MAR ATHANASIUS COLLEGE OF ENGINEERING (Autonomous)

Kothamangalam 686 666

Affiliated to APJ Abdul Kalam Technological University

Thiruvananthapuram

Master of Technology (M. Tech.) Curriculum - 2026

Thermal Power Engineering

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 (AUTONOMOUS)
M.TECH CURRICULUM 2026
(Branch and Specialization)

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	M26ME1D101	Applied Numerical Methods and Programing	60	40	3-0-3-6	6	5
B	M26ME1D102	Advanced Heat Transfer	60	40	3-0-3-6	6	5
C	M26ME1T103	Incompressible Flows	60	40	4-0-0-5	4	4
D	M26ME1E104	Programme Elective 1	60	40	4-0-0-5	4	4
J	M26GE1R105	Research Methodology & IPR	60	40	2-0-0-4	2	2
Total			300	200		22	20

Teaching Assistance: 8 hours/week

Self-study- 26 Hrs

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
D	M26ME1E104A	Artificial Intelligence and Machine Learning in Thermal Engineering	60	40	4-0-0-5	4	4
D	M26ME1E104B	Measurement Methods in Thermal Engineering	60	40	4-0-0-5	4	4
D	M26ME1E104C	Hydrogen And Fuel Cell Technology	60	40	4-0-0-5	4	4

SEMESTER II

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
A	M26ME1D201	Computational Fluid Dynamics	60	40	3-0-3-6	6	5
B	M26ME1D202	Applied Thermal Engineering	60	40	3-0-3-6	6	5
C	M26ME1E203	Programme Elective 2	60	40	4-0-0-5	4	4
E	M26ME1S204	Energy Management and Audit	60	40	4-0-0-5	4	4
G	M26ME1P205	Mini project	100		0-0-4-6	4	2
TOTAL			340	160		24	20

Teaching Assistance: 8 hours/week

Self-study- 28 Hrs

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
D	M26ME1E203A	Solar Thermal Energy Systems	60	40	4-0-0-5	4	4
D	M26ME1E203B	Design Of Heat Transfer Equipments	60	40	4-0-0-5	4	4
D	M26ME1E203C	Thermal Power Plant Design	60	40	4-0-0-5	4	4

SEMESTER III

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
A	M26ME1M301	*MOOC	To be completed successfully		--	--	2
K	M26ME1I302	Internship	50	50	--	--	10
P	M26ME1P303	Dissertation Phase 1	100	--	0-0-12-18	12	8
TOTAL			150	50		12	20

Teaching Assistance:´8 hours/week

*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 minimum 16 weeks duration.

Dissertation Phase 1 may be undertaken either in the college or in the industry. Dissertation Phase 1 can be linked with internship. Students are expected to have the following skills: Technical Skills, Research Skills, Communication Skills, Critical Thinking Skills, and Problem-Solving Skills.

SEMESTER IV

Slot	Course Code	Courses	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
P	M26ME1P401	Dissertation Phase II	100	100	0-0-24-26	24	20
TOTAL			100	100		24	20
Total credits in all four semesters							**80**

COURSE NUMBERING SCHEME

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

D- Lab integrated 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:

M26CE1T103 is a core course of first specialization offered by the Civil Department in semester 1

M26CE1D201 is a lab integrated core course of first specialization offered by the Civil Department in semester 2

M26GE1R106 is Research Methodology & IPR offered in semester 1offered by all Departments

M26EC1E104A is the first subject of Elective 1 of first specialization offered by the EC Department in semester 1.

EVALUATION PATTERN

(i) LAB INTEGRATED COURSES

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

Continuous Internal Evaluation (CIE) : 60 marks

Theory Evaluation : 30 marks

Self-study (Course based task/Seminar/ Quiz/ Micro project) :10 marks

Test paper 1 :10 marks

Test paper 2 :10 marks

Lab Evaluation : 30 marks

Lab work : 10 marks

Final evaluation Test : 20 marks

(Note: 50% of Module 1, 2 and 3 may be considered for each test)

End Semester Examination (ESE) : 40marks

The end semester examination should be conducted by the college. The time duration will be 2 Hrs and will contain 6 questions from first three modules, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

(ii) ELECTIVE COURSES/CORE COURSE

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

Continuous Internal Evaluation : 60 marks

Self-study (Seminar*) : 10 marks

Course based task/Micro Project/Data collection and interpretation/Case study : 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 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 (ESE) : 40marks

The end semester examination will be conducted by the College. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

(iii) RESEARCH METHODOLOGY & IPR

Continuous Internal Evaluation: 60 marks

Self-study (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 : 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 marks

End Semester Examination : 40 marks

The end semester examination should be conducted by the college. The time duration will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question carries 10 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 time scales. 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 objectivesand 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 theirpresentation, 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/ResearchOrganization 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 sixteen 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 theclassroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real timetechnical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subjectarea of training.
- Create conducive conditions with quest for knowledge and its applicabilityon the job.
- Understand the social, environmental, economic and administrativeconsiderations that influence the working environment.
- Expose students to the engineer’s responsibilities and ethics.

Benefits of InternshipBenefits 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 anindustrial setup.
- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industrypeople.
- Provides opportunity to evaluate the organization before committing to a fulltime 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 andprojects.
- 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 theeducational 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 16 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 industrialauthority 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 weeklybasis 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) Internal evaluation & Student's diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

Continuous Internal Evaluation: 50 marks

Internal evaluation & 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 ....

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 tothe 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 _
____

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																					

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

Parameters	**Marks** Rating (0-10 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	
Is punctual	
Uses time effectively	

Evaluation marks: 20 Marks

Overall performance of student: 5 Marks

Intern (Tick one) : Needs improvement (0 - 1 mark) / Satisfactory (1-2 mark) /Good (2-3 mark) / Very Good (3-4 mark) / Excellent (4-5 mark)

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 taught in 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) 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: 60 marks

Self-study (*Seminar)	:	10 marks
Course based task/Seminar/Data collection and interpretation/Case study	:	20marks
Test paper 1 (Module 1 and Module 2)	:	15 marks
Test paper 2 (Module 3 and Module 4)	:	15 marks

End Semester Examination: 40 marks

The examination will be conducted by the College with the question paper provided by the Industry. The examination will be for 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks. The valuation of the answer scripts shall be done by the expert in the Industry handling the course.

(vi) 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.

(vii) 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

(viii) 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.
- 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 internalsupervisor 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.

Internship leading to Dissertation: The M. Tech students who after completion of 16 weeks internship at some reputed organization are allowed to continue their work 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. 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 the Dean (PG) through HoD 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. MOOC can be completed as per the norms mentioned earlier.

Extended Submission for PG Thesis/Project: Extended submission may be permitted for students who have registered for the dissertation / thesis but require additional time for completion. The extended submission period shall be limited to a maximum of three months from the scheduled date of normal submission. Evaluation of theses submitted during the extended period shall be treated as part of the regular examination, and not as a supplementary examination. Extended submission shall be permitted only on the recommendation of the Project Supervisor. If the attendance requirements are not met, an 'FE' grade shall be awarded.

Mark Distribution:

Phase 1: Total marks: 100, only CIE
Phase 2: Total marks: 200, CIE = 100 and ESE = 100 marks

- If the student publishes the dissertation work in a recognized national/international conference or an indexed journal, 10 marks should be awarded.

- 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
- If the quantum of work done by the candidate is found to be unsatisfactory, the evaluation committee may extend the duration of the project up to maximum of three months, giving reasons for this in writing to the student. Normally further extension will not be granted and there shall be no provision to register again for the project. A separate evaluation may be conducted for such candidates

(ix)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 as a 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 all the tutorial problems yourself, approach the teacher if you find any discrepancy or 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 and get 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 laboratoryclass, 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 duringfirst semester and inform them about the mandatory 16 weeks internship that the students should undergo after their second semester. The possibilityof doing their dissertation at the Industry shall also be explored. They should also 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 allottingto 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 discussionsection 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.

MAR ATHANASIUS COLLEGE OF ENGINEERING
(Autonomous)

Kothamangalam 686 666

Affiliated to APJ Abdul Kalam Technological University

Thiruvananthapuram

Syllabus

M. Tech Thermal Power Engineering

(2026 Scheme)

Semester 1

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1D101	**APPLIED NUMERICAL METHODS AND PROGRAMING**	**DISCIPLINE CORE**	**3**	**0**	**3**	**6**	**5**

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 1	Acquire skills necessary for formulating and solving engineering problems through computational methods, illustrated through case studies. (Cognitive Knowledge Level: Apply)
CO 2	Apply interpolation, numerical differentiation, and integration techniques to estimate and analyse engineering data. (Cognitive Knowledge Level: Analyse)
CO 3	Apply numerical methods to obtain solutions for ordinary and partial differential equations arising in engineering applications. (Cognitive Knowledge Level: Apply)
CO 4	Apply and Master Python programming to implement and analyze numerical methods for solving engineering problems involving equations, interpolation, differentiation, integration, and differential equations, and evaluate the accuracy of the results. (Cognitive Knowledge Level: 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	2	1
CO 2	1		2	2	2	1
CO 3	1		2	2	2	1
CO 4	1		2	2	2	1

Assessment Pattern

Bloom's Category	**Applied Numerical Methods and Programing**		
	Continuous Internal Evaluation 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	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Theory Evaluation : **30 marks**

Self-study (Course based task/Seminar/

Quiz/ Micro project) :10 marks

Test paper 1 :10 marks

Test paper 2 :10 marks

Lab Evaluation : **30 marks**

Lab work : 10 marks

Final evaluation Test : 20 marks

(Note: 50% of Module 1, 2 and 3 may be considered for each test)

End Semester Examination Pattern:

The end semester examination should be conducted by the college. The time duration will be 2 hrs. and will contain 6 questions from first three modules, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

Module 1 (10 Hours)

Introduction to Computational methods, system of equations- Formulation of engineering problems using numerical techniques, Errors in numerical computation: Significant figures, accuracy, precision, Round-off error, truncation error. Taylor series expansion of a polynomial.
Roots of equations: Bisection, Newton–Raphson, Bairstow methods. Linear algebraic equations: Gauss Elimination, LU decomposition. Non-linear simultaneous equations: Gauss–Jordan method, Newton–Raphson.

Module 2 (10 Hours)

Interpolation, Numerical differentiation and integration-

Interpolation: Newton's forward and backward interpolation**,** Divided difference (linear & quadratic), Lagrange interpolation, Cubic splines and Hermite interpolation
Numerical Differentiation: Newton's forward, backward, divided difference, Stirling formula.

Numerical Integration: Trapezoidal rule, Simpson's 1/3 and 3/8 rules, Romberg's method, Gauss quadrature (two- and three-point methods), Numerical evaluation of double integrals.

Module 3 (10 Hours)
Numerical solutions to ODEs and PDEs-
Ordinary Differential Equations (ODEs): Taylor's method, Euler's method, Runge–Kutta (4th order), Milne's predictor-corrector method, Initial value problems: Shooting method
Partial Differential Equations (PDEs): Finite difference formulation, Elliptic equations: Laplace and Poisson equations, Liebmann's iterative method, Parabolic equations: Bender–Schmidt, simple implicit, Crank–Nicolson, Hyperbolic equations

Module 4 Experimental studies in Numerical methods (30 hours)

Write a program to:

1. Evaluate Taylor series and compare the results with the values obtained from Python library functions
2. Find the root of a polynomial equation using Bisection Method, Newton Raphson Method and Bairstow method.
3. Solve the system of linear equations using Gauss Elimination with back substitution and LU decomposition
4. Estimate the value of the function from a set of data using Newton's interpolation method.
5. Plot the original data points and interpolate using Lagrange method. Compare Lagrange interpolation value with Newton's divided difference interpolation for the same data set.
6. Estimate the interpolated values using cubic spline interpolation for a given set of data.
7. Perform Hermite interpolation from a given data set.
8. Compute the first derivative using Forward difference, Backward difference, Divided difference and Stirling formulae.
9. Evaluate Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Two-point Gauss quadrature, Three-point Gauss quadrature. Compare all results with the exact value. Tabulate the results and compute the absolute error for each method.
10. Solve an initial value problem using Taylor's method, Euler's method and Runge-Kutta fourth order method. Compare the numerical solution with the exact solution. Tabulate the results and compute the maximum absolute error for each method
11. Solve a first order ordinary differential equation using Milne's predictor-corrector method.
12. Solve the boundary value problem using Shooting method.
13. Solve Laplace's equation using Liebmann's method. Continue the iteration until the maximum change is below some predetermined value. Display the final temperature / potential distribution as a table and (optionally) a contour plot.
14. Solve the one-dimensional heat equation subject to Dirichlet boundary conditions and initial condition using any one of the following methods: Bender-Schmidt, simple implicit, or Crank-Nicolson.
15. Solve the one-dimensional wave equation subject to Dirichlet boundary conditions with initial conditions using the finite difference method.

