	Hydrogen powered fuel cell electric vehicles (FCEVs)	2
5.4	Challenges of BEVs and FCEVs – Environmental impacts of BEVs and FCEVs.	2

Model Question Paper

QP CODE:C Pages: 1

Reg No.:__________________

Name:____________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2E203A
Course Name: Alternative Fuels for IC Engine

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. Why hydrogen is called as fuel of 21st century. Give reasons
2. Compare the emissions from a petrol engine with hydrogen fuelled engine.
3. What is emulsion? What are the types of emulsion? Explain
4. What is shale gas? How is shale gas different from natural gas?
5. What are factors affecting the performance of batteries used in EVs?

PART B

Answer any five questions. Each question carries 8 marks.

6. Which are the important parameters to be considered in the selection of suitable alternative fuel? Discuss.
7. What are the effects on volumetric efficiency and specific fuel consumption when petrol is replace with M85 gasohol.
8. What are the essential properties of an ideal SI engine fuel? How these properties get influenced by the blending of an equal amount of ethanol with petrol.
9. Explain the Haldor Topse process of Methanol manufacturing.
10. Explain transesterification process with the help of neat diagram.
11. Explain the working of an downdraft gasifier used for the generation of producer gas.
12. What are the supporting subsystems in an electric and hybrid vehicle?

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E203B	**Thermal Power plant Design**	**Elective**	**3**	**0**	**0**	**3**	**3**

Preamble: The Thermal Power Plant Design introduces essential principles and practices for designing and optimizing thermal power plants, covering thermodynamic cycles, heat transfer, fluid mechanics, and system design. Through theoretical learning and practical applications, students acquire skills to conceptualize and engineer efficient and sustainable thermal power generation systems.

Prerequisite: Thermodynamics, Heat transfer, Fluid mechanics.

Course Outcomes: After the completion of the course the student will be able to

CO No.	CO statements	Cognitive Knowledge Level
CO 1	Learn about thermal power plant components, thermodynamic cycles, efficiency calculations, and problem-solving skill set for analyzing and optimizing power generation systems.	Understand
CO 2	Analyze, design, and optimize steam generation systems, encompassing boiling mechanisms, boiler classifications, system designs, and insulation requirements.	Analyse
CO 3	Analyze and optimize combustion systems across different fuel types and industrial applications.	Analyse
CO 4	Comprehend steam turbines, including types and governing mechanisms with due considerations on Condenser variations, and Auxiliary systems.	Apply
CO 5	Gain exposure to modeling and simulation techniques applied in thermal power plants, as well as insights into the energy sector in India, its policy decisions, and the environmental ramifications associated with the installation of such facilities.	Evaluate

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2		2		3	1
CO 2	2	1	2		2	
CO 3	2	1	2		2	
CO 4	2	1	2		2	
CO 5	1	1	2	3	3	

Assessment Pattern

Course name	**Thermal Power Plant Design**		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	10	10	10
Apply	30	30	30
Analyze	40	40	40
Evaluate	20	20	20
Create	XX	XX	XX

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (7 Hours)

Thermal power plant – major components and working. Thermodynamic cycle-Rankine cycle, ideal and real cycle, Reheat and regeneration. T-s and P-V diagrams. Work done and efficiency calculation. Supercritical cycles, Combined cycles. Numerical problems to find the efficiency of the plant.

MODULE 2 (7 Hours)

Steam generators: Boiling - pool boiling, Forced convection boiling, DNB, Circulation. Design-water and steam circuit, Draft system and Heat recovery system. Classification-Fire tube boiler and water tube boiler, subcritical and supercritical boiler-advantages and disadvantages only. Design of thermal insulation.

MODULE 3 (7 Hours)

Fuels: solid, liquid and gas (commonly used fuels). Principles of combustion-combustion calculations. Burners- difference in design for solid liquid and gas. Fluidized bed combustion-different categories (BFBC CFBC and PFBC-basic idea only), advantages and disadvantages. Electrostatic precipitator.

MODULE 4 (7 Hours)

Steam turbines: Impulse and reaction turbine. Compounding of turbines. Governing-Throttle, Nozzle and bypass. Droop in speed governing system(concept). Condensers-direct contact and surface condenser. Auxiliary systems-Deaerators, Cooling tower.

MODULE 5 (8 Hours)

Modelling and simulation-Simplified modelling of Boiler, Governing equations. Test case using OpenModelica (basic understanding).

Indian energy scenario. Role of Central Electricity Authority (CAE). Thermal power plants installed in India -coal based power plants, Natural gas based, Oil based, Renewable energy-based power plants. Environmental impacts in operating a thermal power plant. Load duration curves- Base load, Intermediate load, Peak load.

Reference Books

1. P K. Nag, "Power Plant Engineering", McGraw Hill, 2017.
2. Dipak K. Sarkar, "Thermal Power Plant-Design and Operation.", Elsevier, 2015.
3. M.M. El Wakil, "Power Plant Technology", McGraw Hill, 1984.
4. Baligh El Hefni, Daniel Bouskela,"Modelling and Simulation of Thermal Power Plants with ThermoSysPro", Springer, 2019.
5. Xingrang Liu and Ramesh Bansal, "Thermal Power Plants-Modelling, Control and Efficiency improvement", CRC Press NY, 2016.
6. Dipak K. Sarkar, "Thermal Power Plants-Pre-Operational Activities", Elsevier, 2017.
7. Rolf Kehlhofer et.al, "Combined-Cycle Gas & Steam Power Plant", PennWell, 2009.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (7 Hours)	
1.1	Thermal power plant – major components and working-Boiler, Steam turbine, Generator, Condenser, Cooling tower, Feedwater pump. Simple working principle-Fuel combustion, Steam generation, Turbine operation, Electricity generation, Condensation, Water recycling.	2
1.2	Rankine Cycle-Ideal and Real. Simple cycle, Superheat cycles, Reheat cycles, Regenerative cycles. P-V and T-s diagram. Work done efficiency calculation. Comparison with Carnot cycle. Numerical problems.	3
1.3	Supercritical cycles-T-s diagram, advantages and disadvantages compared to superheat Rankine cycle. Combined cycles using Gas turbine and steam turbine power plant. Schematic and T-s diagram. Advantages of combined cycle power generation.	2
	Module 2 (7 Hours)	
2.1	Steam generators: Stages of boiling- natural convection, sub-cooled nucleate boiling, Nucleate boiling, onset of film boiling,	2

	unstable film boiling and stable film boiling. Pool boiling and forced convection boiling(difference), DNB (concept), Circulation-downcomer and riser in a drum type boiler.	
2.2	Water and steam circuit-heat transfer surfaces and evaporation zone. Steam drum separation-gravity, baffle and screen, cyclone and scrubber. Draft system- natural, forced and induced draft system. Heat recovery system-Economizer and air pre heater system.	3
2.3	Classification-Fire tube boiler and water tube boiler, subcritical and supercritical boiler-advantages and disadvantages only. Design of thermal insulation-insulation materials, simple numerical problems. Boiler mountings and accessories	2
Module 3 (7 Hours)		
3.1	Fuels: solid-different grades of coal, coal properties. Liquid-petroleum liquid fuels, Paraffins, Naphthene, Aromatics. Commercial grades of fuel oil-HSD, LDO, HFO, FO, LSHS. Physical properties for fuel oil in boilers. Gas- Natural and Petroleum gas, gas derived from industrial waste and biomass, synthetic fuels, coal gasification.	2
3.2	Principles of combustion-combustion calculations, simple numerical problems.	3
3.3	Burners- Pulverized coal burners, Distributed mixing burner, low NOx burners. Fuel oil burner-atomization. Burner arrangement-turbulent burners, straight flow burners. Fluidized bed combustion-different categories (BFBC CFBC and PFBC-basic idea only), advantages and disadvantages. Electrostatic precipitator	2
Module 4 (7 Hours)		
4.1	Steam turbines: Impulse and reaction turbine. Compounding of turbines-pressure compounding, number of stages required for an enthalpy drop, velocity compounding, velocity triangles, stage efficiency. Numerical problems.	3
4.2	Governing-Methods of governing-Throttle, Nozzle and bypass. Droop in speed governing system(concept).	2
4.3	Condensers-direct contact- Spray, Barometric and Jet condenser. Surface condenser- design calculations, air removal. Auxiliary systems-Deaerators, closed feed water heater, Cooling tower- wet cooling towers, dry cooling towers, cooling tower calculations.	2
Module 5 (7 Hours)		
5.1	Modelling and simulation-Simplified modelling of Boiler - modelling principles. Governing equations- mass and energy	4

	balance. Test case using OpenModelica (basic understanding)-parameterization and implementing the boundary conditions, simulation, results. (The intention is to give a familiarization of the modern design process of a power plant.)	
5.2	Indian energy scenario. Role of Central Electricity Authority (CEA). Thermal power plants installed in India -coal based power plants, Natural gas based, Oil based, Renewable energy-based power plants. Environmental impacts in operating a thermal power plant.	2
5.3	Load duration curves- load factor, capacity factor, reserve factor, demand factor, diversity factor. Base load, Intermediate load, Peak load.	2

Model Question Paper

QP CODE: C Pages: 3

Reg No.:____________________

Name:______________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2E203B

Course Name: Thermal Power Plant Design

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. Illustrate the contrast between the reheat Rankine cycle and the regenerative Rankine cycle through a schematic and a process diagram.
2. In a boiler system, both economizer and reheater are utilized for recovering waste heat, yet each serves a unique function. Clarify the given statement.
3. Enumerate the advantages and disadvantages of fluidized bed combustion boilers compared to conventional boilers.
4. The concept of 'Droop' is a fundamental aspect of turbine governing systems designed to ensure stable operation and effective load sharing in power generation systems. Elaborate.
5. Explain the terms load factor, capacity factor, reserve factor and demand factor in the context of power plant load calculations.

PART B

Answer any five questions. Each question carries 8 marks.

6. The net power output of an ideal reheat regenerative steam cycle is 80 MW. Steam enters the h.p turbine at 80 bar, 500^{0}C and expands till it becomes saturated vapour. Some of the steam then goes to a open feedwater heater and the balance is reheated to 400^{0}C, after which it expands in an l.p turbine to 0.07bar. Compute (a) the reheat pressure, (b) the steam flow rate to the h.p turbine, (c) the cycle efficiency and (d) the rate of flow of cooling water in the condenser if the temperature rise of the water is 8^{0}C, (e) If the velocity of the steam flowing from the turbine to the condenser is limited to 130 m/s, find the diameter of the connecting pipe.

7. In a once-through boiler, feedwater enters through the bottom of tubes, receives heat from combustion of coal, and escapes from the top of the tubes as superheated steam. Calculate the heat transfer coefficients of water and superheated steam using the following data: Pressure of feedwater at tube inlet = 27 MPa; Absolute temperature of feedwater = 563 K; Pressure of superheated steam at tube outlet = 24.5 MPa; Absolute Temperature of superheated steam = 838 K; Velocity of Feedwater through each tube = 6 m/s; Internal diameter of each tube = 63.5 mm; Length of pipe = 30 m.

8. In an oil-fired boiler the fuel had an analysis by mass: Carbon 84%, Hydrogen 10%, Sulphur 3.2%, Oxygen 1.6%, remainder incombustible. The analysis of dry flue gas by volume gave: combined CO_2 + SO_2 15.72%, O_2 1%, there being no CO or SO_3. Calculate per kg of fuel (a) mass of air supplied, (b) percentage excess air supplied, (c) mass of dry flue gas formed, and (d) mass of water vapour formed.

9. With a neat sketch explain the working of a Circulating fluidized bed combustion system (CFBC) and a Pressurized fluidized bed combustion system (PFBC).

10. Water at 30^0C flows into a cooling tower at the rate of 1.15 kg per kg air. Air enters the tower at dbt of 28^0C and 90% relative humidity. Make up water is supplied at 20^0C. Determine (a) the temperature of water leaving the tower, (b) the fraction of water evaporated, and (c) the approach and range of the cooling tower.

11. (a) Distinguish between subcritical and supercritical Boilers.

(b) Steam at a temperature of 623 K is flowing through a pipe with an outer diameter of 100 mm. The pipe is insulated with 20 mm thick mineral wool, the average thermal conductivity of which is 0.055 W/m K. Determine the outside surface temperature of mineral wool if the ambient air temperature is 300 K. Assume the hot-surface temperature of the mineral wool is the same as that of the flowing steam and the value of the surface coefficient of the insulating material is 30 W/m^2 K.

12. (a) In the context of the Indian energy scenario, what are the key challenges and opportunities associated with the integration of renewable energy sources into the existing power grid?

(b) How does the Central Electricity Authority (CEA) of India contribute to the regulation and planning of thermal power plants, and what measures does it implement to address environmental concerns associated with their operation?

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E203C	**Design of Heat Transfer Equipments**	**Elective**	**3**	**0**	**0**	**3**	**3**

Preamble: Make the students to design heat transfer equipments by integrating heat transfer physics design concepts.