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	
1.1	Introduction to Computational methods, system of equations	1
1.2	Formulation of engineering problems using numerical techniques.	1
1.3	Errors in numerical computation: Significant figures, accuracy, precision, Round-off error, truncation error.	1
1.4	Taylor series expansion of a polynomial.	1
1.5	Roots of equations: Bisection, Newton–Raphson.	1
1.6	Roots of equations: Bairstow methods.	1
1.7	Linear algebraic equations: Gauss Elimination.	1
1.8	Linear algebraic equations: LU decomposition	1
1.9	Non-linear simultaneous equations: Gauss–Jordan method.	1
1.10	Non-linear simultaneous equations: Newton–Raphson.	1
	Module 2	
2.1	Interpolation: Newton's forward and backward interpolation.	1
2.2	Interpolation: Newton's Divided difference (linear & quadratic).	1
2.3	Interpolation: Lagrange interpolation.	1
2.4	Interpolation: Cubic splines and Hermite interpolation.	1
2.5	Numerical Differentiation: Newton's forward, backward, Stirling formula.	1
2.6	Numerical Differentiation: Newton's divided difference method.	1

2.7	Numerical Integration: Trapezoidal rule, Simpson's 1/3 and 3/8 rules.	1
2.8	Numerical Integration: Romberg's method.	1
2.9	Numerical Integration: Gauss quadrature (two- and three-point methods).	1
2.10	Numerical Integration: Numerical evaluation of double integrals.	1
	Module 3	
3.1	Ordinary Differential Equations (ODEs): Taylor's method, Euler's method.	1
3.2	Ordinary Differential Equations (ODEs): Runge–Kutta (4^{th} order).	1
3.3	Milne's predictor-corrector method.	1
3.4	Initial value problems: Shooting method	1
3.5	Partial Differential Equations (PDEs): Finite difference formulation.	1
3.6	Partial Differential Equations (PDEs): Elliptic equations: Laplace equations, Liebmann's iterative method	1
3.7	Partial Differential Equations (PDEs): Poisson equations	1
3.8	Partial Differential Equations (PDEs): Parabolic equations: Bender–Schmidt, simple implicit.	1
3.9	Partial Differential Equations (PDEs): Crank–Nicolson method	1
3.10	Partial Differential Equations (PDEs): Hyperbolic equations	1
	Module 4	
4.1	Write a program to evaluate Taylor series and compare the results with the values obtained from Python library functions Write a program to find the root of a polynomial equation using Bisection Method, Newton Raphson Method and Bairstow method.	3
4.2	Write a program to solve the system of linear equations using Gauss Elimination with back substitution and LU decomposition. Write a program to estimate the value of the function from a set of data using Newton's interpolation method.	3
4.3	Write a program to plot the original data points and interpolate using Lagrange method. Compare Lagrange interpolation value with Newton's divided difference interpolation for the same data set. Write a program to estimate the interpolated values using cubic spline interpolation for a given set of data.	3
4.4	Write a program to perform Hermite interpolation from a given data set. Write a program to compute the first derivative using Forward difference, Backward difference, Divided difference and Stirling formulae.	3

4.5	Write a program to evaluate Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Two-point Gauss quadrature, Three-point Gauss quadrature. Compare all results with the exact value. Tabulate the results and compute the absolute error for each method. Write a program to solve an initial value problem using Taylor's method, Euler's method and Runge-Kutta fourth order method. Compare the numerical solution with the exact solution. Tabulate the results and compute the maximum absolute error for each method	3
4.6	Write a program to solve a first order ordinary differential equation using Milne's predictor-corrector method.	3
4.7	Write a program to solve the boundary value problem using Shooting method.	3
4.8	Write a program to solve Laplace's equation using Liebmann's method. Continue the iteration until the maximum change is below some predetermined value. Display the final temperature / potential distribution as a table and (optionally) a contour plot.	3
4.9	Write a program to solve the one-dimensional heat equation subject to Dirichlet boundary conditions and initial condition using any one of the following methods: Bender-Schmidt, simple implicit, or Crank-Nicolson.	3
4.10	Write a program to solve the one-dimensional wave equation subject to Dirichlet boundary conditions with initial conditions using the finite difference method.	3

Model Question Paper

QP CODE: Pages: 2

Reg No.:___________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26ME1D101

Course Name: Applied Numerical Methods and Programing

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. a. 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.

   b. Solve the following system of equations using the Gauss elimination with partial pivoting?

$$2x_1 + x_2 + x_3 - 2x_4 = -10$$
$$4x_1 + 2x_3 + x_4 = 8$$
$$3x_1 + 2x_2 + 2x_3 = 7$$
$$x_1 + 3x_2 + 2x_3 - x_4 = -5$$

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

   b. Solve the following system of equations by L U decomposition method

$$2x - 6y + 8z = 24$$
$$5x + 4y - 3z = 2$$
$$3x + y + 2z = 16$$

3. a. Evaluate $\int_{-1}^{1} Cos\ x\ dx$ by 2-point Gaussian quadrature formula

   b. Find the gradient at the middle point of the elevation above the datum line of seven points of a road which are given below

x	0	300	600	900	1200	1500	1800
y	135	149	157	183	201	205	193

4. a. Evaluate $\int_0^1 \int_0^1 xy\ dxdy$ using Trapezoidal rule with h = k = 1/2

b. Use Lagrange's interpolation formula to find the value of f(x) corresponding to x = 27 from the following data

x	14	17	31	35
$f(x)$	68.7	64	44	39.1

5. a. Given $dy/dx = 1/(x+y)$, $y(0) = 2.0$. If $y(0.2) = 2.09$, $y(0.4) = 2.17$ and $y(0.6) = 2.24$, find $y(0.8)$ using Mile's method

   b. Applying Liemann's method to approximate the solution of Laplace's equation $\nabla^2 u=0$ with $h = 1/3$ in a square with vertices $A(0, 0)$, $B(0, 1)$, $C(1, 1)$, $D(1, 0)$ given that the unknown functions on the boundary is $u(x, y) = 9x^2y^2$.

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

   b. 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.

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

   (i) Euler's method with h = 0.5 and 0.25.

   (ii) Fourth-order RK method with h = 0.5.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1D102	ADVANCED HEAT TRANSFER	PROGRAMME CORE	3	0	3	6	5

Preamble: This advanced heat transfer course equips engineering students with a comprehensive understanding of conduction, convection, and radiation mechanisms, bridging fundamental theory with practical experimentation. Through rigorous analysis of heat diffusion equations, boundary layer dynamics, multimode interactions, and hands-on laboratory validation, students develop skills to model, predict, and optimize thermal performance in complex engineering systems such as fins, pipes, cylinders, and boiling setups. The curriculum fosters proficiency in analytical, numerical, and empirical methods, preparing graduates for design challenges in thermal management, energy systems, and HVAC applications.

Prerequisite: Basic knowledge in Thermodynamics and Heat Transfer

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

CO 1	Solve heat conduction problems involving steady, transient, multidimensional, and numerical heat transfer in Cartesian, cylindrical, and spherical coordinate systems, including fins and semi-infinite solids. (Cognitive Knowledge Level: Apply)
CO 2	Solve forced convection heat transfer problems in external and internal flows using boundary layer concepts and standard heat transfer correlations for plates, ducts, annuli, cylinders, spheres, and tube banks. (Cognitive Knowledge Level: Apply)
CO 3	Analyze combined heat transfer systems involving natural convection, boiling, condensation, thermal radiation, and multimode heat transfer in engineering applications. (Cognitive Knowledge Level: Analyse)
CO 4	Conduct heat transfer experiments and analyze experimental data to determine thermal properties and heat transfer characteristics in conduction, convection, boiling and radiation systems. (Cognitive Knowledge Level: Analyse)

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	**Advanced Heat Transfer**		
	Continuous Internal Evaluation 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	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Theory Evaluation : 30 marks

Self-study (Course based task/Seminar/
Quiz/ Micro project) :10 marks

Test paper 1 :10 marks

Test paper 2 :10 marks

Lab Evaluation : 30 marks

Lab work : 10 marks

Final evaluation Test : 20 marks

(Note: 50% of Module 1, 2 and 3 may be considered for each test)

End Semester Examination Pattern:

The end semester examination should be conducted by the college. The time duration will be 2 hours and will contain 6 questions from first three modules, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

Module 1: (10 hours)

Advanced Conduction Heat Transfer: Heat diffusion equation – derivation in cartesian, cylindrical and spherical coordinates, boundary and initial conditions. Steady heat conduction – conduction with internal heat generation, heat transfer through extended surfaces (fins). Multidimensional conduction – two-dimensional heat conduction, analytical solution using separation of variables. Numerical methods in conduction – finite difference method, formulation using energy balance approach. Transient heat conduction – lumped capacitance method, Biot and Fourier numbers, transient conduction in semi-infinite solids.

MODULE 2: (10 hours)

Boundary layer theory and forced convection correlations: Fundamentals of convection – conservation equations (continuity, momentum, energy).

Boundary layer theory – hydrodynamic and thermal boundary layer development. External forced convection – flat plate (isothermal and constant heat flux), liquid metal heat transfer. Internal forced convection – fully developed flow, circular and non-circular ducts, concentric tube annulus. Convective heat transfer correlations – Reynolds-Colburn analogy, cylinder and sphere in cross flow, tube banks.

MODULE 3: (10 hours)
Natural Convection, Phase-Change and Radiation Heat Transfer:
Natural Convection – Laminar free convection over vertical and inclined plates, Convection in enclosed and parallel channels, Convection through pipes.

Boiling heat transfer – pool boiling, boiling curve, regimes and correlations, critical heat flux. **Condensation heat transfer** – film condensation theory, condensation over vertical and horizontal surfaces, dropwise condensation.

Thermal radiation fundamentals – blackbody radiation; Planck's law, Wien's displacement law, Stefan-Boltzmann law. Radiation exchange – view factors; radiation exchange between diffuse-gray surfaces; radiation shields.

MODULE 4: Experimental Studies in Heat Transfer (30 hours)
1. Determination of thermal conductivity of insulating materials.
2. Heat conduction through composite walls.
3. Heat transfer through extended surfaces (fins).
4. Forced convection heat transfer over a flat plate.
5. Forced convection heat transfer in internal pipe flow.
6. Natural convection heat transfer from a vertical plate.
7. Natural convection heat transfer in a pipe.
8. Heat transfer from a cylinder in cross flow.
9. Pool boiling experiment for determination of critical heat flux.
10. Determination of Stefan–Boltzmann constant
11. Measurement of emissivity of surfaces.

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	
1.1	Heat diffusion equation – derivation in Cartesian coordinates; boundary and initial conditions	2
1.2	Heat diffusion equation in cylindrical and spherical coordinates	1
1.3	Steady heat conduction with internal heat generation	2
1.4	Heat transfer through extended surfaces (fins)	1
1.5	Multidimensional conduction and analytical solution using separation of variables	2
1.6	Numerical methods in conduction – finite difference method using energy balance approach	1
1.7	Transient heat conduction – lumped capacitance method, Biot and Fourier numbers; semi-infinite solids	1
	Module 2	
2.1	Fundamentals of convection – conservation equations (continuity, momentum, energy)	2
2.2	Hydrodynamic boundary layer development	1
2.3	Thermal boundary layer development	1
2.4	External forced convection over flat plates – isothermal and constant heat flux surfaces	2
2.5	Liquid metal heat transfer	1
2.6	Internal forced convection – fully developed flow in circular and non-circular ducts; concentric tube annulus	2
2.7	Convective heat transfer correlations – Reynolds–Colburn analogy; cylinder and sphere in cross flow; tube banks	1
	Module 3	
3.1	Natural convection over vertical and inclined plates	2
3.2	Natural convection in enclosed spaces, parallel channels and pipes	1
3.3	Boiling heat transfer – pool boiling and boiling curve	2
3.4	Boiling regimes, correlations and critical heat flux	1
3.5	Condensation heat transfer – film condensation theory and condensation over vertical and horizontal surfaces	1
3.6	Dropwise condensation	1
3.7	Thermal radiation fundamentals – blackbody radiation; Planck’s law, Wien’s displacement law, Stefan–Boltzmann law	1
3.8	Radiation exchange – view factors, diffuse-gray surfaces and radiation shields	1
	Module 4	
4.1	Determination of thermal conductivity of insulating materials.	3
4.2	Heat conduction through composite walls.	3
4.3	Heat transfer through extended surfaces (fins).	3
4.4	Forced convection heat transfer over a flat plate.	3

4.5	Forced convection heat transfer in internal pipe flow.	3
4.6	Heat transfer from a cylinder in cross flow.	3
4.7	Natural convection heat transfer from a vertical plate.	3
4.8	Natural convection heat transfer in a pipe	3
4.9	Pool boiling experiment for determination of critical heat flux.	3
4.10	a. Determination of Stefan–Boltzmann constant. b. Measurement of emissivity of surfaces	3

Model Question Paper

QP CODE: Pages: 2

Reg No.:___________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26ME1D102
Course Name: Advanced Heat Transfer

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1 a. Derive the general heat diffusion equation in Cartesian coordinates starting from the energy balance principle. Clearly state the assumptions involved. (5 Marks)

b. Explain the lumped capacitance method for transient heat conduction. Define Biot number and Fourier number and discuss their physical significance. (5 Marks)

2 a. Derive the temperature distribution and heat transfer rate for a straight fin of uniform cross-section with an insulated tip. (5 Marks)

b. Explain the finite difference method for solving two-dimensional steady heat conduction problems using the energy balance approach. (5 Marks)

3 a. Explain the development of hydrodynamic and thermal boundary layers over a flat plate. Discuss the significance of Reynolds number and Prandtl number in boundary layer development. (5 Marks)

b. Derive or discuss the heat transfer correlation for laminar flow over an isothermal flat plate. (5 Marks)

4 a. Explain fully developed flow in internal forced convection and discuss heat transfer in circular and non-circular ducts. (5 Marks)

b. Discuss the Reynolds–Colburn analogy and its significance in convective heat transfer correlations. (5 Marks)

5 a. Explain laminar free convection over a vertical plate and discuss the important dimensionless numbers governing natural convection. (5 Marks)

b. With the help of a diagram, explain the pool boiling curve and the different boiling regimes, including the concept of critical heat flux. (5 Marks)

6

a. Explain the pool boiling experiment used for determining the critical heat flux. Describe the experimental setup, working principle, and the different regimes of the boiling curve. (5 Marks)

b. During a pool boiling experiment, the following data were obtained:

- Diameter of heating surface = 60 mm
- Electrical voltage supplied = 220 V
- Current through heater = 4 A

Assuming that all the electrical power is converted into heat transferred to the liquid, determine:

i) Total heat supplied to the heater

ii) Heat flux at the heating surface (5 Marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1T103	INCOMPRESSIBLE FLOWS	PROGRAMME CORE	4	0	0	5	4

Preamble: The core ideas and techniques of incompressible fluid 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 flow dynamics and the ability to apply those concepts to the analysis of fluid mechanical systems.

Prerequisite: An introductory course in Fluid Mechanics

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

CO 1	Model physical fluid kinematic and dynamics systems using application of proper governing equations with suitable boundary conditions. (Cognitive Knowledge Level: Apply)
CO 2	Apply conservation equations to analytically solve simple fluid dynamics problems on the broad area of potential flows and vortex flows. (Cognitive Knowledge Level: Analyse)
CO 3	Solve benchmark problems using governing equations to estimate the velocity profile and shear stress. (Cognitive Knowledge Level: Apply)
CO 4	Understand boundary layer theory and analysing realistic problems such as sports ball dynamics. (Cognitive Knowledge Level: Analyse)

Mapping of course outcomes with program outcomes

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

Assessment Pattern

	Incompressible Flows		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember	x	x	x
Understand	20	20	20
Apply	40	40	40
Analyse	40	40	40
Evaluate	x	x	x
Create	x	x	x

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) : 10 marks

Course based task/Micro Project/

Data collection and interpretation/Case study: 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 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. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (12 hours)

Introduction: 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 (08 hours)

Vorticity Dynamics: Vortex lines and tubes, Role of viscosity in rotational and irrotational vortices- Kelvin's circulation theorem, Helmholtz Laws, Sources of vorticity production.

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

MODULE 3 (10 hours)

Viscous Laminar Flows - Steady: Fully Developed Flows, Low Reynolds number flows, Unsteady Flows: Impulsively started plate/Oscillating plate, Vortex Sheet, Ekman Layer.

Geophysical Fluid Dynamics: Surface Gravity Waves, Boussinesq approximation, Internal gravity waves.

MODULE 4 (10 hours)

Boundary Layer concept: Boundary layer equations for 2D flows, Blasius Similarity Solution, Karman Momentum integral Equation, Boundary layer thicknesses, Boundary Separation with various pressure gradient, Laminar and Turbulent boundary layers, sports ball dynamics.

Hydrodynamic Instability: Kelvin Helmholtz Instability, Orr Sommerfeld Equation, Transition to turbulence.

Reference Books

1. R. L. Panton, "Incompressible Flows, John Wiley & Sons Inc., 2011
2. P. K. Kundu, I. M. Cohen, & D. M. Dowling, "Fluid Mechanics", Academic Press, 2012
3. Y. A Cengel & J. Cimbala, "Fluid Mechanics: Fundamentals and Applications", McGraw Hill., 2017
4. K Muralidhar and G Biswas, "Advanced Engineering Fluid Mechanics", ,Narosa Publishing House, 2001.
5. F.M.White, "Viscous Fluid Flow", Mc Graw Hill, 2006
6. H. Schlichting and K. Gersten. "Boundary Layer Theory", Springer, 2000.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	
1.1	Introduction to Cartesian Tensors - index notation and Einstein's summation convention- Mathematical Operators – Stokes theorem- Divergence Theorem	03
1.2	Lagrangian and Eulerian Approach- Acceleration of fluid flows- Stream line, Path line and Streak line	02
1.3	Fluid deformation, Reynolds Transport Theorem, Concept of Vorticity, Potential Function, and Stream Function	02
1.4	Conservation of mass	01
1.5	Conservation of momentum	03
1.6	Conservation of energy	01
	Module 2	
2.1	Vorticity Dynamics: Vortex lines and tubes, Role of viscosity in rotational and irrotational vortices	02
2.2	Kelvin's circulation theorem-Helmholtz laws, Interaction of vortices	02

2.3	Irrotational Flow Theory: Application of complex variables, Source, Sink, Doublet- Flow at a wall angle	02
2.4	Flow past a circular cylinder with circulation- Forces on 2D body, Method of Images- Conformal Mapping-	02
	Module 3	
3.1	Exact Solutions of N-S equations: Plane Couette flow and Poiseuille flow-; Hagen -Poiseuille flow	02
3.2	Exact Solutions of N-S equations: Steady flow between concentric cylinders, axi-symmetric flows	02
3.3	Unsteady flows: Impulsively started plates: Similarity solutions; Ekman layer	02
3.4	Waves: introduction, Surface gravity waves, boussinesq approximation, internal waves	04
	Module 4	
4.1	Boundary Layer Approximations-Measures of boundary layer thickness- displacement and momentum thickness	02
4.2	Blasius Solution, Falkner Skan Solution	02
4.3	Momentum Integral equations, Effect of Pressure gradient, Separation, Sport ball dynamics	02
4.4	Theory of Instability: method of normal modes, Orr-Sommerfield equation, Transition to turbulence	03
4.5	Types of Instabilites: Benard Cells, K-H instability	01

Model Question Paper

QP CODE: Pages: 3

Reg No.:___________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26ME1T103
Course Name: Incompressible Flows

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1a. Consider a steady, two-dimensional flow field described by the stream function $\psi(x, y) = Axy$, where A =0.3 s^{-1} and the spatial co-ordinates are measured in meters. A square is marked in the fluid at t=0, with its four corners located at A (1,1), B (1,2), C (2,2) and D (2,1). (i) Determine the Eulerian velocity field $\vec{v}(x, y)$. (i) Evaluate the vorticity and divergence of this flow. (ii) Using Lagrangian description, mathematically track the fluid particles and evaluate the exact new co-ordinates of the four corner points when the fluid particles originally at point A has moved horizontally to x = 1.5 meters. (iii) Calculate the net volumetric flux (per unit depth) passing through the straight spatial line segment initially connecting the bottom corners A (1,1) abd D (2,1), using the fundamental scalar properties of the stream function. Conceptually verify why the area of fluid square from part (ii) must remain constant based on your divergence calculation in part (i).

b. The viscous stress tensor τ_{ij} in a fluid is generally symmetric ($\tau_{ij} = \tau_{ji}$) due to conservation of angular momentum on a differential element. Under what physical conditions, does this symmetry rigorously breaks down?

2a. Consider a simplified 2D model of a tornado, consisting of inviscid, incompressible air. The flow is modelled as a superposition of a potential sink with a volume flow rate m per unit depth and a free irrotational vortex of circulation Γ. (i) Write down the expressions for the radial velocity u_r and tangential velocity u_θ. Then determine the expression of total wind speed magnitude $\vec{v}(r)$ at a radial distance r. (ii) Apply the Bernoulli equation for steady, irrotational flow in the horizontal plane. Derive the expression for the pressure variation $p(r)$. Assume the pressure far away ($r \to \infty$) is p_{atm} and density is ρ. What is the exact pressure drop $\Delta_P = p_{atm} - p(R)$ at radius R?

b. For an incompressible, irrotational flow, the velocity potential satisfies Laplace equation ($\nabla^2\phi = 0$). Explain why the flow field at any instant depends only on the current boundary conditions and is completely independent of the boundary's motion history?

3a. The "Burger's vortex" models a slender vortex tube under constant stretching. Consider an axisymmetric, incompressible flow in cylindrical coordinates (r, θ, z). The velocity field is:

$$\boldsymbol{u} = (u_r, u_\theta, u_z) = (-\alpha r, u_\theta(r), 2\alpha z)$$

where $\alpha > 0$ is a constant strain rate and ν is the kinematic viscosity. The only non-zero component of vorticity is in the axial direction, $\boldsymbol{\omega} = \omega_z(r)\hat{e}_z$. The steady z-component vorticity equation is:

$$u_r\frac{\partial\omega_z}{\partial r} + u_z\frac{\partial\omega_z}{\partial z} = \omega_z\frac{\partial u_z}{\partial z} + \nu\,\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial\omega_z}{\partial r}\right)$$

(i) Substitute the given velocity components into the governing equation above. Clearly label which specific mathematical terms represent radial advection, vortex stretching, and viscous diffusion. (ii) Verify that the Gaussian vorticity profile:

$$\omega_z(r) = \omega_0\, exp\left(\frac{-\alpha r^2}{2\nu}\right)$$

is an exact solution to the differential equation you derived in part (i). Show your steps by calculating the necessary derivatives and proving that the LHS equals the RHS

b. Kelvin's theorem implies that irrotational flow will remain irrotational. What are the four restrictions to be satisfied to apply the Kelvin's theorem?

4a. Consider stationary surface gravity waves in a rectangular container of length L and breadth b, containing water of undisturbed depth H. Show that the velocity potential, $\phi = A\cos\left(\frac{m\pi x}{L}\right)\cos\left(\frac{n\pi y}{b}\right)\cosh[k(z+H)]e^{-i\omega t}$ satisfies the Laplace equation and the wall boundary conditions, if $\left(\frac{m\pi}{L}\right)^2 + \left(\frac{n\pi}{b}\right)^2 = k^2$. Here m and n are integers. To satisfy the linearized free-surface boundary condition, show that the allowable frequencies must be $\omega^2 = gk\tanh(kH)$.

b. Write down the simplified form of Navier-Stokes equation for a steady flow between two parallel plates, with a relative motion between two plates. List out the assumptions.

5a. Planar Couette flow is generated by placing a viscous fluid between two infinite parallel plates and moving one plate (say, the upper one) at a velocity U with respect to the other one. The plates are a distance h apart. Two immiscible viscous liquids are placed between the plates as shown in the Figure 1. The lower fluid layer has thickness d. Solve for the velocity distributions in the two fluids. List your assumptions.

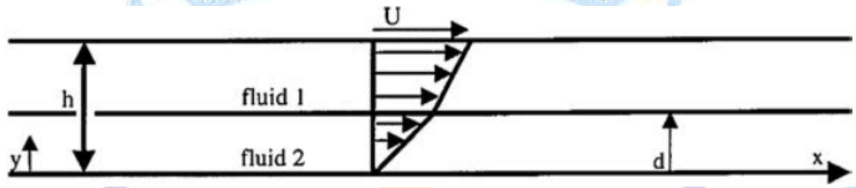

Figure 1

b. Why and when similarity solutions are applicable for a range of problems including Stokes' first problem (impulsive motion of a flat plate parallel to itself)? Write down momentum equations and boundary conditions for Stoke's first problem in terms of a similarity parameter.

6a. Describe any two types of instability encountered in fluid flows with typical examples. Explain how instabilities in a laminar flow lead to turbulent flows.

b. A flat plate 4 m wide and 1 m long (in the direction of flow) is immersed in kerosene at 20 C (ν = 2.29×10^{-6} m^2/s, ρ= 800 kg/m^3), flowing with an undisturbed velocity of 0.5 m/s. Verify that the Reynolds number is less than critical everywhere, so that the flow is laminar. Show that the thickness of the boundary layer and the shear stress at the center of the plate are $\delta =$ 0.74 cm and τ_ω =0.2 N/m^2, and those at the trailing edge are δ =1.05 cm and τ_ω = 0.14 N/m^2. Show also that the total frictional drag on one side of the plate is 1.14 N. Assume that the similarity solution holds for the entire plate.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1E104A	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN THERMAL ENGINEERING	ELECTIVE	4	0	0	5	4

Preamble: This course introduces the fundamental principles of Artificial Intelligence and Machine Learning with a focus on applications in thermal engineering. Students will learn essential data analytics concepts, supervised and unsupervised learning methods and neural network fundamentals.

Prerequisite: A background knowledge in thermal Engineering.

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

CO 1	Understand the fundamentals of AI/ML with a focus on thermal engineering data. (Cognitive Knowledge Level: Understand)
CO 2	Build and evaluate prediction and classification models for thermal engineering applications. (Cognitive Knowledge Level: Evaluate)
CO 3	Apply unsupervised learning methods for pattern discovery and feature extraction. (Cognitive Knowledge Level: Apply).
CO 4	Apply basic neural network models, including CNNs, for thermal engineering applications. (Cognitive Knowledge Level: 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	1
CO 2	2	1	3	1	3	2
CO 3	2	-	2	1	2	2
CO 4	2	1	3	1	2	2

Assessment Pattern

	Artificial Intelligence and Machine Learning in Thermal Engineering		
Bloom's Category	**Continuous Internal Evaluation 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	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) : 10 marks

Course based task/Micro Project/

Data collection and interpretation/Case study: 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 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. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (10 hours)

Introduction to Artificial Intelligence (AI) and Machine Learning (ML); evolution of AI; Scientific Machine Learning (SciML); Data-Driven Engineering, Fundamentals of Data Analytics: types and sources of data in thermal systems, data life cycle; data visualization. Machine Learning concepts: training, validation, and testing. Types of learning: supervised, unsupervised, and reinforcement learning. Applications of AI/ML in Thermal engineering.

MODULE 2 (10 hours)

Prediction and Classification problems in thermal engineering. Regression methods for thermal parameter prediction, linear regression; evaluation metrics for regression models; overfitting and regularization. Classification: decision trees, k-Nearest Neighbour (k-NN) and logistic regression;

evaluation metrics—accuracy, precision, recall, F1-score. Case studies: Predicting heat transfer coefficient, estimating boiler efficiency, Predicting cooling load etc.

MODULE 3 (10 hours)
Association and clustering problems in thermal engineering: concept, relevance, and applications. Association rule mining: basic concepts and Apriori algorithm. Clustering methods for thermal data analysis, k-means clustering. Dimensionality reduction: fundamentals of Principal Component Analysis (PCA) and feature extraction. Applications in energy usage patterns, fault grouping, and thermal behavior analysis.

MODULE 4 (10 hours)
Artificial Neural Networks (ANNs): fundamentals, perceptron model, activation functions, feed-forward neural networks, backpropagation. Introduction to deep learning, Image recognition techniques and feature extraction fundamentals. Convolutional Neural Networks (CNN): convolutional layer, pooling, flattening. Applications in image-based fault detection and thermal imaging. ANN-based modeling and analysis of thermal systems. Intelligent thermal system monitoring using AI-based techniques.

Reference Books

1. Srinivasan B & Balaji C., Machine Learning and Bayesian Methods in Inverse Heat Trasfer, Elsevier, 2026
2. Jay Lee, Yoon Kyung Lee & Behrad Bagheri, Industrial AI, 1st Edition, Springer, 2020.
2. Abhijit Pandey, Artificial Intelligence for Engineers, 1st Edition, Wiley, 2021.
3. A. C. Capretz, Machine Learning for Engineering and Applied Science, 1st Edition, Springer, 2020.
4. Ramanathan Subramanian, Applied Machine Learning for Engineers, 1st Edition, CRC Press, 2019.
5. Simon Haykin, Neural Networks and Learning Machines, 3rd Edition, Pearson, 2009.

COURSE CONTENTS AND LECTURE SCHEDULE

No	**Topic**	**No. of Lecture/ Tutorial hours**
	Module 1	
1.1	Introduction to AI & ML, Evolution, Scientific ML, Data-driven engineering	2
1.2	Data analytics fundamentals: types, sources, data life cycle	2
1.3	Data visualization techniques, handling thermal data	3
1.4	ML basics: training, validation, testing; types of learning; applications in thermal engineering	3
	Module 2	

2.1	Prediction & classification problems in thermal engineering, regression basics	3
2.2	Linear regression, evaluation metrics, overfitting & regularization	2
2.3	Classification methods: decision trees, k-NN, logistic regression	3
2.4	Evaluation metrics; case studies (heat transfer, boiler efficiency, cooling load)	2
	Module 3	
3.1	Association & clustering concepts, applications in thermal engineering	2
3.2	Association rule mining, Apriori algorithm	3
3.3	Clustering methods: k-means, applications in thermal systems	2
3.4	PCA fundamentals, feature extraction, applications in energy and fault analysis	3
	Module 4	
4.1	ANN fundamentals, perceptron model, activation functions	2
4.2	Feedforward networks, backpropagation algorithm	3
4.3	Deep learning basics, CNN concepts (convolution, pooling, flattening)	3
4.4	Applications: thermal imaging, fault detection, ANN-based modeling & monitoring	2

Model Question Paper

QP CODE: Pages: 1

Reg No.:___________

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MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26ME1E104A
Course Name: Artificial Intelligence and Machine Learning in Thermal Engineering

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1 a. Discuss the data life cycle in engineering applications. (5 Marks)

b. Explain the concepts of training, validation, and testing in ML. (5 Marks)

2 a. Explain regression techniques with emphasis on linear regression. (5 Marks)

b. Discuss the evaluation metrics in prediction problems. (5 Marks)

3 a. Discuss classification methods and explain decision trees with suitable thermal engineering examples. (5 Marks)

b. Explain evaluation metrics associated with classification. (5 Marks)

4 Explain association rule mining and discuss their applications in thermal engineering data analysis. (10 Marks)

5 a. Explain the concepts of dimensionality reduction. (5 Marks)

b. Explain PCA. (5 Marks)

6 Explain the working of Artificial Neural Networks, including perceptron model, activation functions, and backpropagation. (10 Marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1E104B	MEASUREMENT METHODS IN THERMAL ENGINEERING	ELECTIVE	4	0	0	4	4

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, analyzing, and optimizing thermal systems.