Prerequisite: A foundation course in Heat and Mass Transfer

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Analyse the performance of various heat exchangers.	Analyze
CO 2	Design a shell and tube heat exchanger.	Apply
CO 3	Design a plate and frame heat exchanger.	Apply
CO 4	Evaluate the performance of regenerators and compact heat exchangers.	Evaluate
CO 5	Evaluate the performance of cooling towers and heat pipes.	Evaluate

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	1	3	1	1	1
CO 2	2		3	3	3	1
CO 3	2		3	3	3	1
CO 4	2		3	3	3	1
CO 5	2		3	3	3	1

Assessment Pattern

Course name	**Design of Heat Transfer Equipments**		
Bloom's Category	**Continuous Assessment Tests**		**End SemesterExamination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	10	10	10
Apply	40	40	40
Analyse	30	30	30
Evaluate	20	20	20
Create	XX	XX	XX

Mark Distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project : 10 marks

Course based task/Seminar/Quiz : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (7 Hours)

Classification and selection of heat exchangers: Heat transfer and flow friction characteristics, pressure drop analysis, Basic thermal design, Theory of heat exchangers, ε-NTU, P-NTU and LMTD methods, F-factor for various configurations.

MODULE 2 (7 Hours)

Shell and tube heat exchangers: Construction and thermal features, Different types of shell and tube heat exchangers, Tube layout, Baffles spacing, Thermal design procedure, Kern method, Bell Delaware method.

MODULE 3 (7 Hours)

Plate heat exchangers: Construction and thermal features, Flow configurations, Limitations, Applications, Analysis of plate heat exchangers, Rating and sizing of plate heat exchangers.

MODULE 4 (8Hours)

Thermal design of regenerators: Classifications**,** Governing equations, Design parameters. **Compact heat exchangers:** Classifications and selection, Design of plate fin heat exchangers, Design of tube fin heat exchangers.

MODULE 5 (7 Hours)

Direct contact heat exchangers: Classifications and types of cooling towers, Cooling tower requirements, Diffusion theory, Design of cooling towers.

Heat pipes: Working principle, Types of heat pipes, Applications.

Reference Books

1. Donald Q. Kern, “Process Heat Transfer”, McGraw-Hill.1997.
2. Ozisik M.N., “Heat transfer. A Basic Apprroach”, McGraw-Hill, 1988.
3. P.K Nag, “Heat and Mass Transfer”, Tata McGraw-Hill
4. Nicholas Cheremisinoff, Cooling Tower: Selection, Design and Practice”, Ann Arbor Science pub. 1981.
5. Ramesh K. Shah and Dusan P. Sekulic, “Fundamentals of Heat Exchanger Design”. Wiley India (P) Ltd.
6. TEMA Hand book, “Tubular Exchanger Manufacturer Association”. New York, 1981.
7. T. Kuppan, “Heat exchanger design hand book”, Taylor & Francis, 2009.
8. Sarit K. Das, “Process Heat Transfer”, Narosa Publishing House.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (7 Hours)	
1.1	Heat transfer and flow friction characteristics, pressure drop analysis.	1
1.2	Basic thermal design, Theory of heat exchangers.	2
1.3	ε-NTU, P-NTU and LMTD methods.	2
1.4	F factor for various configurations.	2
	Module 2 (7 Hours)	
2.1	Construction and thermal features, Different types of shell and tube heat exchangers.	1
2.2	Tube layout, Baffles spacing, Thermal design procedure.	2
2.3	Kern method.	2
2.4	Bell Delaware method.	2

Module 3 (7 Hours)		
3.1	Construction and thermal features, Flow configurations.	2
3.2	Limitations, Applications, Analysis of plate heat exchangers.	2
3.3	Rating and sizing of plate heat exchangers.	3
Module 4 (8 Hours)		
4.1	Classifications, Governing equations.	2
4.2	Design parameters.	2
4.3	Classifications and selection, Design of plate fin heat exchanger.	2
4.4	Design of tube fin heat exchanger.	2
Module 5 (7 Hours)		
5.1	Classifications and types of cooling towers.	1
5.2	Cooling tower requirements, Diffusion theory.	2
5.3	Design of cooling towers.	2
5.4	Working principle, Types of heat pipes, Applications.	2

Model Question Paper

QP CODE: C Pages: 2

Reg No.:______________________

Name:________________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

***Course Code:* M24ME2E203C**

Course Name: Design of Heat Transfer Equipments

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries* 4 *marks.

1. Explain the parameters for selection of heat exchangers.
2. Analyze the role of baffles used in shell and tube heat exchangers.
3. List the advantages and disadvantages of plate heat exchangers.
4. Analyze single blow test technique in regenerators.
5. Explain diffusion theory.

PART B

Answer any five questions. Each question carries 8 marks.

6. In a double pipe parallel flow heat exchanger, hot exhaust gases of specific heat 1300 J/kg-K flowing at the rate of 0.3 kg/s is cooled from 460^{O}C to 180^{O}C. The cooling is done by water with specific heat 4180 J/kg-K entering the unit at 0.42 kg/s and 20^{O}C. The overall heat transfer coefficient of the exchanger is 140 W/m^2-K. Determine the surface area of the exchanger by Effectiveness-NTU method.
7. A shell and tube heat exchanger with 2-shell passes and 4-tube passes is used for cooling oil from 125^{O}C to 55^{O}C. The coolant is water which enters the shell side at 25^{O}C and leaves at 46^{O}C. The overall heat transfer coefficient is 900 W/m^2-K. The flowrate of oil is 10 kg/s. The specific heats of oil and water are 2000 J/kg-K and 4178 J/kg-K respectively. Determine the heat transfer area of the heat exchanger.
8. A shell and tube heat exchanger is to be designed to sub-cool the condensate of a methanol condenser from 90^{O}C to 40^{O}C. The flow rate of methanol is 120000 kg/h. Water will be used as the coolant, with a temperature rise from 30^{O}C to 50^{O}C. Kern’s method should be used for the shell side design.

9. A heat exchanger is required to heat 10 kg/s of fluid from 20^{O}C to 100^{O}C using waste heat from water, cooling from 90^{O}C to 55^{O}C. Assume that the plates are 1m by 0.25 m in size with spacing between them of 5 mm. Determine the number of plates required for a one pass configuration and for a two-pass arrangement.

10. A fixed bed regenerator consists of two vessels containing slabs of a refractory material, each 19 m high, 2 m wide and 18 cm thick, and having 7 cm of gap between the slabs. Air at 20^{O}C is to be preheated using waste gas at 1100^{O}C. The flow velocity is 20 m/s and flow rate is assumed to be same on both heating and cooling stages. Determine the air outlet temperature for a cooling period of 60 minutes.

11. A finned tube compact heat exchanger having the core configuration CF7.0-5/8 J. The core is fabricated from aluminium and the tubes have an inside diameter of 14 mm. In a waste heat recovery application, water flow through the tubes provides an inside convection coefficient of 1400 W/m^{2}K, while combustion gases at 1 bar and 800 K are in cross flow over the tubes. If the gas flow rate is 1.5 kg/s and the frontal area is 0.25 m^2, determine the gas side overall heat transfer coefficient. If a water flow rate of 1 kg/s is to be heated from 300 to 400 K, determine the required heat exchanger volume.

12. Explain the classifications of cooling towers with figures.

Programme Elective 4

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E204A	Solar Thermal Energy Systems	Elective	3	0	0	3	3

Preamble: This course serves as a comprehensive introduction to the principles, technologies, applications, and advancements within the realm of solar thermal energy. Through a combination of theoretical knowledge, practical applications, and case studies, participants will develop a holistic understanding of how solar thermal energy systems function and their diverse array of applications across various sectors.

Prerequisite: Foundation knowledge in physics and thermodynamics along with a familiarity in renewable energy concepts.

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Understand solar radiation principles and measurement techniques essential for optimizing solar energy systems design and performance.	Understand
CO 2	Analyse various solar energy collection methods, including flat plate and concentrating collectors, focusing on their construction, efficiency and thermal analysis for optimal utilization of solar energy.	Analyse
CO 3	Acquire knowledge and skills to design, analyze, and assess the efficiency and economic viability of solar air and water heaters.	Analyse
CO 4	Evaluate diverse methods of solar energy storage, emphasizing considerations such as quality, capacity, and duration of storage.	Evaluate
CO 5	Evaluate solar thermal systems and applications focusing on power output and conversion efficiency.	Evaluate

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	1	1			1
CO 2	2	1	1	2	2	1
CO 3	2	1	1	2	2	1
CO 4	1	1	1	1	1	1
CO 5	1	1	1			1

Assessment Pattern

Bloom's Category	SOLAR THERMAL ENERGY SYSTEMS		
	Continuous Assessment Tests		End Semester Examination (Marks %)
	Test 1 (Marks %)	Test 2 (Marks %)	
Remember	XX	XX	XX
Understand	20	20	10
Apply	40	40	40
Analyse	30	30	30
Evaluate	10	10	10
Create	XX	XX	XX

Mark Distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project/Data

Collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course.

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contains 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (7 Hours)

Solar radiation: Energy from the sun, Solar constant, Spectral distribution of extra-terrestrial radiation, Revolution of earth, Seasons, Basic earth sun angles, Diffuse and direct radiation, Solar radiation under actual conditions, Air mass, Solar radiation on horizontal and inclined surfaces, Shading, Sun path diagram, Concept of time, Standard time, Solar time, Day length, Hourly, daily and monthly average solar radiation, Measurement of solar radiation, Pyrheliometers, Pyranometers, Sunshine recorder

MODULE 2 (8 Hours)

Collection of Solar Energy: Greenhouse effect, Flat plate collectors, Classification and construction, Thermal losses and collector efficiency, Thermal analysis of flat plate collectors, Collector performance, Heat removal factor, Concentrating collectors, Classification of concentrators, Orientation and sun tracking systems, Cylindrical parabolic collector, Thermal analysis, Compound parabolic collector, Paraboloid dish collector, Central receiver collector.

MODULE 3 (7 Hours)

Solar air and water heaters: Solar air heaters, Description and classification, Non-porous absorber plate type air heaters, Air heaters with porous absorbers, Thermal analysis, Two pass solar air heaters, Air heaters with finned absorbers, Solar water heaters, Non-porous absorber plate type collectors, Thermal analysis, Natural circulation and forced circulation water heaters, Integral collector storage systems, Testing and rating of solar water heaters, Economics of solar water heating.

MODULE 4 **(7 Hours)**

Solar energy storage: Thermal, mechanical, electrical and chemical methods of storage, Quality, capacity and duration of storage, Sensible heat storage, Liquid, Solid, packed bed, Latent heat storage, Phase change materials for storage, Thermochemical storage, Energy storage in building materials, Energy storage using solar ponds.

MODULE 5 (7 Hours)

Solar thermal systems: Solar heating systems, Passive and active systems, Solar house, Solar cooling systems, Solar drying, Solar cooking, Solar distillation, Solar thermal power plant, Solar thermal energy for process heating, Solar thermal electric systems, Solar photovoltaic cells, Photovoltaic principles, Power output and conversion efficiency.

Reference Books

1. John A. Duffie, William A. Beeckman, "Solar Engineering of Thermal Processes", John Wiley & Sons, Inc.
2. Ibrahim Dincer, Marc A. Rosen, "Thermal Energy Storage Systems and Applications", 3rd Edition,Wiley .
3. G.N. Tiwari, "Solar Energy: Fundamentals, Design, Modelling and Applications", Narosa Publishing House.
4. D.Y. Goswami, F Kreith and J.F. Krieder, "Principles of Solar Engineering", Taylor and Francis, Philadelphia, 2000
5. J. Twidell and T. Weir, "Renewable Energy Resources", E & F.N. Spon Ltd, London, 1986.
6. G.D.Rai, "Solar Energy Utilisation", Khanna Publishers.
7. S.P Sukhatme, "Solar Energy - Principles of Thermal Collection and Storage", Tata Mc-Graw Hill Publishing Company Limited.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (7 Hours)	
1.1	Energy from the sun, Solar constant, Spectral distribution of extra-terrestrial radiation, Revolution of earth.	2
1.2	Seasons, Basic earth sun angles, Diffuse and direct radiation, Solar radiation under actual conditions, Air mass, Solar radiation on horizontal and inclined surfaces.	2

1.3	Shading, Sun path diagram, Concept of time, Standard time, Solar time, Day length, Hourly, daily and monthly average solar radiation.	2
1.4	Measurement of solar radiation, Pyrheliometers, Pyranometers, Sunshine recorder.	1
Module 2 (8 Hours)		
2.1	Greenhouse effect, Flat plate collectors, Classification and construction.	2
2.2	Thermal losses and collector efficiency, Thermal analysis of flat plate collectors, Collector performance, Heat removal factor.	2
2.3	Concentrating collectors, Classification of concentrators, Orientation and sun tracking systems, Cylindrical parabolic collector.	2
2.4	Thermal analysis, Compound parabolic collector, Paraboloid dish collector, Central receiver collector.	2
Module 3 (7 Hours)		
3.1	Solar air heaters, Description and classification, Non-porous absorber plate type air heaters, Air heaters with porous absorbers, Thermal analysis, Two pass solar air heaters.	3
3.2	Air heaters with finned absorbers, Solar water heaters, Non-porous absorber plate type collectors, Thermal analysis.	2
3.4	Natural circulation and forced circulation water heaters, Integral collector storage systems, Testing and rating of solar water heaters, Economics of solar water heating.	2
Module 4 (7 Hours)		
4.1	Thermal, mechanical, electrical and chemical methods of storage, Quality, capacity and duration of storage, Sensible heat storage.	2
4.2	Liquid, Solid, packed bed, Latent heat storage, Phase change materials for storage, Thermochemical storage.	3
4.3	Energy storage in building materials, Energy storage using solar ponds.	2
Module 5 (7 Hours)		
5.1	Solar heating systems, Passive and active systems, Solar house, Solar cooling systems, Solar drying, Solar cooking.	2
5.2	Solar distillation, Solar thermal power plant, Solar thermal energy for process heating.	2
5.3	Solar thermal electric systems, Solar photovoltaic cells, Photovoltaic principles, Power output and conversion efficiency.	3

Model Question Paper

CODE: D Pages: 1

Reg No.:______________

Name:________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2E204A

Course Name: Solar Thermal Energy Systems

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. Analyse the spectral distribution of extra-terrestrial radiation.
2. Explain the sun tracking systems.
3. Explain the working principle of natural circulation water heater.
4. Analyse thermochemical storage of solar thermal energy.
5. Analyse passive and active systems.