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

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

CO No	CO Statements
CO 1	Understand advanced measurement techniques and to apply the various steps involved in error analysis and uncertainty analysis. (Cognitive Knowledge Level: Apply)
CO 2	Understand principles and applications of various pressure and temperature measuring instruments and the calibration procedures. (Cognitive Knowledge Level: Apply)
CO 3	Understand the application and implementation of measurement science and engineering in gas flow (Cognitive Knowledge Level: Analyse)
CO 4	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). (Cognitive Knowledge Level: Apply)

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

Assessment Pattern

Bloom's Category	Measurement Methods in Thermal Engineering		
	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 2 (Marks)	
Remember	xx	xx	xx
Understand	20	20	20
Apply	30	30	30
Analyse	50	50	50
Evaluate	xx	xx	xx
Create	xx	xx	xx

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) : 10 marks

Course based task/Micro Project/

Data collection and interpretation/Case study: 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 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. Total duration of the examination will be 2 hrs. and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (10 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, Theory of measurements- First and second order.

MODULE 2 (12 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

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 3 (8 hours)

Field Measurements- Introduction to image processing, Shadowgraph, Schlieren imaging, Interferometer, Field laser measurement techniques-Laser Doppler Anemometer, Particle Image Velocimetry. Hot Wire Anemometer, Turbine Flow Meters, Telemetry, Orsat apparatus, 5 Gas Analysers, Smoke meters.mini

MODULE 4 (**10 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. N.V. Raghavendra and l. Krishnamurthy, Engineering Metrology and Measurements, Oxford University Press 2013.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
	Module 1	
1.1	Measurement characteristics, Measurement and Instrument Classifications	2
1.2	Characteristics of Instruments – Static and dynamic Measurements	2
1.3	Errors in Measurements, Systematic and Random errors	3
1.4	Uncertainty, Selection of measuring instrument	2
1.5	Reliability of Measuring instruments	1
	Module 2	
2.1	Various Pressure sensing elements, Bellows Inductance, Resistance types, Capacitive Pressure Transducers,	2
2.2	Piezoelectric and Potentiometric Pressure Transducers, Strain gauge pressure sensors	2
2.3	Bridgeman Gauge-High-Pressure Measurement. Vacuum Measurement and McLeod gauge Low-Pressure Measurement	2

2.4	Pirani Gauge. Calibration Process, Dead weight Tester	1
2.5	Thermometers, Thermocouple, Resistance Temperature Detector (RTD), Thermistor, Bi-metallic Thermometers.	2
2.6	Thermo-electric Pyrometers, Total radiation Pyrometers, Optical Pyrometers Pressure Thermometers.	2
2.7	Infrared Thermometers, Temperature Calibration RTD and Thermocouple calibration.	1
	Module 3	
3.1	Advance Measurement Techniques- Shadowgraph, Schlieren imaging	2
3.2	Interferometer, Laser Doppler Anemometer.	1
3.3	Particle Image Velocimetry Hot Wire Anemometer	1
3.4	Turbine Flow Meters, Rotameters, Telemetry, Orsat apparatus.	2
3.5	5 Gas Analysers, Smoke meters, Gas Chromatography.	2
	Module 4	
4.1	Microprocessors and Computers in measurement, Data logging and data acquisition (DAQ) system.	2
4.2	Analog to Digital (A-D) and Digital to Analog Conversion (DAC).	3
4.3	Pulse Code Modulation (PCM), 4-bit DAC convertor	3
4.4	R- 2R Ladder DAC.	2

Model Question Paper

QP CODE: Pages: 1

Reg No.:___________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M. TECH DEGREE EXAMINATION DECEMBER 2026

Course Code: M24ME2E104B

Course Name: Measurement Methods in Thermal Engineering

Max. Marks:40 Duration: 2 hours

PART A

Answer any four questions. Each question carries 10 marks.

1. a. Identify and analyze the types of errors. Propose methods to minimize both systematic and random errors, and evaluate how calibration improves measurement reliability.
   b. Mention the uses of gauges, micrometers and dial gauge indicators in measurement system
2. a. Explain the working of Carbon pile pressure transducer
   b. Discuss the working of Pirani gauge with suitable sketches
3. a. Discuss the principle of turbine flow meter
   b. Why are digital display units more preferred by researchers in measurement?
4. a. Discuss the principle of any two-pressure sensing instrument
   b. Explain the working of strain gauge pressure sensor instrument
5. a. With neat sketches explain the working of Bridgman gauge and Mcleod gauge in measurement
   b. Explain the working of Flat Top and Natural top type of A/D convertors
6. a. With neat sketch explain Particle Image Velocimetry technique. Mention its advantages and disadvantages
   b. Analyse the working of five gas analyzer and the working of a smoke meter. Mention its advantages and disadvantages.

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1E104C	HYDROGEN AND FUEL CELL TECHNOLOGY	ELECTIVE	4	0	0	5	4

Preamble: 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 1	Understand the relevance of hydrogen energy in sustainable clean power applications. (Cognitive Knowledge Level: Understand)
CO 2	Apply knowledge of hydrogen production methods to design and evaluate efficient and sustainable systems for generating hydrogen fuel. (Cognitive Knowledge Level: Apply)
CO 3	Analyze hydrogen storage methods, safety aspects, applications, and environmental impacts of hydrogen energy systems. (Cognitive Knowledge Level: Analyse)
CO 4	Apply fundamental concepts of fuel cell technology to analyze and troubleshoot basic fuel cell systems. (Cognitive Knowledge Level: 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	1	-	-
CO 2	1	2	2	1	-	1
CO 3	1	2	1	1	1	1
CO 4	1	2	2	1	1	2

Assessment Pattern

Bloom's Category	Hydrogen and Fuel Cell Technologies		
	Continuous Internal Evaluation Tests		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	x	x	x
Understand	20	20	20
Apply	60	60	60
Analyse	20	20	20
Evaluate	x	x	x
Create	x	x	x

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) : 10 marks

Course based task/Micro Project/

Data collection and interpretation/Case study: 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 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. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (10 hours)

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

Fuel Cells - Fuel cell definition, Fuel cell basic chemistry and thermodynamics, difference between batteries and fuel cells, fuel cell history, components of fuel cells.

MODULE 2 (10 hours)

Hydrogen Production Technologies: Steam Methane Reforming, Coal Gasification, Partial Oxidation of Hydrocarbons. Renewable Methods: Water Electrolysis (Alkaline, PEM, Solid Oxide), Biomass Gasification, Photoelectrochemical Water Splitting, Thermochemical Water Splitting, Biological Hydrogen Production. Emerging Technologies: Plasma-Assisted Hydrogen Production, Green Hydrogen via Wind and Solar Integration.

MODULE 3 (10 hours)

Hydrogen storage, applications, and safety: Compressed Gas Storage, Liquid Hydrogen Storage, Cryogenic Storage Systems. Material-Based Storage: Metal Hydrides, Chemical Hydrides, Carbon-Based and Novel Materials for Hydrogen Adsorption. Advanced Storage Solutions: Solid-State Storage Technologies, Challenges in Scaling Up Hydrogen Storage Solutions, safety and management of hydrogen, applications of hydrogen, hydrogen transportation, and hydrogen refueling methods.
Economic and Environmental Aspects of Hydrogen, Cost Analysis of Hydrogen Production Methods, Life Cycle Assessment of Hydrogen Production and Use, Carbon Footprint and Environmental Impact.

MODULE 4 (**10 hours)**
Fuel Cells - Classification of fuel cells - AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits, Principle of working of fuel cell, Performance evaluation and 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. 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. Hydrogen Fuel: Production, Transport, and Storage by Ram B. Gupta, CRC Press.
2. Hydrogen and Fuel Cell: Technologies and Market Perspectives by Johannes Topler, Jochen Lehmann, Springer.
3. Hydrogen and Fuel Cells: A Comprehensive Guide by RL Busby, Penn Well Books.
4. Hoogers G., Fuel Cell Technology Hand Book, CRC Press, 2003.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	
1.1	**Introduction to Hydrogen Energy:** Introduction to hydrogen economy - Hydrogen as a source of energy	2
1.2	Physical and chemical properties, salient characteristics, relevant issues, and concerns, fundamentals.	2
1.3	**Fuel Cells** - Fuel cell definition, Fuel cell basic chemistry and thermodynamics.	3
1.4	Difference between batteries and fuel cells, fuel cell history, components of fuel cells.	3
	Module 2	
2.1	**Hydrogen Production Technologies:** Steam Methane Reforming, Coal Gasification, Partial Oxidation of Hydrocarbons	3
2.2	Renewable Methods: Water Electrolysis (Alkaline, PEM, Solid Oxide), Biomass Gasification.	2

2.3	Photoelectrochemical Water Splitting, Thermochemical Water Splitting, Biological Hydrogen Production.	3
2.4	Emerging Technologies: Plasma-Assisted Hydrogen Production, Green Hydrogen via Wind and Solar Integration.	2
	Module 3	
3.1	**Hydrogen storage, applications, and safety:** Compressed Gas Storage, Liquid Hydrogen Storage, Cryogenic Storage Systems.	2
3.2	Material-Based Storage: Metal Hydrides, Chemical Hydrides, Carbon-Based and Novel Materials for Hydrogen Adsorption. Advanced Storage Solutions: Solid-State Storage Technologies.	3
3.3	Challenges in Scaling Up Hydrogen Storage Solutions, safety and management of hydrogen, applications of hydrogen, hydrogen transportation, and hydrogen refueling methods.	2
3.4	Economic and Environmental Aspects of Hydrogen, Cost Analysis of Hydrogen Production Methods, Life Cycle Assessment of Hydrogen Production and Use, Carbon Footprint and Environmental Impact.	3
	Module 4	
4.1	**Fuel Cells** - Classification of fuel cells - AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits.	2
4.2	Principle of working of fuel cell, Performance evaluation and performance characteristics of fuel cells, 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
4.4	Fuel cell usage for power generation, automobile, space applications, Economic and environmental analysis on usage of fuel cells, Future trends of fuel cells.	2

Model Question Paper

QP CODE: Pages: 1

Reg No.:___________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26ME1E104C

Course Name: Hydrogen and Fuel Cell Technology

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1 a. Explain the concept of hydrogen economy and its significance. (5 Marks)

b. Discuss the physical and chemical properties of hydrogen relevant to energy applications. (5 Marks)

2 a. Explain fuel cell basics and differentiate between batteries and fuel cells. (5 Marks)

b. Describe the basic components of a fuel cell. (5 Marks)

3 a. Explain Steam Methane Reforming and Coal Gasification for hydrogen production. (5 Marks)

b. Discuss water electrolysis methods for hydrogen production. (5 Marks)

4 a. Explain hydrogen storage methods including compressed and liquid storage. (5 Marks)

b. Discuss safety issues and challenges in hydrogen storage and transportation. (5 Marks)

5 a. Explain environmental and economic aspects of hydrogen energy systems. (5 Marks)

b. Discuss life cycle assessment and carbon footprint of hydrogen production. (5 Marks)

6 a. What are the primary criteria for selecting an optimal electrolyte for fuel cell applications? (5 Marks)

b. Explore the different strategies for enhancing the kinetic performance of a fuel cell. (5 Marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26GE1R105	RESEARCH METHODOLOGY AND IPR	THEORY	2	0	0	4	2

Preamble: Research methodology and intellectual property rights form an essential foundation for postgraduate students and research scholars engaged in advanced engineering studies. This course introduces the principles of scientific research, problem identification, experimental and analytical methods, and effective technical communication. It also emphasizes ethical research practices, scholarly publication processes, and the protection of intellectual property arising from research and innovation. The course aims to equip M Tech students and research scholars with the skills required to conduct systematic research, communicate findings effectively, and understand the legal and ethical frameworks governing intellectual property and technology development.

Pre-requisite: Nil

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

CO 1	Explain the principles, processes, and characteristics of scientific research and apply creative and logical thinking approaches for identifying research directions. (Cognitive Knowledge Level: Understand).
CO 2	Apply literature survey techniques and analytical reasoning to identify research gaps and formulate well-defined research problems. (Cognitive Knowledge Level: Apply).
CO 3	Analyze experimental data and develop appropriate experimental or modelling approaches for solving engineering research problems. (Cognitive Knowledge Level: Analyze)
CO 4	Demonstrate effective technical communication while adhering to research ethics and intellectual property regulations. (Cognitive Knowledge Level: Apply)

Mapping of Course Outcomes with Program Outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2		2		1	1
CO 2	3	1	2	1	2	1
CO 3	3		2	2	3	1
CO 4	1	3	2		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	20	xx	xx
Understand	40	40	40
Apply	40	40	40
Analyse	xx	20	20
Evaluate	xx	xx	xx
Create	xx	xx	xx

Mark Distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern

Self-study (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 : 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 marks

End Semester Examination Pattern

The end semester examination will be conducted by the college. The time duration will be 2 hours and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question carries 10 marks.

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SYLLABUS

MODULE 1: (6 Hours)

Foundations of Research and Creative Thinking: Meaning, objectives and significance of research – types of research, basic, applied and interdisciplinary research – characteristics of good research and stages in the research process – skills, habits and attitudes required for researchers – motivation for research with discussion of Richard Hamming's lecture *"You and Your Research"* – thinking skills in research, levels and styles of thinking, common sense versus scientific thinking, logical reasoning and decomposition of complex problems – creativity in research, definitions and characteristics, intelligence versus creativity, creative thinking process and requirements for innovation.

MODULE 2: (5 Hours)

Literature Survey and Research Problem Formulation: Importance of literature survey in research – sources of scientific information, journals, conference papers, patents and technical reports – techniques for information search using digital databases – reading, documentation and referencing practices – integration of research literature and identification of research gaps – attributes and sources of research problems – problem formulation and research questions – multiple approaches to solving research problems – techniques for problem representation, graphical methods and reasoning – analytical and analogical reasoning – creative problem solving approaches including TRIZ.