PART B

Answer any five questions. Each question carries 8 marks.

6. Determine the average value of total radiation on a horizontal surface at latitude $22^0 13'$N and longitude$73^0 13'$E during the month of March. The constants a and b are equal to 0.28 and 0.48 respectively and average sunshine hours per day is 10.15.
7. Determine the top loss coefficient for a single glass cover with the following specifications: Plat emittance = 0.94, Plate to cover spacing = 2.54 cm, Ambient temperature =25^{O}C, Wind speed = 10 m/s, Mean plate temperature = 70^{O}C, Back insulation thickness = 5 cm, Insulation conductivity = 0.045 W/m-K. Collector tilt = 30^{O}.
8. Analyse the thermal losses in a flat plate solar collector.
9. Analyse the different types of non-porous absorber plate type collectors.
10. Explain solar thermal power generation system with concentrating collectors.
11. Explain the working of solar pond.
12. Explain the classification of solar cooling systems.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E204B	Combustion and Emissions in IC Engines	Elective	3	0	0	3	3

Preamble: A comprehensive examination of combustion fundamentals, emission reduction strategies, and the integration of electric propulsion systems, this course aim to equip learners with a profound understanding of the present and future landscape of combustion engineering.

Prerequisite: A foundational understanding of thermodynamics, fluid mechanics, and basic principles of IC engine technology is recommended.

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Demonstrate proficiency in understanding the fundamental principles of combustion and to analyze and mitigate harmful effects associated with combustion processes.	Apply
CO 2	Analyze normal and up normal combustion phenomena specific to spark ignition engines, while exploring the design considerations of combustion chambers and the implementation of advanced combustion systems.	Analyse
CO 3	Master the intricacies of normal and up normal combustion in compression ignition engines, while exploring aftertreatment solutions tailored to mitigate emissions from diesel engines.	Apply
CO 4	Understand the major and minor pollutants, their impacts, and formation mechanisms in both SI and C engines, while exploring emission control technologies. Also acquire proficiency in detection methods for monitoring emissions.	Analyse
CO 5	Understand the concept of emission controls and engine modifications when alternate fuels are used.	Analyse

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1	1	3	1	1	
CO 2	1	1	3	1	1	1
CO 3	1	1	3	2	1	1
CO 4	1	1	3	1	2	1
CO 5	1	1	3	1	1	1

Assessment Pattern

	Combustion and Emissions in IC Engines		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	10	10	10
Apply	30	30	30
Analyse	60	60	60
Evaluate	XX	XX	XX
Create	XX	XX	XX

Mark distribution

Total Marks	CIA marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project : 10 marks

Course based task/Seminar/Quiz : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

MODULE 1 (7 hours)

Combustion of fuel, Combustion principles, Ricardo's theory of Combustion, Combustion equations of fuels, Stoichiometric Ratio, Air Fuel Ratio. Flame velocity, Flame Propagation. Laminar and Turbulent Flame Propagation in Engines (Assignment), Chemical equilibrium and dissociation-harmful effects Specific heat values during combustion.

MODULE 2 (7 hours)

Combustion in Spark Ignition engine, Compression ratio used, Stages of Combustion in SI engines, Theoretical and actual P-Ɵ diagram, Normal and Abnormal combustion, Flame structure and speed, Cycle by cycle variations in pressure, knocking combustion, pre-ignition, knock and engine variables. Features and various design consideration of combustion chambers. Stratified Charge combustion system and Lean Burn Combustion, After treatment devices for SI engines.

MODULE 3 (8 hours)

Combustion in Compression Ignition engine, Compression ratio used, Stages of Combustion in CI engines, Theoretical and actual P-Ɵ diagram, Spray formation at different injection pressures and droplet vaporization, Swirl Motion, Direct and indirect injection systems, Detonation and its undesirable effects, Flame structure and speed, Cycle by cycle variations in pressure with normal injection and CRDI mode, Design considerations and features of CI engine combustion chambers, After treatment devices for diesel engines.

MODULE 4 **(8 hours)**

Emissions- Major pollutants in engine exhaust, Effect of pollutant emissions on environment and human beings, Unburned Hydrocarbons, sources, formation in SI and CI engines, CO, NOx and Soot formation in SI and CI engines, Particulate Matter in Diesel Engines, Particulate Traps, Catalytic Convertors- One way, Two way and Three-way Catalytic convertors, Emission control measures for HC and CO emissions from SI and CI engines.

MODULE 5 (8 hours)

Exhaust Gas Recirculation - EGR on engine emissions, Urea-SCR injection for NOx reduction, Engine modifications to reduce emissions. Engine modifications for alternate fuels (liquid and gaseous fuels), HCCI- Homogenous Charge Compression Ignition engines. Additives for enhancing performance and pollution control.

Text Books

1. John B.Heywood, "Internal Combustion Engine Fundamentals", McGraw Hill Book, 1998

2. Ganesan, V, "Internal Combustion Engines", Tata McGraw Hill Book Co., 2003.

3. Obert,E.F., "Internal Combustion Engine and Air Pollution", International Text Book Publishers, 1983.

4. Mathur,M.L., and Sharma,R.P., "A Course in Internal Combustion Engines", DhanpatRai Publications, 1993.

5. Ramalingam, K.K., "Internal Combustion Engines", Scitech Publications (India) Pvt. Ltd., 2004.

6. Cohen,H, Rogers,G,E.C, and Saravanamuttoo, H.I.H., "Gas Turbine Theory", Longman Group Ltd., 1980.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
	Module 1 (7 Hours)	
1.1	Combustion of fuel, Combustion principles	1
1.2	Ricardo's theory of Combustion, Combustion equations of fuels	1
1.3	Stoichiometric Ratio, Air Fuel Ratio	1
1.4	Flame velocity, Flame Propagation	1
1.5	Laminar and Turbulent Flame Propagation in Engines (Assignment)	1
1.6	Chemical equilibrium and dissociation, its harmful effects	1
1.7	Specific heat values during combustion	1
	Module 2 (7 Hours)	
2.1	Combustion in Spark Ignition engine, Compression ratio used	1
2.2	Stages of Combustion in SI engines, Theoretical and actual P-Ө diagram	1
2.3	Normal and Abnormal combustion	1
2.4	Flame structure and speed, Cycle by cycle variations in pressure	1
2.5	Knocking combustion, pre-ignition, knock and engine variables	1
2.6	Features and various design consideration of combustion chambers.	1
2.7	Stratified Charge combustion system and Lean Burn Combustion, After treatment devices for SI engines	1
2.8	After treatment devices for SI engines	1
	Module 3 (7 Hours)	
3.1	Combustion in Compression Ignition engine, Compression ratio used	1
3.2	Stages of Combustion in CI engines, Theoretical and actual P-Ө diagram	1
3.3	Spray formation at different injection pressures and droplet vaporization	1
3.4	Swirl Motion, Direct and indirect injection systems	1
3.5	Detonation and its undesirable effects	1
3.6	Flame structure and speed, Cycle by cycle variations in pressure with normal injection and CRDI mode	1

3.7	Design considerations and features of CI engine combustion chambers, After treatment devices for diesel engines	1
Module 4 (8 Hours)		
4.1	Emissions- Major pollutants in engine exhaust, Effect of pollutant emissions on environment and human beings	1
4.2	Unburned Hydrocarbons, sources, formation in SI and CI engines	1
4.3	CO, NOx and Soot formation in SI and CI engines	1
4.4	Particulate Matter in Diesel Engines	1
4.5	Particulate Traps	1
4.6	Catalytic Convertors- One way, Two way and Three-way Catalytic convertors	1
4.7	Emission control measures for HC and CO emissions from SI engines	1
4.8	Emission control measures for HC and CO emissions from CI engines	1
Module 5 (7 Hours)		
5	Exhaust Gas Recirculation - EGR on engine emissions,	1
5.2	Urea-SCR injection for NOx reduction	1
5.3	Engine modifications to reduce emissions.	1
5.4	Engine modifications for alternate fuels -liquid fuels	1
5.5	Engine modifications for -gaseous fuels	1
5.6	Homogenous Charge Compression Ignition Engines.	1
5.7	Additives for enhancing performance of engines	1
5.8	Additives for pollution control.	1

Model Question Paper

QP CODE: **D** Pages: 1

Reg No.:________________

Name:___________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: **M24ME2E204B**

Combustion and Emissions in IC Engines

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. What is combustion? Mention Richards theory of combustion
2. Explain normal and abnormal combustion in engines
3. Discuss the detonation process in engines and its undesirable effects
4. Discuss the major pollutants from CI engines
5. Explain the effect of EGR on engine emissions

PART B

Answer any five questions. Each question carries 8 marks.

6. Discuss the term dissociation and its effects on specific heat values during combustion.
7. Explain the laminar and turbulent flame propagation in engines
8. With the help of P-Θ diagram explain the various stages of combustion in CI engine.
9. Explain Stratified charge engines and Lean burn combustion process
10. What is the effect of injection pressure on combustion? Why is CRDI advantageous over normal injection process?
11. Explain the working of a 3-way catalytic converter with suitable sketches
12. Analyse the requirement of engine modifications when alternate fuels are used.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E204C	**HVAC System Design**	**Elective**	**3**	**0**	**0**	**3**	**3**

Preamble: This course is designed to equip with the fundamental principles, practical knowledge, and analytical skills necessary to tackle the complexities of HVAC system design.

Prerequisite: A foundational level understanding of psychrometrics, heat transfer, fluid dynamics, equipment selection, energy efficiency and sustainability is desirable.

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Analyze psychrometric processes, estimate heat loads, and apply various methods for heat load calculations in HVAC systems.	Analyze
CO 2	Comprehend the fundamentals of airflow in ducts, perform pressure drop calculations, and design duct systems using various methods, while also understanding duct materials, insulation, and the function of different air distribution	Analyze
CO 3	Understanding of ventilation requirements, sources of infiltration air, and their impact on cooling load, along with knowledge of fan and blower.	Apply
CO 4	Evaluate various types of evaporative coolers, and insights into the design of air conditioning equipment and systems.	Evaluate
CO 5	Understand the classification, design principles, and standards governing various air conditioning systems and equipment for specific purpose.	Apply

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	3	3	3	1
CO 2	3	1	3	3	3	1
CO 3	2	1	3	3	3	1
CO 4	2	1	3	3	3	1
CO 5	2	1	2	2	1	1

Assessment Pattern

Course name	**HVAC System Design**		
Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	10	10	10
Apply	40	40	40
Analyse	40	40	40
Evaluate	10	10	10
Create	XX	XX	XX

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of theexamination will be 3 Hrs.

SYLLABUS

Module -1 (9 Hours)

Cooling Load Estimation: Applied Psychrometry, Psychrometric processes using chart Load Estimation: solar heat gain, study of various sources of the internal and external heat gains, heat losses, etc. Methods of heat load calculations: Equivalent temperature Difference Method, Cooling Load Temperature Difference, and Radiance Method, RSHF, GSHF, ESHF, etc. Inside and outside design conditions.

Module -2 (6 Hours)

Air Distribution: Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method, equal friction method and static regain method, duct materials and properties, insulating materials, types of grills, diffusers, wall registers.

Module -3 (5 Hours)

Ventilation and Infiltration: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load. Fans and Blowers: Types, performance characteristics, series and parallel arrangement, selection procedure.

Module -4 (8 Hours)

Direct and Indirect Evaporative Cooling: Basic psychometric of evaporative cooling, types of evaporative coolers, design calculations, Air Conditioning Equipments and Controls: Chillers, Condensing units, Cooling coils, bypass factors, humidifiers, dehumidifiers, various types of filters, air washers, thermostat, humidistat, cycling and sequence controls, modern control of parity, odour and bacteria, Air filtration- Study of different types of filters, Cooling Towers.

Module -5 (8 Hours)

Air conditioning systems: Classification, design of central and unitary systems, typical air conditioning systems such as automobile, air plane, ships, railway coach air-conditioning, warm air system, hot water systems, heat pump, clean rooms (descriptive treatments only). Standards and Codes: ASHRAE/ARI, BIS standards study and interpretation, ECBC, NBC codes JNTUACEA R-15 2015-16.