MODULE 3: (8 Hours)

Experimental Design, Modelling and Data Analysis: Scientific method and hypothesis formulation – experimental variables, dependent and independent variables, control and reproducibility in experiments – precision, accuracy and measurement errors – random and systematic errors, detection and reduction – statistical treatment and interpretation of experimental data – principles of design of experiments and experimental documentation – modelling in engineering research, types of models and stages in modelling – curve fitting and approximations – mathematical representation and logical reasoning in models – continuum, meso and micro scale modelling approaches – introduction to numerical simulation methods with illustrative case studies.

MODULE 4: (6 Hours)

Technical Communication, Research Ethics and Intellectual Property Rights: Importance of effective communication in research – communication process and barriers – oral communication skills for seminars, conferences and project presentations – preparation and delivery of technical presentations – guidelines for effective presentation slides – principles of scientific writing – structure of technical papers, theses and reports – language, layout, typography, tables and figures – referencing and citation styles – tools for document preparation including LaTeX – scholarly publications including journals and conferences – journal selection and peer review process – research metrics – plagiarism, research integrity and ethical publication practices- Introduction to Intellectual Property Rights – types of IPR: patents, copyrights, trademarks and industrial designs – patent concepts, objectives and patentability criteria – patent application procedures and documentation – technology transfer and IPR agreements.

References

1. Panneerselvam, R., *Research Methodology*, PHI Learning, New Delhi.
2. Kothari, C. R. and Garg, G., *Research Methodology: Methods and Techniques*, New Age International.
3. Phillips, E. M. and Pugh, D. S., *How to Get a PhD*, Viva Books.
4. Leedy, P. D. and Ormrod, J. E., *Practical Research: Planning and Design*, Pearson.
5. Day, R. A. and Gastel, B., *How to Write and Publish a Scientific Paper*, Cambridge University Press.
6. Thiel, D. V., *Research Methods for Engineers*, Cambridge University Press.
7. Bouchoux, D. E., *Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets*.
8. Resnik, D. B., *The Ethics of Science: An Introduction*, Routledge.
9. Medawar, P., *Advice to a Young Scientist*.
10. Wilson, E. O., *Letters to a Young Scientist*.
11. Hamming, R., *You and Your Research*, Bell Labs Lecture.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	
1.1	Meaning, objectives and significance of research – types of research: basic, applied and interdisciplinary	1
1.2	Characteristics of good research – stages in the research process	1
1.3	Skills, habits and attitudes required for researchers – motivation for research – discussion of Richard Hamming's lecture "You and Your Research"	1
1.4	Thinking skills in research – levels and styles of thinking – common sense versus scientific thinking	1
1.5	Logical reasoning and decomposition of complex problems	1
1.6	Creativity in research – intelligence versus creativity – creative thinking process and requirements for innovation	1
	Module 2	
2.1	Importance of literature survey – sources of scientific information: journals, conference papers, patents and technical reports	1
2.2	Techniques for information search using digital databases	1
2.3	Reading, documentation and referencing practices	1
2.4	Integration of research literature and identification of research gaps	1
2.5	Research problem formulation – attributes and sources of research problems – research questions – introduction to problem representation and TRIZ	1
	Module 3	
3.1	Scientific method and hypothesis formulation	1
3.2	Experimental variables – dependent and independent variables – control and reproducibility in experiments	1
3.3	Precision, accuracy and measurement errors – random and systematic errors	1
3.4	Detection and reduction of experimental errors – statistical treatment and interpretation of experimental data	1
3.5	Principles of design of experiments – experimental documentation	1
3.6	Modelling in engineering research – types of models and stages in modelling	1
3.7	Curve fitting, approximations and mathematical representation of models	1
3.8	Continuum, meso and micro scale modelling approaches – introduction to numerical simulation methods with examples	1
	Module 4	
4.1	Importance of communication in research – communication process and barriers	1
4.2	Oral communication skills – preparation and delivery of technical presentations – presentation slide design	1
4.3	Scientific writing – structure of technical papers, theses and reports – referencing and citation styles	1

4.4	Scholarly publications – journal selection – peer review process – research metrics	1
4.5	Research ethics – plagiarism, research integrity and ethical publication practices	1
4.6	Intellectual Property Rights – types of IPR – patentability criteria – patent application procedures – technology transfer	1
	Total	**25 hours**

MODEL QUESTION PAPER

QP CODE: Pages: 1

Reg. No.: ....

Name : ....

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS) KOTHAMANGALAM

FIRST SEMESTER M TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26GE1R105
Course Name: Research Methodology & IPR

Max. Marks: 40 Duration: 2 hours

*Answer any **four** questions. Each question carries 10 marks.*

1	a.	Explain the stages in the research process and the characteristics of good research.	(5 Marks)
	b.	Discuss the role of creative and logical thinking in research with suitable examples from engineering research.	(5 Marks)
2	a.	Describe the methods used for conducting an effective literature survey and the different sources of research information.	(5 Marks)
	b.	A researcher intends to study energy efficiency improvement in electric vehicles. Explain how the researcher can identify research gaps and formulate a research problem based on literature survey.	(5 Marks)
3	a.	Explain the scientific method and hypothesis formulation in experimental research.	(5 Marks)
	b.	An experiment measures the temperature of a furnace multiple times giving the following readings (°C): 650, 652, 648, 651, 649. Calculate the mean temperature and comment on the precision of the measurements.	(5 Marks)
4	a.	Explain the concept and stages of modelling in engineering research.	(6 Marks)
	b.	Discuss the importance of approximations and curve fitting in engineering models with examples.	(4 Marks)
5	a.	Explain the structure of a scientific research paper and the important rules of scientific writing.	(5 Marks)
	b.	Discuss the principles for preparing effective technical presentation slides for conferences or seminars.	(5 Marks)
6	a.	Explain the peer review process and discuss the criteria used for selecting a suitable journal for publication.	(5 Marks)
	b.	Explain the concept of patents, the criteria for patentability, and the steps involved in the patent filing process.	(5 Marks)

Semester 2

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1D201	COMPUTATIONAL FLUID DYNAMICS	DISCIPLINE CORE	3	0	3	6	5

Preamble: Computational Fluid Dynamics (CFD) is a powerful tool for analysing fluid flow and heat transfer in engineering systems. This course introduces the governing equations of fluid flow and their numerical solution using the finite volume method. Emphasis is placed on discretisation, solution strategies, convergence assessment, and grid independence. The course integrates theory with applications in thermal management systems, enabling students to interpret CFD results critically and apply simulation tools in practical engineering design.

Prerequisite: Fluid mechanics and thermal engineering and basic understanding of differential equations and numerical methods

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

CO 1	Understand the fundamentals of CFD, governing equations and classification of PDEs. (Cognitive Knowledge Level: Understand)
CO 2	Apply discretisation techniques to convert governing equations into algebraic form. (Cognitive Knowledge Level: Apply)
CO 3	Understand pressure–velocity coupling, solution methods and turbulence modelling concepts. (Cognitive Knowledge Level: Apply)
CO 4	Analyse internal, external and thermal flow problems using CFD for engineering applications. (Cognitive Knowledge Level: Analyse)

Mapping of course outcomes with program outcomes

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

Assessment Pattern

	Computational Fluid Dynamics		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember	xx	xx	xx
Understand	30	10	40
Apply	60	50	40
Analyse	10	40	20
Evaluate	xx	xx	xx
Create	xx	xx	xx

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Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Theory Evaluation : **30 marks**

Self-study (Course based task/Seminar/

Quiz/ Micro project) :10 marks

Test paper 1 :10 marks

Test paper 2 :10 marks

Lab Evaluation : **30 marks**

Lab work : 10 marks

Final evaluation Test : 20 marks

(Note: 50% of Module 1, 2 and 3 may be considered for each test)

End Semester Examination Pattern:

The end semester examination should be conducted by the college. The time duration will be 2 hours and will contain 6 questions from first three modules, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (10 hours)

Introduction to CFD: Introduction to CFD – Scope and Applications: Role of CFD in engineering analysis, advantages and limitations, applications in various domains. CFD Solution Procedure: Pre-processing (problem definition, geometry, domain, mesh generation, boundary conditions), Solver (discretisation concept, algebraic equation formation, iterative solution, convergence), post-processing (contours, vectors, streamlines, drag, lift).

Governing Equations: Vector and Tensor form of Continuity equation, Navier–Stokes equations, energy equation, general scalar transport equation, integral control volume concept, physical meaning of convection, diffusion and source terms.

Classification of PDEs: General form. Linear and non-linear PDEs, elliptic, parabolic and hyperbolic equations and their physical interpretation in fluid flow problems

MODULE 2 (10 hours)

Discretisation Techniques: Finite Difference Method based on Taylor series expansion. Finite Volume Method for convection diffusion problems. Discretisation of 2D convection–diffusion equation of the general scalar transport equation.

Central Differencing Scheme and Upwind Differencing Scheme, Hybrid, Higher order differencing schemes (QUICK, MUSCL), TVD schemes, Peclet number and its significance. False diffusion and numerical diffusion, Flux limiters and TVD schemes (concept), Formal order of accuracy analysis.

Types of meshes. Brief discussion on accuracy, stability and convergence of numerical schemes (Lax theorem concept), Von Neumann stability analysis. Implementation of boundary conditions: Dirichlet, Neumann, wall (slip and no-slip), periodic boundary conditions.

MODULE 3 (10 hours)

Solution Strategy and Basics of Turbulence Modelling: Discretised momentum equations and the pressure–velocity coupling issue in incompressible flows. SIMPLE, PISO and SIMPLEC algorithms (comparison). Examples of SIMPLE algorithm solution of descretised equations.

Solution of algebraic equation systems: Sparse matrix concepts, direct and iterative methods, TDMA. Gauss–Seidel iteration and under-relaxation for convergence control. Time discretisation (explicit vs implicit).CFL condition (concept). Convergence criteria and residual monitoring. Grid independence study, verification and validation

Introduction to turbulence modelling: RANS concept, closure problem, k-epsilon and k-omega models, LES, RNS DNS. Suitability of turbulence models.

Intro to Compressible Flow CFD: Mach number regimes, Shock waves (concept), Density-based solver (concept).

MODULE 4 (30 hours)

List of experiments

1. Air at 300 K flows over a horizontal flat plate (length = 0.5 m) maintained at a constant temperature of 350 K with an inlet velocity of 2 m/s. (a) Develop the CFD model with 2D geometry and structured mesh with boundary layer refinement; (b) Apply velocity inlet, pressure outlet and constant wall temperature boundary condition; (c) Solve and plot velocity and temperature profiles along the plate; (d) Analyse the development of the hydrodynamic and thermal boundary layers; (e) Interpret the results in terms of heat transfer mechanisms and relevant non-dimensional numbers (Reynolds and Prandtl numbers).

2. A horizontal solid plate (k = 50 W/m K, thickness = 10 mm) is subjected to a constant heat flux of 1000 W/m^2 at the bottom surface. Air at 300 K flows over the top surface at 2 m/s. (a) Create the fluid and solid domains and generate an appropriate mesh; (b) Apply heat flux boundary condition (bottom), velocity inlet and pressure outlet (air side); (c) Perform conjugate heat transfer simulation and obtain temperature distribution in solid and fluid; (d) Verify temperature and heat flux continuity at the interface; (e) Interpret the results in terms of heat transfer mechanisms and relevant non-dimensional numbers (Reynolds and Prandtl numbers).

3. A silicon chip (k = 150 W/m·K, 20 mm × 20 mm × 2 mm) is mounted on an aluminium

base (k = 205 W/m·K, thickness = 5 mm). The chip generates 20 W heat. Air at 300 K flows over the plate at 3 m/s. (a) Develop the CFD model by specifying geometry, fluid–solid domains and mesh strategy; (b) Apply appropriate boundary conditions and solve the conjugate heat transfer problem; (c) Plot temperature distribution and heat flux; (d) Verify temperature continuity at the interface and identify the maximum temperature location.

4. Using the system in Experiment 3: (a) Compute the heat transfer coefficient from CFD results; (b) Develop a thermal resistance network model and estimate total resistance; (c) Compare CFD and analytical temperature predictions; (d) Comment on the dominant resistance and sources of error.

5. A plate-fin heat sink (50 mm × 50 mm base, fin height = 20 mm, thickness = 2 mm, spacing = 4 mm) is cooled by air at velocities 2, 4 and 6 m/s. (a) Create the CFD model with appropriate meshing and boundary conditions; (b) Simulate the flow for different velocities; (c) Determine maximum temperature and pressure drop; (d) Analyse the cooling vs pressure drop trade-off and identify the best operating condition.

6. Using the same heat sink, vary fin spacing as 2 mm, 4 mm and 6 mm. (a) Modify geometry and generate suitable meshes for each case; (b) Perform CFD simulations at 4 m/s inlet velocity; (c) Compare temperature and pressure drop for all cases; (d) Determine the optimal fin spacing and justify your answer.

7. Cooling water flows through a circular pipe (diameter = 0.05 m, length = 2 m) with a uniform wall heat flux of 2000 W/m². The inlet velocity is 2 m/s and inlet temperature is 300 K. (a) Develop the CFD model specifying geometry, mesh and boundary conditions; (b) Select an appropriate turbulence model (k–ε or k–ω) and justify your choice based on flow characteristics; (c) Analyse the variation of temperature, pressure drop and heat transfer coefficient; (d) Evaluate how the choice of turbulence model influences the predicted heat transfer and pressure drop.

8. Air at 300 K flows over a heated circular cylinder (diameter = 0.1 m) at a velocity of 5 m/s. The cylinder surface is maintained at 350 K. (a) Set up the CFD model including domain, mesh and boundary conditions; (b) Compare two turbulence models (k–ε and k–ω) for this problem and justify their suitability; (c) Analyse the wake structure, drag coefficient and heat transfer characteristics; (d) Discuss how turbulence modelling affects flow separation and heat transfer prediction.

9. During a lunar mission similar to Chandrayaan-3, onboard electronics must operate safely despite extreme thermal conditions. One side of the satellite is exposed to direct solar radiation, reaching high temperatures, while the opposite side faces deep space and becomes extremely cold. A sensitive electronic module (size: 100 mm × 100 mm × 10 mm, heat generation: 25 W) is mounted inside the satellite. Thermal Conditions: - Sun-facing wall temperature is +120°C, Space-facing wall temperature is –150°C, Internal air (or nitrogen) is circulated at 2 m/s for cooling. (Assume negligible microgravity effects), Maximum allowable electronics temperature is 80°C.
   (a) Develop a CFD model of the system, including: Electronic module (solid domain), Internal fluid domain, Appropriate meshing strategy (refinement near walls and module);
   (b) Apply realistic boundary conditions: - Hot wall: +120°C, Cold wall: –150°C, Internal flow: velocity inlet (2 m/s)
   (c) Select a suitable turbulence model and justify its use in this confined internal flow.

(d) Perform the simulation and analyse: Temperature distribution inside the satellite, Hot spot formation in the electronic module, Effectiveness of internal cooling flow,
(e) Evaluate whether the electronics remain within safe operating temperature.

10. A two-dimensional wedge of semi-angle 10° and length 0.5 m is placed in a supersonic airflow. The freestream conditions are Mach number 2.5, static pressure 50 kPa and static temperature 220 K. Air is assumed to behave as an ideal gas. (a) Develop the CFD model by defining the computational domain, wedge geometry and appropriate mesh with refinement near the wedge surface and expected shock region; (b) Select a suitable density-based solver and justify its use for this compressible flow problem; (c) Apply appropriate boundary conditions, including freestream (supersonic inlet), outlet and wall conditions for the wedge; (d) Perform the simulation and obtain Mach number and pressure contours, clearly identifying the oblique shock formed over the wedge; (e) Calculate the lift force, drag force and moment about the leading edge of the wedge.

Reference Books

1. H.K. Versteeg & W. Malalasekera, *An Introduction to Computational Fluid Dynamics – The Finite Volume Method*, Pearson.
2. Ferziger, J.H., Perić, M., and Street, R.L., *Computational Methods for Fluid Dynamics*, Springer.
3. Anderson, J.D., *Computational Fluid Dynamics: The Basics with Applications*, McGraw-Hill.
4. Patankar, S.V., *Numerical Heat Transfer and Fluid Flow*, Hemisphere Publishing.
5. Tu, Jiyuan, Yeoh, Guan Heng & Liu, Chaoqun, *Computational Fluid Dynamics: A Practical Approach*, Butterworth-Heinemann, 2007.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	
1.1	Introduction to CFD – Scope and Applications: Role of CFD in engineering analysis, advantages and limitations, applications in various domains. CFD Solution Procedure: Pre-processing (problem definition, geometry, domain, mesh generation, boundary conditions), Solver (discretisation concept, algebraic equation formation, iterative solution, convergence), post-processing (contours, vectors, streamlines, drag, lift).(show with an example)	2
1.2	Governing Equations: Continuity equation, Navier–Stokes equations. Differential form. Vector representation. Tensor form (index notation).	3
1.3	Governing equation-Energy equation, general scalar transport equation, integral form of general scalar transport equation and explanation of the convection, diffusion and source term. (concept)	3
1.4	Classification of PDEs: General form. Linear and non-linear PDEs, elliptic, parabolic and hyperbolic equations and their physical interpretation in fluid flow problems.	2
	Module 2	
2.1	Discretisation: Finite Difference Method - Taylor series	1

	expansion, First and second order derivatives. Forward, backward and central difference. Concept of truncation error and order of accuracy. approximations.	
2.2	Discretisation: Finite Volume Method - Control volume concept, Integral form of governing equations, Conversion of PDEs into algebraic equations	1
2.3	Discretisation of 2D Convection–Diffusion Equation. General scalar transport equation (GSTE). Control volume formulation. Discretisation Schemes-Central Difference Scheme (CDS), Upwind Difference Scheme (UDS)	2
2.4	Hybrid Schemes, Higher order differencing schemes (QUICK, MUSCL), TVD schemes, Peclet number and its significance. Identifying convection-dominated and diffusion-dominated flows.	2
2.5	False diffusion and numerical diffusion, Flux limiters and TVD schemes (concept), Formal order of accuracy analysis. Types of Meshes- Structured and unstructured.2D and 3D, Hybrid mesh and boundary layer mesh (inflation).	2
2.6	Brief discussion on accuracy, stability and convergence of numerical schemes (Lax theorem concept), Von Neumann stability analysis. Implementation of boundary conditions: Dirichlet, Neumann, wall (slip and no-slip), periodic boundary conditions.	2
	Module 3	
3.1	Discretised momentum equations and the pressure–velocity coupling issue in incompressible flows. Checkerboard pattern. Staggered grid	1
3.2	Concept of SIMPLE algorithm (concept). Linear Equation Solution Methods -Direct methods (concept), Iterative methods. Gauss–Seidel iteration and under-relaxation for convergence control.	2
3.3	Solution of algebraic equation systems: Sparse matrix concepts, TDMA. Time discretisation (explicit vs implicit). CFL condition (concept)	2
3.4	Convergence Monitoring, Residual definition, Residual monitoring, Convergence criteria. Grid Independence Study-Importance of mesh refinement. Procedure for grid independence test.	1
3.5	Introduction to Turbulence Modelling: Characteristics of turbulent flows. Need for turbulence modelling in CFD. Reynolds averaging concept and the derivation of RANS equations.	2
3.6	Turbulence Models- Turbulence closure problem. Eddy viscosity concept. Standard turbulence models: k–ε model and k–ω model (basic idea and applications). LES and DNS-suitability of turbulence models	2
	Module 4	
4.1	Experiment -1	3
4.2	Experiment - 2	3
4.3	Experiment -3	3

4.4	Experiment – 4	3
4.5	Experiment – 5	3
4.6	Experiment – 6	3
4.7	Experiment – 7	3
4.8	Experiment – 8	3
4.9	Experiment – 9	3
4.10	Experiment – 10	3

Model Question Paper

QP CODE: Pages: 1

Reg No.:___________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M. TECH DEGREE EXAMINATION, APRIL 2027

Course Code: M26ME1D201
Course Name: Computational Fluid Dynamics

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. a. Explain the Navier–Stokes equations in differential form and discuss their physical significance in fluid flow problems. (7 Marks)
   b. Write the general scalar transport equation and briefly explain the convection, diffusion and source terms. (3 Marks)
2. a. Derive the forward, backward and central difference approximations for the first derivative using Taylor series expansion. (7 Marks)
   b. Define the Peclet number and explain how it helps identify convection-dominated and diffusion-dominated flows. (3 Marks)
3. Derive the discretised form of the one-dimensional steady convection–diffusion equation using the finite volume method. Apply the control-volume formulation to obtain the discretised algebraic equation for a typical node. Explain the discretisation schemes used for convective and diffusive terms. (10 Marks)
4. Describe the SIMPLE algorithm and explain how it is used to achieve pressure velocity coupling in CFD simulations. (10 Marks)
5. Describe the turbulence closure problem arising from the Reynolds-averaged Navier–Stokes (RANS) equations and explain the eddy viscosity concept used to model turbulent stresses. (10 Marks)
6. a. Explain conjugate heat transfer? Discuss the role of fin spacing in heat sink performance. (4 Marks)
   b. Explain the thermal boundary conditions used in CFD, namely fixed wall temperature, specified heat flux and adiabatic wall, with suitable examples from heat transfer applications. (6 Marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1D202	APPLIED THERMAL ENGINEERING	PROGRAMME CORE	3	0	3	6	5

Preamble: This course is designed to provide a comprehensive understanding of the fundamental properties and behaviors of Combustion in engines, Pollution from engine exhaust. Also, it provides a practical knowhow of the theory part along with some matlab Simulink programming skills.

Prerequisite: Basic knowledge in thermal engineering.

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

CO No	CO Statements
CO 1	Explain the basic concept, the principle, and theories of combustion of fuels and combustion in Spark Ignition and Compression Ignition engines. (Cognitive Knowledge Level: Analyse)
CO 2	Explain the emissions from engines, emission control methods and after treatment devices in Internal Combustion Engines. (Cognitive Knowledge Level: Analyse)
CO 3	Explain the thermal cycles and to practice Matlab Simulink applications in Internal Combustion Engines. (Cognitive Knowledge Level: Apply)
CO 4	Acquire practical knowledge in finding engine performance and operating conditions (Cognitive Knowledge Level: Apply)

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	
CO 2	1		1	2	1	
CO 3	1		1	2	1	
CO 4	2	1	2			2

Assessment Pattern

	Applied Thermal Engineering		
Bloom's Category	Continuous Internal Evaluation Tests		End Semester Examination (%Marks)
	Test 1 (%Marks)	Test 2 (%Marks)	
Remember	xx	xx	xx
Understand	10	10	10
Apply	40	40	40
Analyse	50	50	50
Evaluate	xx	xx	xx
Create	xx	xx	xx

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Theory Evaluation	**: 30 marks**
Self-study (Course based task/Seminar/ Quiz/ Micro project)	:10 marks
Test paper 1	:10 marks
Test paper 2	:10 marks
Lab Evaluation	**: 30 marks**
Lab work	: 10 marks
Final evaluation Test	: 20 marks

(Note: 50% of Module 1, 2 and 3 may be considered for each test)

End Semester Examination Pattern:

The end semester examination should be conducted by the college. The time duration will be 2 Hrs and will contain 6 questions from first three modules, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (10 hours)

Combustion of fuel- Ricardo's theory of Combustion, Combustion in Spark Ignition engine, Stages of Combustion in SI engines, Theoretical and actual P-Θ diagram, Normal and Abnormal combustion Cycle by cycle variations in pressure, knocking combustion, pre-ignition, knock and engine variables, Stratified Charge combustion system and Lean Burn Combustion.

Combustion in CI engines, Theoretical and actual P-Θ diagram, Spray formation at different injection pressures and droplet vaporization Swirl Motion, Direct and indirect injection systems. Detonation and its undesirable effects, Cycle by cycle variations in pressure with normal injection and CRDI mode.

MODULE 2 (**10 hours)**

Emissions- Major pollutants in exhaust of SI and CI Engines, Effect of pollutant emissions, Unburned Hydrocarbons, CO, NOx and Soot sources and formations in SI and CI engines.

Emission control for HC and CO from SI and CI engines, Particulate Matter in Diesel Engines. National and International Emission Standards.

After treatment devices for SI and CI engines, Particulate Traps, Catalytic Convertors- One way, Two way and Three-way Catalytic convertors. Complete combustion strategies for emission reduction, electronic control of engines for emission reduction. Exhaust Gas Recirculation, Urea-SCR injection for NOx reduction. 5 Gas analysers, Smoke analysers, Smoke opacity filter paper measurements.

MODULE 3 (8 hours)

Introduction to thermal power cycles: Carnot cycle, Reversible and Irreversible cycles, Analysis of Otto cycle, Analysis of Diesel cycle, Cycle improvements, Influence of operating parameters, Stirling cycle, Organic Rankine cycle, Kalina cycle. Introduction Matlab Simulink, applications in IC engines.

MODULE 4 (30 hours)

List of Experiments

1. Performing Morse test on petrol engine (Fiat)
2. Analysing Retardation test on IC engines (Ruston Engine)
3. Analysis of automobile exhaust gas and flue gas using Exhaust Gas Analyzer. (Five gas analyzer / Smoke meter)
4. Testing performance characteristics on Twin cylinder diesel engine
5. Conducting performance characteristics test on Textool engine.
6. Anlysing the performance characteristics two stroke diesel engine
7. Analysing the performance characteristics of a VCR multifuel engine.
8. Determination of Volumetric Efficiency and Air-fuel ratio of Kirloskar engine.
9. Analysing the Heat Balance test on Textool diesel engines
10. Analysing the Cooling curve of Kirlosker engines.
11. Matlab Simulink Lab Practice.
12. Matlab Simulink Engine combustion simulation lab practice.
13. Matlab Simulink Engine combustion simulation lab practice.
14. Matlab Simulink Engine combustion simulation lab practice.

Reference 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 Dhanpat Rai Publications Pvt. New Delhi-2, 1993.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	
1.1	**Combustion of fuel**- Ricardo's theory of Combustion, Combustion in Spark Ignition engine.	1
1.2	Stages of Combustion in SI engines, Theoretical and actual P-Ɵ diagram, Normal and Abnormal combustion.	1
1.3	Cycle by cycle variations in pressure, knocking combustion, pre-ignition, knock and engine variables.	2

1.4	Stratified Charge combustion system and Lean Burn Combustion.	1
1.5	Combustion in CI engines, Theoretical and actual P-Θ diagram.	1
1.6	Spray formation at different injection pressures and droplet vaporization.	1
1.7	Swirl Motion, Direct and indirect injection systems. Detonation and its undesirable effects.	2
1.8	Cycle by cycle variations in pressure with normal injection and CRDI mode.	1
Module 2		
2.1	Emissions- Major pollutants in exhaust of SI and CI Engines, Effect of pollutant emissions.	1
2.2	Unburned Hydrocarbons, CO, NOx and Soot sources and formations in SI and CI engines.	1
2.3	Emission control for HC and CO from SI and CI engines, Particulate Matter in Diesel Engines.	2
2.4	National and International Emission Standards.	1
2.5	After treatment devices for SI and CI engines, Particulate Traps, Catalytic Convertors.	1
2.6	One way, Two way and Three-way Catalytic convertors. Complete combustion strategies for emission reduction.	2
2.7	Electronic control of engines for emission reduction. Exhaust Gas Recirculation, Urea-SCR injection for NOx reduction.	1
2.8	5 Gas analysers, Smoke analysers, Smoke opacity filter paper measurements.	1
Module 3		
3.1	Introduction, Carnot Cycle	1
3.2	Introduction, Carnot Cycle	1
3.3	Analysis of Otto Cycle	1
3.4	Analysis of Otto Cycle	1
3.5	Analysis of Diesel Cycle	1
3.6	Stirling Cycle, Organic Rankine Cycle, Kalina Cycle: theory	1
3.7	Introduction Matlab Simulink.	1
3.8	Introduction Matlab Simulink.	1
3.9	Applications of Matlab Simulink in IC engines.	1
3.10	Applications of Matlab Simulink in IC engines.	1
Module 4 List *of experiments*		
4.1	Performing Morse test on petrol engine (Fiat) Analysing Retardation test on IC engines (Ruston Engine)	3
4.2	Analysis of automobile exhaust gas and flue gas using Exhaust Gas Analyzer. (Five gas analyzer / Smoke meter) Testing performance characteristics on Twin cylinder diesel engine	3
4.3	Conducting performance characteristics test on Textool engine.	3

	Anlysing the performance characteristics two stroke diesel engine	
4.4	Analysing the performance characteristics of a VCR multifuel engine. Determination of Volumetric Efficiency and Air-fuel ratio of Kirloskar engine.	3
4.5	Analysing the Heat Balance test on Textool diesel engines	3
4.6	Analysing the Cooling curve of Kirlosker engines.	3
4.7	Matlab Simulink Lab Practice.	3
4.8	Matlab Simulink Engine combustion simulation lab practice.	3
4.9	Matlab Simulink Engine combustion simulation lab practice.	3
4.10	Matlab Simulink Engine combustion simulation lab practice.	3