Reference Books

1. C P Arora, "Refrigeration and Air conditioning", Tata McGraw Hill Publication, New Delhi.
2. Manohar Prasad, "Refrigeration & Air Conditioning", New Age Publishers.
3. ASHRAE Handbooks
4. ISHRAE Handbook.
5. Handbook of Air Conditioning System Design, Carrier Incorporation, McGraw Hill Book Co., USA.
6. Trane air conditioning manual,
7. Refrigeration and Air conditioning, ARI, Prentice Hall, New Delhi.
8. Norman C. Harris, "Modern air conditioning" McGraw Hill, 3rd Ed., 1983.
9. Jones W. P., "Air conditioning Engineering", Edward Arnold Publishers Ltd, London, 1984.
10. Jones W. P., "Air conditioning Engineering – Applications", Edward Arnold Publishers Ltd, London, 1984
11. Hainer R. W., "Control System for Heating, Ventilation and Air conditioning", Van Nastrand Reinhold Co., New York, 1984.
12. McQuiston F.C., Parker J.D., Spitler J.D, "Heating, Ventilating and Air Conditioning-Analysis and Design", 5th ed. John Wiley & Sons.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (9 Hours)	
1.1	**Cooling Load Estimation -** Applied Psychrometry, Psychrometric processes using chart Load Estimation: solar heat gain	2
1.2	study of various sources of the internal and external heat gains, heat losses, etc.	2
1.3	Methods of heat load calculations: Equivalent temperature Difference Method, Cooling Load Temperature Difference, and Radiance Method	3
1.4	RSHF, GSHF, ESHF, etc. Inside and outside design conditions.	2

Module 2: (6 Hours)		
2.1	**Air Distribution -** Fundamentals of air flow in ducts, pressure drop calculations	2
2.2	Design ducts by velocity reduction method, equal friction method and static regain method	2
2.3	Duct materials and properties, insulating materials, types of grills, diffusers, wall registers.	2
Module 3 (5 Hours)		
3.1	**Ventilation and Infiltration -** Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load.	3
3.2	Fans and Blowers: Types, performance characteristics, series and parallel arrangement, selection procedure.	2
Module 4 (8 Hours)		
4.1	**Direct and Indirect Evaporative Cooling** - Basic psychometric of evaporative cooling, types of evaporative coolers, design calculations	2
4.2	Air Conditioning Equipments and Controls: Chillers, Condensing units, Cooling coils, bypass factors, humidifiers, dehumidifiers	2
4.3	Various types of filters, air washers, thermostat, humidistat, cycling and sequence controls	2
4.4	Modern control of parity, odour and bacteria, Air filtration- Study of different types of filters, Cooling Towers.	2
Module 5 (8 Hours)		
5.1	**Air conditioning systems -** Classification, design of central and unitary systems,	2
5.2	Typical air conditioning systems such as automobile, air plane, ships, railway coach air-conditioning, warm air system	2
5.3	hot water systems, heat pump, clean rooms (descriptive treatments only).	2
5.4	Standards and Codes: ASHRAE/ARI, BIS standards study and interpretation, ECBC, NBC codes JNTUACEA R-15 2015-16.	2

Model Question Paper

QP CODE: **C** Pages: 2

Reg No.:________________

Name:__________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2E204C

Course Name: HVAC System Design

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. Evaluate the various sources of heat losses in a building, including conduction, convection, and infiltration. Compare the impact of each source on the total heat loss and discuss strategies for minimizing heat loss through building envelope improvements.

2. Analyze the selection of grills and diffusers for air distribution in HVAC systems. Evaluate factors such as airflow patterns, noise levels, and aesthetic considerations to recommend suitable grill and diffuser types for different building environments.

3. Analyze the procedure for selecting fans for HVAC system design.

4. Explain the different types of air filters used in HVAC systems, including fiberglass filters, pleated filters, and HEPA filters.

5. Explain the principles of operation and applications of Hyperbolic cooling tower.

PART B

Answer any five questions. Each question carries 8 marks.

6. A commercial office building located in a tropical climate zone undergoes a detailed heat load calculation process. The building has the following characteristics: a floor area of 5000 square meters, with occupancy for 150 people, equipment load of 200 W/person, lighting load of 15 W/square meter, and a solar heat gain coefficient of 0.7. The outdoor design conditions are 35°C dry bulb temperature and 70% relative humidity. Using the appropriate heat load calculation method, determine the following: i) The sensible heat load. ii) The latent heat load. iii) The total heat load on the building.

7. Analyse the challenges and considerations involved in estimating heat gains and losses in HVAC system design for buildings located in extreme climates. Provide strategies to mitigate these challenges and optimize system performance.

8. Design a duct system for a commercial building with a total airflow rate of 5000 cubic feet per minute (CFM). The velocity limit for the main duct is 1200 feet per minute (fpm). Determine the required duct size for the main duct and branches using the velocity reduction method.

9. Calculate the thickness of insulation required for a duct carrying chilled air at 10°C with an ambient temperature of 30°C. The desired temperature drop across the insulation is 5°C, and the thermal conductivity of the insulation material is 0.03 W/mK.

10. Analyze the ventilation air requirements for a commercial building with a floor area of 500 square meters and occupancy for 50 people. Calculate the minimum ventilation air volume required per person based on ASHRAE standards and determine the total ventilation air volume needed for the building.

11. Explain the modern control strategies for managing air quality parameters such as odor and bacteria in HVAC systems. Evaluate the effectiveness of UV germicidal lamps, photocatalytic oxidation, and activated carbon filters in controlling airborne contaminants and improving indoor air quality.

12. Analyze the design criteria for clean rooms in pharmaceutical manufacturing facilities. Consider the required air cleanliness level, airflow patterns, filtration efficiency, and temperature and humidity control parameters to maintain strict contamination control.

Industry Integrated Course

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2S205	Modelling and Simulation of Thermal Systems	Industry Course	3	0	0	3	3

Preamble: The goal of the course is the simulation of thermal systems. Simulating a thermal system is an intermediate stage in the design of optimal thermal systems. Simulating thermal systems helps in predicting system performance. This may be used in optimizing the design or for off-design performance evaluation. The principles presented in the course may be pursued further to predict dynamic behavior of thermal systems.

Prerequisite: Numerical Methods

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Understand the utility of modeling and simulation	Understand
CO 2	Model thermal components using governing equations and performance data	Apply
CO 3	Model and simulate steady state operations of thermal systems	Apply
CO 4	Model and simulate dynamic and complex thermal systems	Apply
CO 5	Utilize OpenModelica and Cycle-Tempo to model and simulate thermal systems	Analyse

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3	1	2	1
CO 2			3	1	2	2
CO 3			3	1	2	2
CO 4			3	1	2	3
CO 5			3	1	2	3

Assessment Pattern

Course name	Modelling and Simulation of Thermal Systems		
Bloom's Category	**Continuous Assessment Tests**		**End SemesterExamination (Marks %)**
	Test 1 (Marks %)	**Test 2 (Marks %)**	
Remember	XX	XX	XX
Understand	20	20	20
Apply	50	50	50
Analyse	30	30	30
Evaluate	XX	XX	XX
Create	XX	XX	XX

Mark Distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation

Seminar : 10 marks

Course based task/Seminar/

Data collection and interpretation/Case study : 10marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

End Semester Examination

The examination will be conducted by the College with the question paper provided by the Industry. The examination will be for 3 Hrs and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks. The valuation of the answer scripts shall be done by the expert in the industry handling the course.

SYLLABUS

MODULE 1 (8 Hours)

Introduction: Concept of modelling and Simulation, Building and Analyzing Model, Kinds of mathematical models, Types of equations, Dynamic and Static Model, Types of models, Case study: Gas turbine model

MODULE 2 (7 Hours)

Modeling Thermal Components: Counterflow heat exchangers, Evaporators and condensers, Binary solutions, Temperature-concentrations-pressure characteristics, developing T Vs X diagram, Condensation of a binary mixture, single stage distillation, Rectification, Pumping power, turbomachinery, Mathematical modeling of thermodynamic properties

MODULE 3 (8 Hours)

Steady State simulation: Case Study 1: Modeling a heat exchanger in Cycle-Tempo: Design calculation-Input and results, Energy and exergy calculations, Off-design calculations, Calculation of UA value. **Case study 2**: Modeling a simple steam cycle: Base calculation, Results, calculation using user subroutine.

MODULE 4 (8 Hours)

Introduction to OpenModelica : Overview of OMEdit, Connectors, developing equation based model, Control flow and event handling, functions and types, Arrays, Modelica Packages

Designing Interfaces, Block diagram models, types of variables and constants in mathematical models, **Case study 3:** Modeling a tank system in Open Modelica-Traditional approach, Component based approach

MODULE 5 (5 Hours)

Dynamic Simulation of thermodynamic systems: Case Study 4: Modeling an air-filled control volume interfacing with subsytems: Control volume model, Governing equations, Connector interfaces to the control volume, Boundary conditions

Case Study 5: Pressure dynamics in 1D ducts: Solving the wave equations, Boundary conditions, plotting simulation results

Reference Books

1. Peter Fritzson, "Principles of Object-oriented modeling and simulation with Modelica 3.3", Wiley
2. Baligh El Hefni, "Modeling and Simulation of Thermal Power Plants with ThermoSysPro", Springer.
3. W. F Stoecker, "Design of thermal Systems", McGraw Hill.
4. P L Dhar, "Thermal System design and simulation", Academic Press.
5. C. Balaji, "Essentials of Thermal System Design and Optimization", Ane Books.
6. Y. Jaluria, "Design and Optimization of Thermal Systems", McGraw Hill.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1 (8 hours)	
1.1	Concept of modelling and Simulation	2
1.2	Building and Analyzing Model,	1
1.3	Kinds of mathematical models	1
1.4	Types of equations	1
1.5	Dynamic and Static Model	1
1.6	Types of models	1
1.7	Case study: Gas turbine model	1
	Module 2 (7 hours)	
2.1	Modeling Thermal Equipment: Counterflow heat exchangers	1
2.2	Binary solutions, Temperature-concentrations-pressure characteristics, developing T Vs X diagram,	1
2.3	Condensation of a binary mixture	1
2.4	Evaporators and condensers	1
2.5	Single stage distillation, Rectification	1
2.6	Pumping power, Turbomachinery	1
2.7	Mathematical modeling of thermodynamic properties	1

Module 3 (8 hours)		
3.1	**Case Study 1**: Modeling a heat exchanger in Cycle-Tempo: Design calculation-Input and results, Energy and exergy calculations	2
3.2	Off-design calculations, Calculation of UA value	2
3.3	**Case study 2**: Modeling a simple steam cycle: Base calculation, Results,.	2
3.4	Calculation using user subroutine	2
Module 4 (8 hours)		
4.1	**Introduction to OpenModelica :** Overview of OMEdit, Connectors	2
4.2	Developing equation-based model, Control flow and event handling, functions and types, Arrays, Modelica Packages	2
4.3	Designing Interfaces, Block diagram models, types of variables and constants in mathematical models,	2
4.4	Case study 3: Modeling a tank system in Open Modelica-Traditional approach	1
4.5	Component based approach	1
Module 5 (5 hours)		
5.1	**Dynamic Simulation of thermodynamic systems: Case Study 4**: Modeling an air-filled control volume interfacing with subsytems: Control volume model, Governing equations,	1
5.2	Connector interfaces to the control volume, Boundary conditions	2
5.3	**Case Study 5:** Pressure dynamics in 1D ducts: Solving the wave equations, Boundary conditions, plotting simulation results	2

Model Question Paper

QP CODE: E Pages: 1

Reg No.:__________________

Name:____________________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2024

Course Code: M24ME2S205

Course Name: Modelling and simulation of Thermal Systems

Max. Marks:60 Duration: 3 hours

Answer any five questions. Each question carries 12 marks.

1. Describe the different mathematical equations encountered in thermal modeling studies.

2. Differentiate steady state modeling and dynamics modeling using suitable examples

3. What is the effectiveness of a counterflow heat exchanger that has a UA value of 24kW/K if the respective mass flow rates of flow and specific heats of the two fluids are 10 kg/s, 2kJ/(kg.K) and 4 kg/s, 4kJ/(kg.K) .

4. Describe the procedure for modeling a simple steam cycle using Cycle-Tempo.

5. Derive the governing equations for pressure dynamics in 1D duct? Describe how these can be solved using Open Modelica.

6. Describe the salient features of Open Modelica using examples

7. Illustrate the capabilities of Cycle-Tempo in modeling thermal systems. List its limitations

Mini Project

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2P206	**Mini project**	**Project**	**0**	**0**	**3**	**3**	**2**

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem-solving skills. The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator. Demonstrate the novelty of the project through the results and outputs. The progressof the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee - Programme Coordinator, One Senior Professor an Guide.

Sl. No.	Type of Evaluation	Marks	Evaluation Criteria
1	Interim evaluation 1	20	
2	Interim evaluation 2	20	
3	Final evaluation by a committee	35	Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	15	The committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level (not more than 25%)
5	Supervisor / Guide	10	
	Total Marks	100	

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2L207	**Computational Fluid Dynamics Lab**	**Laboratory**	**0**	**0**	**3**	**3**	**2**

Preamble: The course aims to provide a hands-on experience in Computational Fluid Dynamics in commercial CFD codes.

Prerequisite: A foundation level course on Thermodynamics, Fluid Mechanics, Numerical Methods and basics of computer programming.