Model Question Paper

QP CODE: Pages: 2

Reg No.:___________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M. TECH DEGREE EXAMINATION, APRIL 2027

Course Code: ME26ME1D202
Course Name: Applied Thermal Engineering

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. a. Analyze the combustion process in an SI engine using P-θ diagram and explain the deviations between theoretical and actual diagrams. (5 Marks)

   b. Compare combustion characteristics and pressure variations in conventional diesel injection and CRDI systems. Analyze how injection parameters influence detonation and emissions. (5 Marks)

2. a. Analyze spray formation and droplet vaporization in a CI engine at different injection pressures. Evaluate how swirl motion enhances combustion efficiency in direct injection systems. (5 Marks)

   b. Analyze flame development and propagation in SI engines, and evaluate how ignition timing affects engine performance. (5 Marks)

3. a. Evaluate the effectiveness of in reducing NOx emissions. Analyze its impact on engine efficiency and soot formation. (5 Marks)

   b. Analyze the formation of particulate matter and evaluate the effectiveness of particulate traps and after-treatment devices in reducing emissions. (5 Marks)

4. a. Explain the formation mechanisms of major pollutants such as CO, HC, NOx, and soot in SI and CI engines under varying air-fuel ratios. (10 Marks)

5. a. Evaluate the differences between reversible and irreversible cycles using and analyze the sources of irreversibility in practical engines. (5 Marks)

b. Explain the working and advantages of Kalina cycles in improving thermal efficiency. (5 Marks)

6. Apply simulation concepts using to analyze IC engine performance. Evaluate how modeling helps in optimizing combustion and emissions. Explain the working of a 5-gas analyser with the help of suitable sketches. (10 Marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1E203A	SOLAR THERMAL ENERGY SYSTEMS	ELECTIVE	4	0	0	5	4

Preamble: This course provides a comprehensive introduction to the principles, technologies, applications and advancements in solar thermal energy. Combining theoretical concepts with practical insights and case studies, it enables students to gain holistic understanding of solar thermal energy systems and their wide range of applications across various sectors.

Prerequisite: Basic knowledge in heat transfer.

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

CO 1	Explain solar radiation principles and measurement techniques essential for optimising design and performance of solar energy systems. (Cognitive Knowledge Level: Understand
CO 2	Demonstrate various types of solar collectors and compute the performance of solar air and water heaters. (Cognitive Knowledge Level: Apply)
CO 3	Demonstrate diverse methods of solar energy storage, emphasizing considerations such as quality, capacity, and duration of storage. (Cognitive Knowledge Level: Apply)
CO 4	Analyse different solar thermal systems and examine solar photovoltaic cells focusing on power output and conversion efficiency. (Cognitive Knowledge Level: Analyse)

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	1	
CO 2	3	1	1	1	2	1
CO 3	3	1	1	1	2	1
CO 4	2	1	1	1	1	1

Assessment Pattern

	Solar Thermal Energy Systems		
Bloom's Category	**Continuous Internal Evaluation 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	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) : 10 marks

Course based task/Micro Project/

Data collection and interpretation/Case study: 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 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. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (9 hours)

Solar radiation: Structure of the sun, Solar constant, Terrestrial radiation, 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, Greenwich civil time, Local civil time, Solar time, Day length, Hourly, daily and monthly average solar radiation.

Measurement of solar radiation: Pyrheliometers, Pyranometers, Sunshine recorder.

MODULE 2 (11 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, Optical losses, Thermal analysis, Compound parabolic collector, Paraboloid dish collector, Central receiver collector. Thermal and radiative properties of collector cover materials.

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, Natural circulation and forced circulation water heaters, Testing and rating of solar water heaters. Economics of solar water heating.

MODULE 3 (10 hours)

Solar energy storage: Thermal, electrical and chemical methods of storage, Quality, capacity and duration of storage, Sensible heat storage, Properties of sensible heat storage materials, Liquid storage, Size and configuration, Packed bed exchanger storage, Latent heat storage, Phase change materials for storage, Properties of phase change materials, Thermochemical storage, Electrical storage, Chemical storage, Energy storage in building materials, Solar ponds, Convecting solar ponds, Non convecting solar ponds, Salt gradient solar ponds

MODULE 4 (10 hours)

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

Reference Books

1. John A. Duffie, William A. Beeckman, Solar Engineering of Thermal Processes, John Wiley & Sons, Inc., 4th edition,2013.
2. Ibrahim Dincer, Marc A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons, Inc., 3rd edition,2021.
3. G.N. Tiwari, Solar Energy - Fundamentals, Design, Modelling and Applications, Narosa Publishing House, 2005.
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. Solar energy and non - conventional energy sources, Dhanpat Rai & Co. (P) Ltd., 1st edition, 2010.
7. G.D. Rai, Solar Energy Utilisation, Khanna Publishers, 5th edition, 2012.
8. S.P.Sukhatme, Solar Energy - Principles of Thermal Collection and Storage, Tata Mc-Graw Hill Publishing Company Limited, 2nd edition, 2004.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	
1.1	Structure of the sun, Solar constant, Terrestrial radiation, Spectral distribution of extra-terrestrial radiation.	2
1.2	Revolution of earth, Seasons, Basic earth sun angles, Diffuse and direct radiation, Solar radiation under actual conditions.	2
1.3	Air mass, Solar radiation on horizontal and inclined surfaces, Shading, Sun path diagram.	2
1.4	Greenwich civil time, Local civil time, Solar time, Day length, Hourly, daily and monthly average solar radiation.	2
1.5	Pyrheliometers, Pyranometers, Sunshine recorder.	1
	Module 2	
2.1	Greenhouse effect, Flat plate collectors, Classification and construction, Thermal losses and collector efficiency, Thermal analysis of flat plate collectors.	2
2.2	Collector performance, Heat removal factor, Concentrating collectors, Classification of concentrators, Orientation and	2

	sun tracking systems, Cylindrical parabolic collector.	
2.3	Optical losses, Thermal analysis, Compound parabolic collector, Paraboloid dish collector, Central receiver collector. Thermal and radiative properties of collector cover materials.	2
2.4	Solar air heaters, Description and classification, Non-porous absorber plate type air heaters, Air heaters with porous absorbers.	2
2.5	Thermal analysis, Two pass solar air heaters, Air heaters with finned absorbers, Solar water heaters.	1
2.6	Natural circulation and forced circulation water heaters, Testing and rating of solar water heaters, Economics of solar water heating.	2
Module 3		
3.1	Thermal, electrical and chemical methods of storage, Quality, capacity and duration of storage.	2
3.2	Sensible heat storage, Properties of sensible heat storage materials, Liquid storage, Size and configuration.	2
3.3	Packed bed exchanger storage, Latent heat storage, Phase change materials for storage, Properties of phase change materials.	2
3.4	Thermochemical storage, Electrical storage, Chemical storage, Energy storage in building materials.	2
3.5	Solar ponds, Convecting solar ponds, Non convecting solar ponds, Salt gradient solar ponds.	2
Module 4		
4.1	Solar heating systems, Passive and active systems.	2
4.2	Solar house, Solar cooling systems, Solar drying.	2
4.3	Solar distillation, Solar cooking, Solar thermal power plant.	2
4.4	Low temperature, medium temperature and high temperature thermal power systems, Solar thermal energy for process heating.	2
4.5	Solar photovoltaic cells, Photovoltaic principles, Power output and conversion efficiency, Solar furnaces, Solar pumps.	2

Model Question Paper

QP CODE: Pages: 1

Reg No.:___________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M. TECH DEGREE EXAMINATION, APRIL 2027

Course Code:M26ME1E203A
Course Name: Solar Thermal Energy Systems

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. a. Explain solar constant and its significance. (4 marks)
   b. Explain the working of pyrheliometer. (6 marks)
2. a. Explain a Fresnel lens collector with figure. (4 marks)
   b. Analyse the thermal losses in a flat plate collector. (6 marks)
3. a. Explain the concept of thermosiphon in solar water heater. (4 marks)
   b. Explain forced circulation water heating system with figure. (6 marks)
4. a. Explain the limitations of sensible heat storage system. (4 marks)
   b. Explain the principle of operation of salt gradient solar pond. (6 marks)
5. a. Differentiate passive and active solar systems. (4 marks)
   b. Explain a solar cooker with figure. (6 marks)
6. a. Explain the concept of photoelectric effect in solar cells. (4 marks)
   b. Explain the tower concept for solar power generation with figure. (6 marks)

	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1E203B	DESIGN OF HEAT TRANSFER EQUIPMENTS	ELECTIVE	4	0	0	5	4

Preamble: This course is designed to provide fundamental and advanced knowledge required for analysis, selection and design of various heat transfer equipments used in chemical process industries.

Prerequisite: Heat and Mass Transfer.

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

CO 1	Acquire knowledge about different heat exchangers, design and analyse the performance of heat exchangers. (Cognitive Knowledge Level: Understand)
CO 2	Design and analyse the flow arrangements of shell and tube heat exchangers (Cognitive Knowledge Level: Apply)
CO 3	Design cooling towers and acquire knowledge about heat pipes. (Cognitive Knowledge Level: Apply)
CO 4	Design plate heat exchangers, regenerators and compact heat exchangers. (Cognitive Knowledge Level: Apply)

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	1	1
CO 2	3	1	1	1	3	2
CO 3	3	1	1	1	3	2
CO 4	3	1	1	1	3	2

Assessment Pattern

	Design of Heat Transfer Equipments		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember	xx	xx	xx
Understand	20	20	20
Apply	70	70	70
Analyse	10	10	10
Evaluate	xx	xx	xx
Create	xx	xx	xx

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) : 10 marks

Course based task/Micro Project/

Data collection and interpretation/Case study: 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 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. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (9 hours)

Classification and selection of heat exchangers: Heat transfer and flow friction characteristics, pressure drop analysis, Basic thermal design, P-NTU and LMTD methods, F-factor for various configurations. Double pipe heat exchangers, Caloric or average fluid temperature, Pipe-wall temperature, Film coefficients for tubes and annuli, Equivalent diameter, Fouling factors, Double pipe exchangers in series-parallel arrangements, Design calculation of double pipe heat exchanger.

MODULE 2 (11 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. Flow arrangements for increased heat recovery.

MODULE 3 (10 hours)

Direct contact heat exchangers: Classifications and types of cooling towers, Cooling tower requirements, Lewis number, Diffusion theory, Design of cooling towers.
Heat pipes: Working principle, Applications, Heat pipe design procedure, Determination of heat pipe diameter, Design of heat pipe containers, Wick design, Entrainment and boiling limits.

MODULE 4 (10 hours)

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

Reference Books

1. Kern D.Q., Process Heat Transfer, Tata McGraw-Hill 4th edition, 2013.
2. Sarit K. Das, Process Heat Transfer, Narosa Publishing House.
3. Dunn P.D. and Reay D.A., Heat pipes 4th edition, Pergamon Press, 1994.
4. Fraas A.P., Heat Exchanger Design, Second Edition, John Wiley & Sons.
5. Chi S.W., Heat Pipe Theory and Practice - A Source Book, McGraw Hill,1976.
6. R.K. Shah, Dusan P. Sekulic, Fundamentals of Heat Exchanger Design, John Wiley & Sons.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	
1.1	Heat transfer and flow friction characteristics, pressure drop analysis, Basic thermal design, P-NTU and LMTD methods, F-factor for various configurations.	2
1.2	Double pipe heat exchangers, Caloric or average fluid temperature, Pipe-wall temperature.	2
1.3	Film coefficients for tubes and annuli, Equivalent diameter, Fouling factors.	3
1.4	Double pipe exchangers in series-parallel arrangements, Design calculation of double pipe heat exchanger.	3
	Module 2	
2.1	Construction and thermal features, Different types of shell and tube heat exchangers, Tube layout, Baffles spacing, Thermal design procedure.	4
2.2	Kern method.	2
2.3	Bell Delaware method.	2
2.4	Flow arrangements for increased heat recovery.	2
	Module 3	
3.1	Classifications and types of cooling towers.	2
3.2	Cooling tower requirements, Lewis number, Diffusion theory.	2
3.3	Design of cooling towers.	2
3.4	Working principle, Applications, Heat pipe design procedure.	2
3.5	Determination of heat pipe diameter, Design of heat pipe containers, Wick design, Entrainment and boiling limits	2
	Module 4	
4.1	Construction and thermal features, Flow configurations, Limitations, Applications.	2
4.2	Analysis of plate heat exchangers, Rating and sizing of plate heat exchangers.	2
4.3	Classifications, Governing equations, Design parameters.	2
4.4	Classifications and selection, Design of plate fin heat exchangers.	2
4.5	Design of tube fin heat exchangers.	2

Model Question Paper

QP CODE: Pages: 2

Reg No.:___________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M. TECH DEGREE EXAMINATION, APRIL 2027

Course Code: M26ME1203B
Course Name: Design of Heat Transfer Equipments

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. 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. (10 marks)
2. 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. (10 marks)

3 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. (10 marks)

4 a. Explain the classifications of cooling towers. (6 marks)

b. Explain the working principle of a heat pipe. (4 marks)

5 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. (10 marks)

6 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/m2K, 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. (10 marks)

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CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1E203C	**THERMAL POWER PLANT DESIGN**	**ELECTIVE**	**4**	**0**	**0**	**5**	**4**

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 1	Learn about thermal power plant components, thermodynamic cycles, efficiency calculations, and problem-solving skill set for analyzing and optimizing power generation systems. (Cognitive level: Apply)
CO 2	Analyze, design, and optimize steam generation systems, encompassing boiling mechanisms, boiler classifications, system designs, and insulation requirements. (Cognitive level: Analyse)
CO 3	Analyze combustion systems and understand steam turbines, including their types, governing mechanisms, condensers, and auxiliary systems. (Cognitive level: Analyse)
CO 4	Gain exposure to thermal power plant modeling and simulation, along with insights into India's energy sector, policies, and environmental impacts. (Cognitive level: Analyse)

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	3	2
CO 2	3	1	3	2	3	2
CO 3	3	1	3	2	3	2
CO 4	3	1	3	2	3	3

Assessment Pattern

	Course name		
Bloom's Category	**Continuous Internal Evaluation Tests**		**End Semester Examination (%Marks)**
	Test 1 (%Marks)	**Test 2 (%Marks)**	
Remember	xx	xx	xx
Understand	20	10	20
Apply	40	40	40
Analyse	40	50	40
Evaluate	xx	xx	xx
Create	xx	xx	xx

Mark distribution

Total Marks	CIE marks	ESE marks	ESE Duration
100	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (Seminar*) : 10 marks

Course based task/Micro Project/

Data collection and interpretation/Case study: 20 marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 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. Total duration of the examination will be 2 Hrs and will contain 6 questions, with minimum one question from each module of which student should answer any four. Each question can carry 10 marks and can have maximum 2 sub-divisions.