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Apply CFD to solve external flows	Apply
CO 2	Apply CFD to solve internal flows	Apply
CO 3	Apply CFD to solve convection problems	Apply
CO4	Apply CFD to solve turbulent flows	Apply
CO 5	Apply CFD to solve flows with combustion	Apply

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3	3	2	
CO 2			3	3	2	
CO 3			3	3	2	
CO 4			3	3	2	1
CO 5			3	3	2	1

Mark Distribution

Total Marks	CIE marks
100	100

Continuous Internal Evaluation Pattern:

Lab work and Viva-voce : 60 marks

Final assessment Test and Viva voce : 40 marks

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

SYLLABUS

LIST OF EXPERIMENTS

1	Familiarization with CFD solvers and post-processing packages	
2	Flat Plate Laminar Boundary Layer	
3	Flow over an Airfoil	
4	Steady Flow Past a Cylinder	
5	Steady-State Laminar Convection	
6	Partially Premixed Combustion	
7	Steady-State Laminar Convection	
8	Laminar and Turbulent Jets	
9	Unsteady Flow Past a Cylinder	
10	Steady-State Laminar Convection	
11	Turbulent Forced Convection	
12	Turbulent Pipe Flow using RANS	
13	Turbulent Pipe Flow using LES	

Reference books

1. John D Anderson, “Computational Fluid Dynamics the Basics with Applications”, McGraw Hill, 2017
2. H. Versteeg, “An Introduction to Computational Fluid Dynamics”, Pearson, 2008
3. Jiyuan Tu, “Computational Fluid Dynamics”, Elsevier,2020
4. ANSYS Innovation Courses: https://courses.ansys.com/

SEMESTER III

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2M301/ M24ME2M305/ M24ME2M306	**MOOC**	MOOC	0	0	0	0	2

Preamble:

A MOOC course of a minimum 8-week duration must be successfully completed before the end of the fourth semester (starting from Semester 1). The MOOC course shall be considered valid only if it is conducted by AICTE, NPTEL, SWAYAM, or NITTTR. The course must have a minimum duration of 8 weeks and should include syllabus content equivalent to at least 40 hours of teaching. Additionally, it must have a proctored/offline end-semester examination. Students may complete the MOOC course at their convenience but must do so before the end of the fourth semester. The Board of Studies (BoS) will provide a list of approved MOOC courses, provided that at least 70% of the course content aligns with the student's area or stream of study. However, a MOOC course will not be considered if more than 50% of its content overlaps with a core/elective course in the respective discipline or with an open elective. A credit of 2 will be awarded to students who successfully complete the MOOC course as per the evaluation criteria of the respective agency conducting the course.

LIST OF APPROVED MOOC COURSES:

1. **Cooling Technology: Why and How utilised in Food Processing and allied Industries**

   Duration: 12 weeks

   Provider: NPTEL

   Course Content: This course will cover basics of processing and preservation technologies required in any processing industries.

   Relevance: It is highly relevant for students, offering knowledge on thermal processing and preservation technologies required in processing industries.

2. **IC Engines and Gas Turbines**

   Duration: 12 weeks

   Provider: NPTEL

   Course Content: This course deals with the gas power cycles. One part of the course is on IC engines and it focuses on the thermodynamic cycles for different fuels suitable for automobiles. Relevance: It provides students with essential knowledge on thermodynamic cycle of aircraft engines and the components of the aircraft engine.

3. **Solar Photovoltaics: Principles, Technologies & Materials**

Duration: 8 weeks

Provider: NPTEL

Course Content: This course is an introductory course on solar photovoltaics materials and devices covering fundamentals of operation of solar cells, physics of semiconducting materials, P-N junction device characteristics in dark and light.

Relevance: It provides students with a comprehensive understanding about various solar photovoltaic technologies and their status along with fabrication aspects.

4. **MATLAB Programming for Numerical Computation**

Duration: 12 weeks

Provider: NPTEL

Course Content: This course introduces students to MATLAB programming, and demonstrate it's use for scientific computations.

Relevance: It is highly relevant for students to acquire the skills for computational techniques through various coding examples and problems, and practical ways.

5. **Scientific Computing using MATLAB**

Duration: 12 weeks

Provider: NPTEL

Course Content: MATLAB is introduced with hands on MATLAB software. New topics will be introduced followed by hands on to write the MATLAB code of the same topics.

Relevance: This course is very useful for the students who wants to do research projects using numerical techniques to handle data or to solve differential equations.

6. **Steam and Gas Power Systems**

Duration: 8 weeks

Provider: NPTEL

Course Content: The course contains the analysis of vapour power cycle i.e. Rankine cycle, steam generators and their accessories, Performance of Boilers and combustion of fuel, high pressure boilers, flow through steam and gas nozzles, different type of steam turbines for power generation and condensers.

Relevance: This Course provides a simple understanding of the steam and gas power systems.

7. **Introduction to Aerospace Engineering-Flight**

   Duration: 12 weeks

   Provider: NPTEL

   Course Content: The course will consist of ten capsules, each consisting of two Lectures. Each Lecture will cover a specific concept or area relevant to the Aeronautical Engineering.

   Relevance: This course provides students with a comprehensive understanding and general overview of the field of Aeronautical Engineering.

8. **Technologies for Clean and Renewable Energy Production**

   Duration: 12 weeks

   Provider: NPTEL

   Course Content: The course deals with the production of energy from different fossil fuels through cleaner routes as well as from renewable resources.

   Relevance: This course helps students to keep their knowledge upgraded with the current thoughts and newer technology options along with their advances in the field of the utilization of different types of energy resources for cleaner energy production.

9. **Principles and Practices of Process Equipment and Plant Design**

   Duration: 12 weeks

   Provider: NPTEL

   Course Content: The content will primarily cover the typical mass transfer systems and equipment included in undergraduate curriculum viz. distillation, absorption, adsorption and liquid-liquid extraction along with details of internals in packed and tray columns.

   Relevance: This course helps students to comprehend heat transfer basics and design of double pipe and shell and tube heat exchangers along with heat exchanger network analysis. Relevant design problems are also worked out after completion of each topic.

10. Hydrogen Energy: Production, Storage, Transportation and Safety

Duration: 12 weeks

Provider: NPTEL

Course Content: The course will provide a broad knowledge of hydrogen as an energy carrier, the way it will play an important role in various sectors towards decarbonization, current limitations and future scenarios.

Relevance: This course enables students for critically compare various processes and technologies, economic aspects & cost analysis, regulations, codes and standards, global status and future directions.

11. Advanced Calculus for Engineers

Duration: 12 weeks

Provider: NPTEL

Course Content: This course is about fundamental and essential mathematics for all studies in sciences and engineering. This course consists of topics in differential, integral, and vector calculus with applications to various engineering problems.

Relevance: Students will learn how to solve complex engineering problems of practical nature.

12. Aircraft Propulsion

Duration: 12 weeks

Provider: NPTEL

Course Content: This course deals with the gas power cycles for aircraft propulsion. Different types of aircraft engines, their parts and their performance parameters are discussing.

Relevance: It provides students with essential knowledge in gas power cycle analysis and its different attachment for improvisation.

13. Introduction to Industry 4.0 and Industrial Internet of Things

Duration: 12 weeks

Provider: NPTEL

Course Content: Industry 4.0 concerns the transformation of industrial processes through the integration of modern technologies such as sensors, communication, and computational processing. Technologies such as Cyber Physical Systems (CPS), Internet of Things (IoT), Cloud Computing, Machine Learning, and Data Analytics are considered to be the different drivers necessary for the transformation.

Relevance: Students will learn about Industrial Internet of Things (IIoT) and its application in industries to modify the various existing industrial systems.

14. Fundamentals of Nuclear Power Generation

Duration: 12 weeks

Provider: NPTEL

Course Content: This course introduces the students to the fundaments of nuclear power generation. Starting from the atomic structure, students will be gradually familiarized with different concepts, finally leading to the design of different reactors. Important topics such as nuclear waste management, biological impact of radiation and safety issues pertinent to handling nuclear fuels will also be discussed.

Relevance: The depleting stock of fossil fuels and global concern over the preservation of environment has projected nuclear energy as a very relevant option, particularly considering the near-zero emission and huge resource availability.

15. Advanced Thermodynamics and Combustion

Duration: 12 weeks

Provider: NPTEL

Course Content: The course package is mainly composed of the following major contents: (a) Exhaustive discussions on entropy and exergy analysis in thermodynamic systems; (b) Thermodynamic property relations and its application to gas mixtures, phase change processes; (c) Combustion fundamentals involving premixed and non-premixed flames for laminar and turbulent combustion; (d) Combustion phenomena in practical occurring applications such IC and GT engines.

Relevance: It provides students with essential knowledge on entropy and exergy analysis, thermodynamic relations and its application to gas mixtures, phase change processes, fundamentals of premixed and non-premixed flames for laminar and turbulent combustion and its applications such IC and GT engines.

16. Introduction to Uncertainty Analysis and Experimentation

Duration: 8 weeks

Provider: NPTEL

Course Content: This course discuss about experimentation process, errors in measurement, uncertainty in a measurement and in the result, uncertainty propagations, pre- and post- test uncertainty analysis, uncertainty analysis for design of set-up, and regression and correlation.

Relevance: Address fundamental topics on uncertainty analysis and their applications and give an overview of experimentation.

17. Principle of Hydraulic Machines and System Design

Duration: 12 weeks

Provider: NPTEL

Course Content: Present course introduces t the fundamentals of hydraulic machines, starting from the operational principle, velocity triangle, net head developed, finally leading to the design of their system. Topics such as design of pumping system of two dissimilar pumps, are also discussed.

Relevance: Principle of operation of hydraulic machines and their system design is important from the perspective of their huge applications in different industries.

18. System Design for Sustainability

Duration: 12 weeks

Provider: NPTEL

Course Content: This course will discuss these Design approaches, methods and tools along with case examples. It encompasses four approaches: 1. Selection of resources with low environmental impact; 2. Design of products with low environmental impact; 3. Product-Service System Design for eco-efficiency; 4. Design for social equity and cohesion.

Relevance: Design for Sustainability is a design thinking process for widening the boundaries of the objective of design so as to contribute positively to sustainable development.

19. Power Plant Engineering

Duration: 8 weeks

Provider: NPTEL

Course Content: The course contains the details of steam and gas thermal power plants, hydro power plants, nuclear power plants, along with solar, wind and geothermal energy power systems in addition to the direct energy conversion. The economics of power generation and the environmental aspect of power generation are also discussed in this course.

Relevance: This Course provides a simple understanding of the power plant engineering.

20. Applied Thermodynamics for Engineers

Duration: 12 weeks

Provider: NPTEL

Course Content: This course discuss about the properties of pure substance, thermodynamic relations, gas & vapor power cycles principles of cogeneration & combined cycles refrigeration cycles, selection of refrigerants, properties of gas mixtures and gas-vapor mixtures, psychrometry & psychrometric processes.

Relevance: This course enable students to estimate all relevant thermodynamic properties at any particular state point.

21. Finite Element Method: Variational Methods to Computer Programming

Duration: 12 weeks

Provider: NPTEL

Course Content: In this course, finite element formulations will be derived from the governing partial differential equation of different physical systems based on Variational methods. It will start with one-dimensional Bar, Beam, Truss, Frame elements; and will be extended to two-dimensional structural, and thermal problems. Two-dimensional formulation will be represented in Tensorial framework, after building necessary background in Tensor calculus.

Relevance: This course makes students capable to solve boundary value and initial value problems to the domains of any arbitrary geometry

22. Fundamentals of Artificial Intelligence

Duration: 12 weeks

Provider: NPTEL

Course Content: The objective of this course is to present an overview of the principles and practices of AI to address such complex real-world problems.

Relevance: The course empowers students develop a basic understanding of problem solving, knowledge representation, reasoning and learning methods of AI.

23. Aerodynamic Design Of Axial Flow Compressors & Fans

Duration: 12 weeks

Provider: NPTEL

Course Content: Aims to give the students a fundamental understanding of how axial flow compressor and industrial fans work and how they are designed as per specific requirements for land-based power plants, aircraft jet engines, special applications in process industries as well as future electric propulsion systems.

Relevance: Students acquire sound knowledge in the topics of aerodynamics and fluid flow aspects of axial flow compressors and fans.

24. Non-Conventional Energy Resources

Duration: 12 weeks

Provider: NPTEL

Course Content: This course looks at the operating principle of a range of non-conventional energy resources, materials used, characterization, and key performance characteristics. The technologies looked at will include, Solar energy, Wind, Batteries, Fuel cells, and Geothermal conversion. The advantages and limitations of these technologies in comparison to conventional sources of energy are also examined.

Relevance: Students acquire sound knowledge in the topics of non-conventional energy resources, materials used, characterization, and key performance characteristics

25. Rocket Propulsion

Duration: 12 weeks

Provider: NPTEL

Course Content: The fundamental aspects of rockets and the current trends in rocket propulsion are dealt with in this course. Starting with description of motion in space, the requirements of rockets for placing space-crafts in different orbits and escaping the gravitational fields of the planets are examined. The operating principles and design aspects of solid propellant, liquid propellant, electrical, nuclear and other types of rockets are dealt with.

Relevance: It is highly relevant for students to acquire in the field of rocket propulsion.

SEMESTER III
PROGRAM ELECTIVE V

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E302A	INDUSTRIAL SAFETY	Program Elective 5	3	0	0	3	3

Preamble : The course is intended to give knowledge of various safety management systems, accident prevention techniques, various machine guarding devices, different types of hazards and fire prevention methods. Students will be able to understand the impact of safe industrial operations and become aware of safety responsibilities

Prerequisite : NIL

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Understand the principles of Safety Management and develop skills in auditing and budgeting.	Understand
CO 2	Conduct the investigation on accidents and carry out the risk analysis.	Understand
CO 3	Communicate general safety precautions and safe practices to be followed in Engineering Industries.	Apply
CO 4	Identify the occupational health hazards and develop methods for control.	Apply
CO 5	Apply the firefighting techniques and understand the methods of pollution control.	Apply

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1						
CO 2	2				1	2
CO 3		2				
CO 4	1			2	2	1
CO 5					2	

Assessment Pattern

Course name	INDUSTRIAL SAFETY		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember			
Understand	40	40	40
Apply	60	60	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 hrs.

SYLLABUS

MODULE 1 (8 hours)

Introduction to safety and safety management - Objectives and principles of safety management - Need for integration of safety, health and environment, Management's safety policy and Formulation – Safety auditing – Safety budget, Safety committees and its functions - Safety education and training - Motivation and communicating safety, Significance of health and safety culture - 4 E's in industrial safety - Role of management in Industrial Safety - Factors impeding safety.

MODULE 2 (7 hours)

Accidents and Hazard control - Accident causation - Classification of accidents- Heinrich Domino theory, Accident proneness - Cost of accidents - Accident investigation – Hazard control programme, Risk analysis - Quantitative risk assessment- Roles and functions of safety professional- Job safety analysis

MODULE 3 (7 hours)

Machine Guarding - Types of guards - Zero mechanical state , Lock out and tag out – Housekeeping, Personal protective equipments and personal safety - Permit to work system, General safety considerations in material handling - Manual and mechanical - Safety in machine shop, Safety in sewage disposal and cleaning - Disaster management plan for industrial plant.

MODULE 4 (7 hours)

Occupational health and industrial hygiene - Functions of occupational health services, Occupational health risks - Functional units of OHS, Occupational diseases - Silicosis - Asbestosis - lead poisoning - Nickel toxicity - Chromium toxicity, Hearing conservation programme - First aid and CPR, Types of industrial hazards and their control - Physical, Mechanical, Electrical, Chemical and Ergonomic hazards

MODULE 5 (7 hours)

Industrial fire prevention - Basic principle of Fire chemistry – Fire triangle – Methods of extinguishing fire - Classification of fires, Factors contributing towards fire - Fire risk assessment - Fire load, Fire safety plan, Fire detection systems – Fire protection systems, Pollution control in engineering industry - Recent development of safety engineering approaches

Reference Books and Journals

1. R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.
2. Ronald P. Blake. (1973). Industrial safety. Prentice Hall, New Delhi.
3. Krishnan, N.V. (1997). Safety management in Industry. Jaico Publishing House, New Delhi.
4. Frank P Lees, 'Loss prevention in process industries, Vol I, II, III, Butterworth, London 1980
5. Heinrich H.W, 'Industrial accident prevention', McGraw Hill Company, New York, 1980.

COURSE CONTENTS AND LECTURE SCHEDULE

(For 4 credit courses, the content can be for 45 hrs. and for 3 credit courses, the content can be for 36 hrs.)

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to safety and safety management - Objectives and principles of safety management - Need for integration	2

	of safety, health and environment	
1.2	Management's safety policy and Formulation – Safety auditing – Safety budget	2
1.3	Safety committees and its functions - Safety education and training - Motivation and communicating safety	2
1.4	Significance of health and safety culture - 4 E's in industrial safety - Role of management in Industrial Safety - Factors impeding safety.	2
2	**Module II**	
2.1	Accidents and Hazard control - Accident causation - Classification of accidents- Heinrich Domino theory	2
2.2	Accident proneness - Cost of accidents - Accident investigation – Hazard control programme	2
2.3	Risk analysis - Quantitative risk assessment- Roles and functions of safety professional- Job safety analysis	3
3	**Module III**	
3.1	Machine Guarding - Types of guards - Zero mechanical state	1
3.2	Lock out and tag out - Housekeeping	1
3.3	Personal protective equipments and personal safety - Permit to work system	2
3.4	General safety considerations in material handling - Manual and mechanical - Safety in machine shop	1
3.5	Safety in sewage disposal and cleaning - Disaster management plan for industrial plant.	2
4	**Module IV**	
4.1	Occupational health and industrial hygiene - Functions of occupational health services	1
4.2	Occupational health risks - Functional units of OHS	1
4.3	Occupational diseases - Silicosis - Asbestosis - lead poisoning - Nickel toxicity - Chromium toxicity	2
4.4	Hearing conservation programme - First aid and CPR	1
4.5	Types of industrial hazards and their control - Physical, Mechanical, Electrical, Chemical and Ergonomic hazards	2
5	**Module V**	
5.1	Industrial fire prevention - Basic principle of Fire chemistry – Fire triangle – Methods of extinguishing fire - Classification of fires	2
5.2	Factors contributing towards fire - Fire risk assessment - Fire load	1
5.3	Fire safety plan	1
5.4	Fire detection systems – Fire protection systems	1
5.5	Pollution control in engineering industry - Recent development of safety engineering approaches	2

Model Question Paper

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

THIRD SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2025

***Course Code:* M24ME2E302A**

***Course Name:* INDUSTRIAL SAFETY**

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. You are appointed as a safety officer in a manufacturing industry. What measures you will take to communicate safety to the workers?
2. An accident has occurred in an industry. What all factors you will consider to estimate the cost of accident?
3. Mention the factors to be considered in the selection of PPE.
4. A worker while doing maintenance in a workshop got electrocuted and becomes unconscious. How do you perform the CPR to save that worker?
5. Explain how you classify the fire.

PART B

Answer any five questions. Each question carries 8 marks.

6. Why we constitute a safety committee is in an industry? Explain the procedure for the formation of a safety committee.
7. With neat sketch, explain the Heinrich Domino Theory.
8. What are the hazards related with the operation of machines? Explain any five types of machine guards used in industry.
9. How do you conduct the hearing conservation programme when a worker in a production plant is required to enroll in the programme?

10. You are assigned to install the fire protection system in a manufacturing industry. With neat sketches, explain the fire protection systems you are going to install.
11. While inspection you found that, the guard of a hydraulic press is not satisfactory in terms of safety. What all factors you consider for redesigning? Explain the trip guard.
12. As a works manager, what steps will you take to motivate your employees to enhance safety when you observed that the accident rate in your site is high?

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CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E302B	THERMAL MANAGEMENT IN ELECTRIC VEHICLE SYSTEMS	Program Elective 5	3	0	0	3	3

Preamble : This course provides an in-depth understanding of Electric Vehicle (EV) technology, focusing on EV architecture, battery technology, power electronics, and advanced thermal management techniques and future trends and challenges in EVs.

Prerequisite: Basic Electrical and Electronics Engineering, Thermodynamics and Heat Transfer

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statements	Cognitive Knowledge Level
CO 1	Understand the fundamentals of electric vehicles and their powertrain architecture.	Understand
CO 2	Understand battery technologies and its thermal management strategies.	Understand
CO 3	Apply power electronics and motor cooling techniques.	Apply
CO 4	Apply advanced thermal management techniques for EV systems.	Apply
CO 5	Apply emerging trends in EV thermal management and sustainability.	Apply

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			2	2	2	3
CO 2			1	2	1	3
CO 3			1	2	1	3
CO 4			1	2	1	3
CO 5			1	2	1	3

Assessment Pattern

Course name	THERMAL MANAGEMENT IN ELECTRIC VEHICLE SYSTEMS		
Bloom's Category	Continuous Internal Evaluation Tests		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember			
Understand	40	40	40
Apply	60	60	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application,analysis, synthesis, evaluation and understanding of the students), with one question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains seven questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 hrs.

SYLLABUS

MODULE 1 (6 hours)

Introduction to Electric Vehicles: Evolution of EVs and comparison with ICE vehicles, EV powertrain architecture and components, Types of EVs: BEV, HEV, PHEV, FCEV, Energy sources and storage technologies, Regenerative braking, and energy management systems

MODULE 2 (8 hours)

Battery Technology and Thermal Management: Li-ion battery chemistry, configuration, and energy storage capacity, Heat generation mechanisms in batteries during charge/discharge cycles, Battery thermal management systems (BTMS): passive and active cooling, Thermal runaway, and safety considerations.

MODULE 3 (8 hours)

Power Electronics and Motor Thermal Management: Power electronic components: Inverters, converters, and controllers, Heat dissipation in power electronics, Electric motors in EVs: BLDC, PMSM, Induction motors, Motor cooling methods: air cooling, liquid cooling, and oil immersion cooling, Heat sinks.

MODULE 4 (8 hours)

Advanced Thermal Management Techniques: Phase change materials (PCM) for battery cooling, Heat pipes and loop heat pipes for efficient heat transfer, Mini/microchannel liquid cooling and jet impingement cooling, Thermoelectric cooling (Peltier effect) and Seebeck power recovery, Endothermic and emergency cooling strategies.

MODULE 5 (6 hours)

Future Trends and Challenges in EV Thermal Management: Immersion cooling and dielectric liquid cooling for EVs. Case studies: AI applications in thermal management, Battery pack thermal optimization through CFD simulations. Sustainability and eco-friendly cooling strategies.

Reference Books

1. Dave S. Steinberg, Cooling Techniques for Electronic Equipment, 1991, John Wiley & Sons, Inc
2. HoSung Lee, Thermal Design: Heat Sinks, Thermoelectrics, Heat Pipes, Compact Heat Exchangers, and Solar Cells, 2011 John Wiley & Sons, Inc.
3. W.M. Rohsenow, J.P Hartnett, C. Young, Heat Transfer Handbook, 1998, McGraw-Hill
4. Kaveh Azar, Thermal Measurements in Electronics Cooling, 1997, CRC Press
5. Ali Jamnia , Practical Guide to the Packaging of Electronics, 2002, CRC Press
6. Yunus A. Cengel and Michael Boles Thermodynamics: An Engineering Approach, 6th Ed, 2001, McGraw-Hill.

COURSE CONTENTS AND LECTURE SCHEDULE

(For 4 credit courses, the content can be for 45 hrs. and for 3 credit courses, the content can be for 36 hrs.)

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	
1.1	Evolution of Evs and comparison with ICE vehicles	2
1.2	EV components and types	2
1.3	Regenerative braking and energy management	2
	Module 2	
2.1	Li-ion battery chemistry and configurations	2
2.2	Heat generation mechanisms and cooling methods	2
2.3	BTMS: Passive and active cooling and thermal runaway.	3
2.4	Safety Considerations	1
	Module 3	
3.1	Power electronic components and heat dissipation	2
3.2	Electric motors in EVs and cooling methods	2
3.3	Motor cooling methods	2
3.4	Design of heat sinks for power electronics and	2
	Module 4	
4.1	Phase change materials (PCM)	2
4.2	Heat pipes and loop heat pipes for efficient heat transfer	2
4.3	Mini/microchannel liquid cooling and jet impingement cooling	2
4.4	Thermoelectric cooling (Peltier effect) and Seebeck power recovery	2
	Module 5	
5.1	Immersion cooling and dielectric liquid cooling for EVs	2
5.2	Battery pack thermal optimization through CFD simulations	2
5.3	Sustainability and eco-friendly cooling strategies	2

Model Question Paper

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

THIRD SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2025

Course Code: M24ME2E302B

Course Name: **Thermal Management in Electric Vehicle Systems**

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1. Compare the powertrain architecture of an electric vehicle (EV) with that of an internal combustion engine (ICE) vehicle.
2. Explain the different types of EVs: BEV, HEV, PHEV, and FCEV.
3. Describe the heat generation mechanisms in Li-ion batteries during charge and discharge cycles.
4. What are the major cooling techniques used for electric motors in EVs.
5. Briefly explain phase change materials (PCM) and their application in battery thermal management systems.

PART B

Answer any five questions. Each question carries 8 marks.

6. a. Discuss the configuration and energy storage capacity of Li-ion batteries.
   b. Explain the thermal runaway phenomenon and its safety implications
7. a. Discuss different types of electric motors used in EVs.
   b. Explain the various motor cooling techniques.
8. a. Analyse the various power electronic components used in EVs.
   b. Explain the different heat dissipation techniques used in power electronics
9. a. Describe the working principle of heat pipes and loop heat pipes in thermal management.
   b. Explain mini/microchannel liquid cooling and its advantages in EVs.

10. a. Discuss the thermoelectric cooling (Peltier effect) and its application in EV battery cooling.
    b. Explain Seebeck power recovery and its significance in EV systems.
11. a. Explain how battery pack thermal optimization is achieved using CFD simulations.
    b. Discuss the challenges in implementing sustainable and eco-friendly cooling strategies.
12. Describe the steps involved in setting up a CFD model for a battery pack and analyze the impact of airflow design and material properties on the cooling performance.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2E302C	Thermal Design and Optimization	Program Elective 5	3	0	0	3	3

Preamble : This course will explore the intricate relationship between thermal systems and optimization methodologies. This course is structured into five comprehensive modules, each focusing on critical components essential for the effective design and implementation of fluid transport systems and thermal applications.

Prerequisite: Basics of optimization

Course Outcomes: After the completion of the course the student will be able to

CO No	CO Statement	Cognitive Knowledge Level
CO 1	Understand and design fluid transport systems.	Understand
CO 2	Formulate optimization problems related to thermal systems.	Apply
CO 3	Demonstrate proficiency in applying the Lagrange multiplier method to optimize both constrained and unconstrained problems.	Understand
CO 4	Select and implement appropriate search methods for optimization problems.	Apply
CO 5	Apply the concept of exergy in thermal design, conducting exergy balance analyses.	Apply

Mapping of course outcomes with program outcomes

Assessment Pattern

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2		3	3	2	
CO 2	2		3	3	2	
CO 3	2		3	3	2	
CO 4	2		3	3	2	
CO 5	2		3	3	2	

Course name	THERMAL MANAGEMENT IN ELECTRIC VEHICLE SYSTEMS		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember			
Understand	40	40	40
Apply	60	60	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	40	60	3 Hours

Continuous Internal Evaluation Pattern:

Seminar* : 10 marks

Course based task/Micro Project//Data collection and interpretation/Case study : 10 marks

Test paper 1 (Module 1 and Module 2) : 10 marks

Test paper 2 (Module 3 and Module 4) : 10 marks

*Seminar should be conducted in addition to the theory hours. Topics for the seminar should be from recent technologies in the respective course

End Semester Examination Pattern: The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 4 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answerquestions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of whichstudent shall answer any five. Each question can carry 8 marks. Total duration of the examination will be 3 hrs.

SYLLABUS

MODULE 1 (8 hours)

Design of Fluid transport systems: Piping and Tubing Standards, Head Loss due to Friction in Pipes and Tubes, Valves and Fittings, The Hooper 2K Method, The Darby 3K Method, Design and Analysis of Pipe Networks, Parallel Pipe Networks, Economic Pipe Diameter, Cost of a Pipe System, Determination of the Economic Diameter, Cost Curves, Economic Velocity Range, Pumps, Types of Pumps, Dynamic Pump Operation, Dynamic Pump Performance, The System Curve, Pump Selection, Cavitation and the Net Positive Suction Head, Calculating the NPSHa, Series and Parallel Pump Configurations, Affinity Laws.

MODULE 2 (8 hours)

Problem Formulation for Optimization: Optimization in Design, Final Optimized Design, Objective Function, Constraints, Operating Conditions versus Hardware, Mathematical Formulation, Optimization Methods, Calculus Methods, Search Methods, Important Considerations, Different Approaches, Different Types of Thermal Systems, Consideration of the Second Law of Thermodynamic, Practical Aspects in

Optimal Design, Choice of Variables for Optimization, Sensitivity Analysis.

MODULE 3 (7 hours)

Lagrange Multipliers: Introduction to Calculus Methods, The Lagrange Multiplier Method, Basic Approach, Physical Interpretation, Gradient Vector, Lagrange Multiplier Method for Unconstrained Optimization, Lagrange Multiplier Method for Constrained Optimization, Significance of the Multipliers, Optimization of Unconstrained Problems, Use of Gradients for Optimization, Determination of Minimum or Maximum

MODULE 4 (6 hours)

Search Methods: Basic Considerations, Importance of Search Methods, Types of Approaches, Elimination Methods, Hill-Climbing Techniques, Constrained Optimization, Application to Thermal Systems Single-Variable Problem Uniform Exhaustive Search, Fibonacci Search, Steepest Ascent/Descent Method, Penalty Function Method, Search along a Constraint

MODULE 5 (7 hours)

Exergy for thermal design: Exergy Balance Equation, Closed System, Energy Balance of the Closed System, Entropy Balance of the Closed System, Open System, Exergy Transfers at Inlets and Outlets, Standard Chemical Exergy of Gases and Gas Mixtures, Standard Chemical Exergy of Fuels, Exergy Destruction and Exergy Loss, Exergy Destruction through Heat Transfer and Friction, Thermodynamic Average Temperature, Exergy Destruction and Exergy Loss Ratios.

Reference Books

1. Yogesh Jaluria, "*Design and optimization of thermal systems*". CRC press.
2. Adrian Bejan, George Tsatsaronis, and Michael J. Moran. *Thermal design and optimization*. John Wiley & Sons.

COURSE CONTENTS AND LECTURE SCHEDULE

(For 4 credit courses, the content can be for 45 hrs. and for 3 credit courses, the content can be for 36 hrs.)

Sl. No	Topic	No. of Lecture/ Tutorial hours
	Module 1	
1.1	Piping and Tubing Standards,	1
1.2	Head Loss due to Friction in Pipes and Tubes	1
1.3	Types of valves and fittings—function and selection	1
1.4	The Hooper 2K Method & The Darby 3K Method	1
1.5	Design and analysis of pipe networks	1
1.6	Parallel pipe networks and economic pipe diameter, Cost of a pipe system and determining economic diameter	1
1.7	Pumps—types, selection, and operation, Manufacturer's pump curves and system curves	1
1.8	Cavitation and the Net Positive Suction Head, Calculating the NPSHa, Series and Parallel Pump Configurations, Affinity Laws	1
	Module 2	
2.1	Optimization in Design, Final Optimized Design, Objective Function, Constraints	1
2.2	Mathematical approaches for optimization, Calculus-based methods and search techniques	1
2.3	Linear and dynamic programming principles	1
2.4	Different Types of Thermal Systems, Consideration of the Second Law of Thermodynamic	1
2.5	Sensitivity analysis and optimization approaches	1
2.6	Case studies on thermal systems optimization	1
2.7	Operating conditions and constraints in design	1
2.8	Practical aspects in optimal design considerations	1
	Module 3	
3.1	Introduction to Calculus Methods & Basic Approach	1
3.2	Physical Interpretation & Gradient Vector	1
3.3	Lagrange Multipliers for Optimization	1
3.4	Basic Approach, Physical Interpretation, Gradient Vector, Lagrange Multiplier Method for Unconstrained Optimization	1
3.5	Lagrange Multiplier Method for Constrained Optimization, Significance of the Multipliers,	1
3.6	Optimization of Unconstrained Problems, Use of Gradients for Optimization	1
3.7	Determination of Minimum or Maximum	1
	Module 4	
4.1	Basic Considerations, Importance of Search Methods Types of Approaches	1
4.2	Elimination Methods	1

4.3	Hill-Climbing Techniques Constrained Optimization, Application to Thermal Systems	1
4.4	Single-Variable Problem: Uniform Exhaustive Search, Fibonacci Search	1
4.5	Steepest Ascent/Descent Methods	1
4.6	Penalty Function Method, Search along a Constraint	1
	Module 5	
5.1	Exergy Balance Equation, Closed System, Energy Balance of the Closed System, Entropy Balance of the Closed System,	1
5.2	Open System, Exergy Transfers at Inlets and Outlets	1
5.3	Standard Chemical Exergy of Gases and Gas Mixtures, Standard Chemical Exergy of Fuels, Exergy Destruction and Exergy Loss	1
5.4	Exergy Destruction through Heat Transfer and Friction	1
5.5	Thermodynamic Average Temperature	1
5.6	Exergy Destruction and Exergy Loss Ratios	1
5.7	Case studies	1

Model Question Paper

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

THIRD SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2025

***Course Code:* M24ME2E302C**

***Course Name:* Thermal Design and Optimization**

Max. Marks:60 Duration: 3 hours

PART A

Answer all questions. Each question carries 4 marks.

1.What is the primary cause of head loss in fluid transport systems?

2. How does the Hooper 2K method differ from the Darby 3K method in pipe flow analysis?

3. What is the significance of the Lagrange multiplier method in optimization?

4. Explain the concept of exergy destruction in thermal systems.

5. What are the advantages of using the Fibonacci search method in optimization?

PART B

Answer any five questions. Each question carries 8 marks.

6. A large industrial plant requires a new pipeline system. Describe the steps involved in designing the pipe network, considering economic diameter, frictional losses, and pump selection. Apply the Hooper 2K and Darby 3K methods to justify your design choices.
7. A centrifugal pump operates at 1500 RPM with a discharge of 10 L/s. Given the pump curve equation $H = 30 - 0.2Q^2$, find the head developed when the flow rate is 8 L/s
8. An engineering team is tasked with minimizing the material cost of an insulated pipe while maximizing thermal efficiency. How can the Lagrange multiplier method be applied to solve this constrained optimization problem? Discuss its physical significance.
9. Compare and contrast two different search methods—Fibonacci search and steepest ascent/descent method—in solving an optimization problem related to energy efficiency in building design. Which method is more effective in different scenarios?
10. A manufacturing unit is experiencing excessive energy losses in its steam turbine system. Using exergy balance equations, analyze the inefficiencies and propose modifications to improve the overall exergetic efficiency of the system
11. A chemical processing plant needs to transport fluid from one storage tank to another. Using system

curve analysis and pump performance considerations, design an optimized pump-pipe system ensuring minimal energy consumption and maximum efficiency.

12. A heat exchanger costs ₹20,000, and its operational cost per year is ₹5,000. Considering a lifespan of 10 years, formulate the economic optimization model for minimizing the total cost using a discount factor of 10%.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2I303/ M24ME2I307	Internship	Internship	0	0	0	0	3

Summery:
Internship is a structured, short-term, supervised placement designed to provide M.Tech students with practical experience in their field of specialization. Conducted after the second semester for a minimum of 6–8 weeks, the internship can be undertaken at industries, research organizations, or reputed academic institutes. It aims to bridge theoretical knowledge with real-world applications, enhancing students' technical, managerial, and communication skills while offering exposure to industrial environments and professional ethics. Students independently select their internship organization with approval from their faculty advisor, PG Programme Coordinator, or guide, and are assigned a supervisor to oversee their progress.

The internship's objectives include exposing students to industrial settings, sharpening technical and managerial skills, understanding current technological advancements, and appreciating socio-economic and environmental factors in professional contexts. It benefits students by providing hands-on experience, improving employability, and building professional networks. For the institute, it strengthens industry-academia ties and enhances credibility, while industries gain access to motivated pre-professionals and fresh perspectives.

Internship types include industry placements (with/without stipend), government/PSU internships (e.g., BARC, ISRO), academic/research institute internships, and opportunities with incubation centers or startups. Students must adhere to organizational rules, maintain a daily diary/logbook, and submit a report, internship certificate, employer feedback, and stipend proof (if applicable) upon completion. The program mandates weekly progress updates to the college guide and compliance with ethical practices and safety protocols.

Evaluation totals 100 marks, split into Continuous Internal Evaluation (50 marks) and End Semester Evaluation (50 marks). Internal evaluation comprises 25 marks for the student's diary (assessing regularity, quality, and organization of recorded observations) and 25 marks from industry evaluation. The end semester evaluation includes 25 marks for the internship report (judged on originality, structure, and relevance) and 25 marks for a viva voce conducted by a committee of faculty and an external expert. Full details of the evaluation process, including formats and criteria, are available in the M.Tech Curriculum 2024, Section: Evaluation Pattern, Subsection IV.

This internship serves as a critical stepping stone for students, offering practical exposure, skill development, and potential career opportunities while fostering collaboration between academia and industry.

Course Outcomes

CO 1	Students will demonstrate an understanding of industrial practices and real-world applications by integrating theoretical knowledge gained during their M.Tech program into practical settings.
CO 2	Students will develop technical and managerial skills through hands-on experience in industry, research, or academic environments during a 6–8 week supervised internship.
CO 3	Students will apply problem-solving techniques and current technological advancements to address challenges encountered in their chosen internship organization.
CO 4	Students will evaluate socio-economic, environmental, and ethical factors influencing professional engineering practices based on observations recorded during their internship.
CO 5	Students will create a comprehensive internship report and effectively communicate their findings and experiences through a viva voce, showcasing enhanced communication and professional skills.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	2	1	2	2	1	1
CO 2	2	1	3	2	2	1
CO 3	3	1	2	3	2	0
CO 4	2	1	2	1	1	3
CO 5	1	3	2	1	1	1

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2P304/ M24ME2P308	**Dissertation Phase 1**	**Project/Dissertation**	0	0	0	0	11

Overview

Dissertation Phase 1 is a critical component of the M.Tech program conducted during the third semester. It marks the initial stage of the dissertation work, where students begin their research or project under two distinct tracks: Track 1 (conventional M.Tech program) and Track 2 (industry-oriented long-term internship program). The course is designed to enable students to apply their theoretical knowledge and technical skills to address real-world problems in their specialization, fostering research, innovation, and industry readiness.

Structure and Credits

Course Codes:

Track 1: M24EC1P304 (Dissertation Phase 1, conducted in college)

Track 2: M24EC1P308 (Dissertation Phase 1, conducted in industry)

Credits: 11 credits for both tracks

Hours:

Track 1: 16 hours/week

Track 2: Not explicitly specified but aligned with industry work (minimum 16 weeks of prior internship required)

Total Marks: 100 (Continuous Internal Evaluation only)

Objectives

The primary objectives of Dissertation Phase 1 are:

1. Topic Identification and Selection: To identify a relevant, feasible, and innovative research topic aligned with the student's area of interest and the field's current trends or challenges.
2. Literature Review: To conduct a preliminary review of existing research and literature to understand the state of the art, identify gaps, and establish the context for the proposed work.
3. Problem Definition: To clearly define the research problem or question that the dissertation aims to address, ensuring it is specific, measurable, and researchable.
4. Objective Formulation: To establish clear and achievable objectives for the overall dissertation, outlining what the research intends to accomplish.
5. Feasibility Assessment: To evaluate the practicality of the proposed research in terms of available resources, time constraints, and technical requirements.

6. Methodology Outline: To develop a preliminary plan for the research methodology, including the tools, techniques, or approaches that will be used to investigate the problem.
7. Synopsis Preparation: To prepare and submit a concise synopsis or proposal summarizing the research topic, objectives, significance, and planned approach for approval by the academic supervisor or committee.
8. Background Knowledge Building: To deepen the student's understanding of the chosen domain and related concepts, ensuring a solid theoretical foundation for the research.

These objectives are designed to set the stage for Phase 2 and beyond, where the focus typically shifts to implementation, experimentation, and analysis. Phase 1 is critical for ensuring that the research is well-planned and directed toward a meaningful contribution to the field.

Course Outcome

After completing dissertation phase 1 student should be able to

CO 1	Demonstrate Research Topic Selection Skills: Students will be able to identify and select a research topic that is innovative, relevant, and feasible within the scope of their M.Tech program.
CO 2	Conduct Effective Literature Analysis: Students will develop the ability to critically review and synthesize existing literature to identify research gaps and establish the context for their study.
CO 3	Define a Clear Research Problem: Students will acquire the skill to articulate a well-defined research problem or question, ensuring it is specific, measurable, and aligned with their dissertation goals.
CO 4	Formulate Research Objectives and Methodology: Students will be able to formulate clear research objectives and outline a preliminary methodology, demonstrating an understanding of the tools and approaches required for their study.
CO 5	Prepare a Comprehensive Research Proposal: Students will gain the capability to create a structured synopsis or proposal, effectively communicating the significance, objectives, and planned approach of their research for evaluation.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	2	2	2	1
CO 2	3	2	3	2	2	1
CO 3	3	1	3	2	2	1
CO 4	3	1	3	3	3	1
CO 5	2	3	3	2	2	2

Tracks and Eligibility

Track 1 (Conventional M.Tech Program):

- Dissertation Phase 1 is conducted within the college.
- Suitable for students focusing on academic research or projects not requiring extensive industry immersion.

Track 2 (Industry-Oriented Program):

- Designed for students who have completed a long-term internship (minimum 16 weeks) in industry.
- Dissertation Phase 1 is conducted in the industry where the internship was completed.
- Eligibility:
  - Qualified in GATE or achieved an SGPA above 8.0 in the first semester.
  - Successful completion of an interview by an expert committee at the end of the second semester.

Location:

- Track 1: Conducted in college
- Track 2: Conducted in industry, requiring prior approval from the Department Level Advisory Committee (DLAC) and College Level Advisory Committee (CLAC).

Supervision:

- Track 1: Supervised by an internal faculty member.
- Track 2: Co-supervised by an internal faculty member and an external supervisor (scientist/engineer with a minimum postgraduate degree) from the industry.
- Progress Reporting: Students must submit monthly progress and attendance reports, signed by the external guide (for Track 2), to the internal supervisor.
- Prerequisites: Successful completion of coursework up to the second semester is mandatory.

Continuous Internal Evaluation

The evaluation committee consists of the following members:

1. Project Coordinator
2. A Senior Faculty Member
3. Project Supervisor
4.

Dissertation Phase 1 is evaluated through Continuous Internal Evaluation (CIE) only, with a total of 100 marks. The evaluation process is detailed in the M.Tech Curriculum 2024, Section: Evaluation Pattern, Subsection IX (Dissertation):

Mark Allocation

Course Outcome (CO)	Marks Allocated	Justification
CO1: Demonstrate Research Topic Selection Skills	15	Topic selection is foundational but less intensive than later stages; it requires creativity and initial research.
CO2: Conduct Effective Literature Analysis	25	Literature review is critical, time-intensive, and requires critical thinking to identify gaps.
CO3: Define a Clear Research Problem	20	Defining the problem is a pivotal step, requiring clarity and alignment with research goals.
CO4: Formulate Research Objectives and Methodology	25	Formulating objectives and methodology demands detailed planning and technical understanding.
CO5: Prepare a Comprehensive Research Proposal	15	Proposal preparation integrates all prior work into a concise document, focusing on communication.
Total	**100**	

Detailed Breakdown and Rationale:

CO1: Demonstrate Research Topic Selection Skills (15 marks)

- This involves identifying a feasible and innovative topic. It's an essential starting point but less complex than subsequent analytical tasks.
- Assessment: Relevance, originality, and feasibility of the topic.

CO2: Conduct Effective Literature Analysis (25 marks)

- A thorough literature review is a cornerstone of Phase 1, requiring significant effort to survey existing work, analyze gaps, and establish context.
- Assessment: Depth, breadth, and critical evaluation of sources.

CO3: Define a Clear Research Problem (20 marks)

- Defining a specific, measurable research problem is crucial and builds on the literature review. It's moderately weighted as it sets the direction for the dissertation.
- Assessment: Clarity, specificity, and significance of the problem statement.

CO4: Formulate Research Objectives and Methodology (25 marks)

- This requires outlining clear objectives and a preliminary methodology, which involves technical knowledge and planning. It's a high-effort task, justifying equal weight to the literature review.
- Assessment: Achievability of objectives and appropriateness of the methodology.

CO5: Prepare a Comprehensive Research Proposal (15 marks)

- The proposal synthesizes all prior work into a structured document. While important for communication, it's less intensive than analysis or planning, hence a slightly lower weight.
- Assessment: Structure, clarity, and completeness of the proposal.

Evaluation Scheme for Track 2 (Industry-Based)

Overview

Target Students: Those who have completed a long-term internship (16 weeks) and aim to conduct their dissertation in industry.

Focus: In-depth research, industry-relevant problem-solving, and collaboration with industrial mentors.

Total Marks: 100 (for Phase 1).

Eligibility:

Qualified in GATE OR SGPA > 8.0 in the first semester.

Successful qualification in an interview by an expert committee at the end of the second semester.

Evaluation Process

Industry Mentor Involvement: The industry mentor (from the internship or dissertation site) provides feedback and assesses feasibility (e.g., 30% weightage).

Academic Supervisor: Ensures academic rigor and alignment with M.Tech standards (e.g., 50% weightage).

Expert Committee Review: Evaluates the final proposal for originality and industry relevance (e.g., 20% weightage, possibly tied to synopsis approval).

Deliverables:

Interim report (literature review, problem statement) – Mid-Phase 1.

Final proposal (synopsis) – End of Phase 1.

Significance

Dissertation Phase 1 serves as a bridge between coursework and full-fledged research or industry application. For Track 1 students, it fosters academic rigor, while for Track 2 students, it enhances industry-academia collaboration, aligning with the college's mission of producing technically competent professionals with real-world exposure.

For full details, refer to the M.Tech Curriculum 2024, Section: Evaluation Pattern, Subsection IX (Dissertation).

SEMESTER IV

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M24ME2P401/ M24ME2P402	**Dissertation Phase 2**	**Project/Dissertation**	0	0	0	0	18

Overview

Dissertation Phase 2 is the culminating stage of the M.Tech program, conducted during the fourth semester. It builds upon the foundational work completed in Dissertation Phase 1, requiring students to finalize their research or project, present their findings, and demonstrate mastery in their specialization. This phase is offered under two tracks: Track 1(conventional M.Tech program) and Track 2(industry-oriented program), with distinct course codes and execution contexts.

Structure and Credits

- Track 1: M24EC1P401 (Dissertation Phase II, typically conducted in college)
- Track 2: M24EC1P402 (Dissertation Phase II, conducted in industry)
- Credits: 18 credits for both tracks

Hours:

- Track 1: 27 hours/week
- Track 2: Not explicitly specified but aligned with industry work (full-time commitment assumed)

Total Marks: 200 (Continuous Internal Evaluation: 100 marks; End Semester Evaluation: 100 marks)

Objectives

The primary objectives of Dissertation Phase 2 are:

- To complete an in-depth research project or industry-relevant solution in VLSI and Embedded Systems.
- To synthesize and apply knowledge gained throughout the M.Tech program to solve complex problems.
- To produce tangible outcomes, such as prototypes, simulations, or publishable research, demonstrating technical expertise and innovation.
- To prepare students for professional careers or advanced academic pursuits by enhancing their research, analytical, and communication skills.

Outcomes

Upon completion of Dissertation Phase 2, students are expected to:

- Deliver a comprehensive solution or research contribution in VLSI and Embedded Systems.
- Demonstrate advanced technical proficiency, critical thinking, and the ability to address real-world challenges.
- Produce a high-quality dissertation report and defend their work effectively.
- For Track 2, align outcomes with industry needs, potentially leading to employment opportunities or patents.

Significance

Dissertation Phase 2 is the capstone of the M.Tech program, reflecting the college's vision of "Excellence in education through resource integration" and mission to produce "technically competent professionals with moral integrity." It bridges academic learning with practical application, preparing students for careers in industry, research, or entrepreneurship. The dual-track approach ensures flexibility, catering to both academic and industry-oriented aspirations.

Scheme for Track 1: Dissertation Phase 2 (College-Based)

Course Outcomes (COs) for Track 1

CO 1	Implement the research methodology proposed in Phase 1 using appropriate tools and techniques (Technical Skills, Problem-Solving Skills).
CO 2	Conduct experiments or simulations to generate data or validate the approach (Research Skills, Critical Thinking Skills).
CO 3	Analyze results and interpret findings to address the research problem (Critical Thinking Skills, Research Skills).
CO 4	Compile a detailed dissertation report documenting the research process and outcomes (Communication Skills).
CO 5	Present and defend the research work effectively to an academic audience (Communication Skills, Technical Skills).

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	3	3	3	1
CO 2	3	1	3	2	3	1
CO 3	3	1	3	2	3	1
CO 4	2	3	2	1	2	1
CO 5	2	3	3	1	2	1

Evaluation Scheme

1. Continuous Internal Evaluation (CIE) – 100 Marks

Assessed by the project coordinator throughout the semester.

Focus: Progress, effort, and intermediate deliverables.

Component	Marks	CO Assessed	Justification
Methodology Implementation Progress	25	CO1	Monitors execution of the proposed plan in a college lab or simulation setup.
Experimental/Simulation Work	25	CO2	Assesses data collection or validation efforts in a controlled academic setting.
Interim Result Analysis	20	CO3	Evaluates preliminary analysis and critical thinking during the semester.
Draft Report Submission	20	CO4	Checks documentation quality and adherence to academic standards.
Regular Interaction/Presentation	10	CO5	Assesses communication and ability to discuss progress with the supervisor.
Total	**100**		

2. End Semester Evaluation (ESE) – 100 Marks

Assessed by a panel (Project coordinator+ supervisor + external examiner) at the semester's end.

Focus: Final output, rigor, and presentation.

Component	Marks	CO Assessed	Justification
Final Methodology Implementation	20	CO1	Evaluates completeness and technical accuracy of the implemented solution.
Quality of Results/Data	25	CO2	Assesses the robustness and validity of experimental or simulation outcomes.
Depth of Analysis and Conclusions	25	CO3	Examines the interpretation and significance of findings.
Final Dissertation Report	20	CO4	Judges the quality, structure, and clarity of the written report.
Viva Voce/Presentation	10	CO5	Tests ability to defend work and communicate findings to an academic panel.
Total	**100**		

Scheme for Track 2: Dissertation Phase 2 (Industry-Based)

Course Outcomes (COs) for Track 2

CO 1	Implement the industry-oriented methodology proposed in Phase 1 using industry tools/resources (Technical Skills, Problem-Solving Skills).
CO 2	Perform industry-relevant experiments, validations, or prototypes (Research Skills, Critical Thinking Skills).
CO 3	Analyze results and draw conclusions applicable to the industry problem (Critical Thinking Skills, Research Skills).
CO 4	Compile a dissertation report integrating academic and industry perspectives (Communication Skills).
CO 5	Present findings effectively to both academic and industry stakeholders (Communication Skills, Technical Skills).

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	3	3	3	1
CO 2	3	1	3	2	3	1
CO 3	3	1	3	2	3	1
CO 4	2	3	2	1	2	1
CO 5	2	3	3	1	2	1

Evaluation Scheme

1. **Continuous Internal Evaluation (CIE) – 100 Marks**

Assessed jointly by the Project coordinator, supervisor and industry mentor during the semester.

Focus: Industry collaboration, progress, and practical application.

For full details, refer to the M.Tech Curriculum 2024, Section: Evaluation Pattern, Subsection IX (Dissertation).

Component	Marks	CO Assessed	Justification
Methodology Implementation Progress	25	CO1	Tracks execution of the plan in an industry environment using real-world tools.
Industry Validation/Prototype Work	25	CO2	Evaluates practical outputs (e.g., prototypes, tests) relevant to industry needs.
Interim Result Analysis	20	CO3	Assesses industry-applicable insights derived during the process.
Draft Report Submission	20	CO4	Ensures documentation meets both academic and industry standards.
Industry Feedback/Interaction	10	CO5	Gauges communication with industry mentor and progress updates.
Total	100		

2. End Semester Evaluation (ESE) – 100 Marks

Assessed by a panel (Project coordinator, supervisor, industry mentor, external examiner).

Focus: Final deliverables, industry relevance, and dual-audience presentation.

Component	Marks	CO Assessed	Justification
Final Methodology Implementation	20	CO1	Evaluates the technical success of the industry-implemented solution.
Quality of Industry Outputs/Results	25	CO2	Assesses the practical utility and quality of industry-specific deliverables.
Depth of Analysis and Industry Impact	25	CO3	Examines conclusions and their relevance to industry challenges.
Final Dissertation Report	20	CO4	Judges the report's ability to address academic rigor and industry needs.
Viva Voce/Presentation (Dual Audience)	10	CO5	Tests communication to both academic and industry evaluators.
Total	100		