SYLLABUS

MODULE 1 (10 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 (10 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 (10 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 (10 hours)

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

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. 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	
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.	3
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.	4
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.	3
	Module 2	
2.1	Steam generators: Stages of boiling- natural convection, sub-cooled nucleate boiling, Nucleate boiling, onset of film boiling, 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.	4
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	3

	system. Heat recovery system-Economizer and air pre heater system.	
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	3
	Module 3	
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.	3
3.2	Principles of combustion-combustion calculations, simple numerical problems.	4
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	3
	Module 4	
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. Governing-Methods of governing-Throttle, Nozzle and bypass. Droop in speed governing system(concept).	3
4.2	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.	3
4.3	Modelling and simulation-Simplified modelling of Boiler -modelling principles. Test case using OpenModelica (basic understanding)-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. Load duration curves-load factor, capacity factor, reserve factor, demand factor, diversity factor. Base load, Intermediate load, Peak load.	4

Model Question Paper

QP CODE: Pages: 2

Reg No.:___________

Name:_____________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

FIRST SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26ME1E203C
Course Name: Thermal Power Plant Design

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. a. Illustrate the contrast between the reheat Rankine cycle and the regenerative Rankine cycle through a schematic and a process diagram. (2 Marks)

   b. The net power output of an ideal reheat regenerative steam cycle is 80 MW. Steam enters the h.p turbine at 80 bar, 5000C and expands till it becomes saturated vapour. Some of the steam then goes to a open feedwater heater and the balance is reheated to 4000C, after which it expands in an l.p turbine to 0.07bar. Compute (i) the reheat pressure, (ii) the steam flow rate to the h.p turbine, (iii) the cycle efficiency and (iv) the rate of flow of cooling water in the condenser if the temperature rise of the water is 80C, (v) 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. (8 Marks)

2. 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 CO2 + SO2 15.72%, O2 1%, there being no CO or SO3. 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. (10 Marks)

3. 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. (10 Marks)

4. 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? (5 Marks)

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? (5 Marks)

5. a. In a boiler system, both economizer and reheater are utilized for recovering waste heat, yet each serves a unique function. Clarify the given statement. (5 Marks)

b. 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 Marks)

6. Water at 300C flows into a cooling tower at the rate of 1.15 kg per kg air. Air enters the tower at DBT of 280C and 90% relative humidity. Make up water is supplied at 200^{o}C. 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. (10 Marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1S204	ENERGY MANAGEMENT AND AUDIT	INDUSTRY INTEGRATED COURSE	4	0	0	5	4

Preamble: This course introduces the principles and practices of energy management and energy auditing with emphasis on efficient utilization of energy in industrial and commercial sectors. It covers energy scenario, energy conservation policies, audit methodologies, and performance analysis of thermal and electrical utility systems. The course also focuses on field testing techniques and financial analysis for evaluating energy conservation measures. Students will be able to identify energy-saving opportunities and perform techno-economic assessment for sustainable energy management.

Prerequisite: Nil

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

CO 1	Explain energy scenario, energy conservation policies, and fundamentals of energy audit including energy performance indicators and monitoring techniques. (Cognitive Knowledge Level: Understand)
CO 2	Explain and evaluate thermal utility systems such as boilers, steam systems, furnaces, and heat exchangers for improving energy efficiency. (Cognitive Knowledge Level: Apply)
CO 3	Analyze electrical utility systems including motors, HVAC, lighting, pumps, and compressed air systems for energy conservation opportunities. (Cognitive Knowledge Level: Analyse)
CO 4	Apply field testing methods and perform financial analysis techniques for energy performance evaluation. (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Energy Management and Audit		
	Continuous Internal Evaluation 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	60	40	2 Hours

Continuous Internal Evaluation Pattern:

Self-study (*Seminar) : 10 marks

Course based task/Seminar/Data collection and interpretation/Case study : 20marks

Test paper 1 (Module 1 and Module 2) : 15 marks

Test paper 2 (Module 3 and Module 4) : 15 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 2 Hrs and will contain 6 questions, with minimum one question from each module of which students should answer any four. Each question can carry 10 marks. The valuation of the answer scripts shall be done by the expert in the industry handling the course.

SYLLABUS

MODULE 1 (10 hours)

Energy scenario: Global and Indian energy scenario, Energy conservation and its importance, Energy Conservation Act, 2001 and related policies, and National Action Plan on Climate Change (NAPCC).

Energy audit: Definition, need, types and approaches, understanding energy costs and benchmarking, Role of Energy Managers in Industries, Energy performance indicators, Energy monitoring and targeting (EM&T), Energy Management Information System (EMIS), Material and energy balance, Principles and applications, Sankey diagrams, Energy action planning and implementation.

MODULE 2 (10 hours)

Thermal Utility Systems: Boilers- Types, performance evaluation and efficiency, Boiler water treatment and blowdown. Steam systems- Steam generation, distribution and utilization, Steam traps and energy-saving opportunities. Furnaces- Types and performance evaluation, Heat losses and efficiency improvement. Insulation and refractories - Types, properties and applications, Heat loss calculations. FBC boilers - Working and advantages. Cogeneration systems - Principle and classification, Performance parameters. Waste heat recovery systems - Techniques and applications. Heat exchangers - Types, performance evaluation, Pinch analysis basics.

MODULE 3 (10 hours)

Electrical Utility Systems: Electrical Energy Audit – Performance analysis of motors, Compressors, Blowers and fans - Power factor correction techniques, Load factor, Variable frequency drive (VFD), HVAC and refrigeration systems - Heat load estimation, Performance evaluation and energy efficiency. Energy conservation in cooling towers & spray ponds –Case studies, Pumps and pumping systems - Pump characteristics and efficiency, Energy-saving techniques. Lighting systems - Types of lamps and illumination, Energy Efficiency in Lighting – Case studies. Instruments used for energy auditing. Diesel/Natural gas generator systems, Energy conservation in buildings and ECBC.

MODULE 4 (**10 hours)**

Field Testing and Financial Analysis: Measurement techniques and field testing procedures, Performance parameters and efficiency calculations, Specific energy consumption and energy cost calculation methodologies - CUSUM, balanced ratio etc., Financial analysis - Fixed and variable costs, Cash flow analysis, Payback period, Discounted cash flow methods (NPV, IRR), Sensitivity and risk analysis. Industrial applications - Thermal power plants, Steel, cement and textile industries, Buildings and commercial establishments. Visit to energy generation /consumption facility.

Reference Books

1. Y P Abbi and Shashank Jain, "Handbook on Energy Audit and Environment Management", TERI, 2006.
2. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, "Guide to Energy Management", Fairmont Press, 6th ed., April 23, 2008.
3. Bureau of Energy Efficiency - Energy Management Series.
4. Anthony J. Pansini, Kenneth D. Smalling, "Guide to Electric Load Management", Pennwell Pub; (1998).

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lecture/ Tutorial hours
	Module 1	
1.1	Energy scenario: Global and Indian energy scenario, Energy conservation and its importance, Energy Conservation Act, 2001 and related policies, and National Action Plan on Climate Change (NAPCC).	3
1.2	Energy audit: Definition, need, types and approaches, understanding energy costs and benchmarking	2
1.3	Role of Energy Managers in Industries, Energy performance indicators, Energy monitoring and targeting (EM&T)	2
1.4	Energy Management Information System (EMIS), Material and energy balance, Principles and applications, Sankey diagrams, Energy action planning and implementation.	3
	Module 2	
2.1	Thermal Utility Systems: Boilers- Types, performance evaluation and efficiency, Boiler water treatment and blowdown. Steam systems- Steam generation, distribution and utilization, Steam	3

	traps and energy-saving opportunities.	
2.2	Furnaces- Types and performance evaluation, Heat losses and efficiency improvement. Insulation and refractories - Types, properties and applications, Heat loss calculations.	2
2.3	FBC boilers - Working and advantages. Cogeneration systems - Principle and classification, Performance parameters.	2
2.4	Waste heat recovery systems - Techniques and applications. Heat exchangers - Types, performance evaluation, Pinch analysis basics.	3
Module 3		
3.1	Electrical Utility Systems: Electrical Energy Audit – Performance analysis of motors, Compressors, Blowers and fans - Power factor correction techniques, Load factor, Variable frequency drive (VFD).	3
3.2	HVAC and refrigeration systems - Heat load estimation, Performance evaluation and energy efficiency. Energy conservation in cooling towers & spray ponds –Case studies.	2
3.3	Pumps and pumping systems - Pump characteristics and efficiency, Energy-saving techniques.	2
3.4	Lighting systems - Types of lamps and illumination, Energy Efficiency in Lighting – Case studies. Instruments used for energy auditing. Diesel/Natural gas generator systems, Energy conservation in buildings and ECBC.	3
Module 4		
4.1	Field Testing and Financial Analysis: Measurement techniques and field-testing procedures, Performance parameters and efficiency calculations.	3
4.2	Specific energy consumption and energy cost calculation methodologies - CUSUM, balanced ratio etc.	2
4.3	Financial analysis - Fixed and variable costs, Cash flow analysis, Payback period, Discounted cash flow methods (NPV, IRR), Sensitivity and risk analysis.	3
4.4	Industrial applications - Thermal power plants, Steel, cement and textile industries, Buildings and commercial establishments. Visit to energy generation /consumption facility.	2

Model Question Paper

QP CODE: Pages: 1

Reg No.:___________

Name:______________

MAR ATHANASIUS COLLEGE OF ENGINEERING (AUTONOMOUS), KOTHAMANGALAM

SECOND SEMESTER M. TECH DEGREE EXAMINATION, DECEMBER 2026

Course Code: M26ME1S204

Course Name: Energy Management And Audit

Max. Marks:40 Duration: 2 hours

Answer any four questions. Each question carries 10 marks.

1. a. Explain global and Indian energy scenario and the importance of energy conservation. (5 Marks)
   b. Describe energy audit methodology and energy performance indicators. (5 Marks)
2. a. Explain Energy Conservation Act, 2001 and National Action Plan on Climate Change (NAPCC). (5 Marks)
   b. Discuss energy monitoring and targeting (EM&T) and EMIS. (5 Marks)
3. a. Explain the working and performance evaluation of boilers. (5 Marks)
   b. Discuss steam systems, steam traps and energy-saving opportunities in steam distribution. (5 Marks)
4. a. Explain waste heat recovery systems and heat exchangers used in industries. (5 Marks)
   b. Discuss energy efficiency in electric motors and Variable Frequency Drives (VFDs). (5 Marks)
5. a. Explain HVAC systems and energy-saving opportunities. (5 Marks)
   b. Discuss energy conservation in lighting systems and buildings. (5 Marks)
6. a. Explain financial analysis techniques (Payback, NPV, IRR) used in energy management and their applications. (5 Marks)
   b. Discuss field testing and performance evaluation of energy systems. (5 Marks)

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1P205	MINI PROJECT	PROJECT	0	0	4	6	2

Preamble: 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 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 that should lead to their dissertation/research project. 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.

Course Outcome

After completing miniproject student should be able to

CO1: Identify and define an **Engineering problem**: Students will be able to select a relevant and feasible problem based on real-world needs, demonstrating originality and clarity in problem definition.

CO2: Conduct **Literature review** and develop a **methodology**: Students will develop the ability to critically review and synthesize existing literature to identify research gaps and establish the context for their study.

CO3: Implement the proposed **methodology** and **analyze results**: Students will be able to execute the methodology, develop a prototype/model/simulation, and analyze the results to validate the objectives.

CO4: **Communicate** the project outcomes effectively: Students will be able to prepare a structured report and present the work clearly, demonstrating technical knowledge, understanding, and involvement.

Course Outcome (CO)	Mapped Program Outcome (PO)	Justification
CO1: Identify and define an Engineering problem	PO1: Ability to independently carry out research/investigation and development work	Identifying a research topic requires independent exploration, critical thinking, and decision-making, forming the foundation for research activities.
	PO3: Demonstrate mastery over the specialization area	Topic selection reflects an understanding of advanced concepts beyond undergraduate level.
CO2: Conduct literature review and develop a methodology	PO1: Ability to independently carry out research/investigation and development work	Literature analysis develops the ability to critically evaluate existing work and identify research gaps.
	PO3: Demonstrate mastery over the specialization area	Analyzing literature demonstrates depth of knowledge in the chosen field.
CO3: Implement the proposed methodology and analyze results	PO1: Ability to independently carry out research/investigation and development work	Defining a problem and planning methodology are key steps in executing independent and systematic research.
	PO4: Apply stream knowledge to design or develop solutions for real-world problems	A well-formulated problem and methodology enable the application of domain knowledge to address practical engineering challenges.
	PO5: Identify, select, and apply appropriate techniques, resources, and tools	Developing methodology involves selecting suitable tools, techniques, and resources required for effective problem-solving.
CO4: Communicate the project outcomes effectively	PO2: Ability to communicate effectively, write and present technical reports	Preparing a structured report enhances technical writing, presentation, and communication skills for conveying research ideas clearly.
	PO6: Engage in life-long learning with consideration of sustainability, societal aspects	A proposal often encourages awareness of broader impacts, fostering continuous learning

Continuous Internal Evaluation

The evaluation committee comprises

1. Project coordinator
2. A senior faculty
3. Project supervisor

Course Outcome (CO)	Marks Allocated	Justification
CO1: Identify and define an Engineering problem	25	Topic selection is foundational stage requiring creativity and basic exploration of relevant problems
CO2: Conduct literature review and develop a methodology	25	Literature review is essential for understanding existing work and identifying research gaps through critical analysis.
CO3: Implement the proposed methodology and analyze results	25	Defining the problem is a pivotal step, formulating objectives and methodology demands detailed planning and technical understanding
CO4: Communicate the project outcomes effectively	25	Proposal preparation integrates all prior work into a concise document, focusing on communication
Total	**100**	

Detailed Breakdown and Rationale:

1. **CO1: Identify and define an Engineering problem (25 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.

2. **CO2: Conduct literature review and develop a methodology (25 marks)**

- A thorough literature review needs significant effort to survey existing work, analyze gaps, and establish context.
- Assessment: Depth, breadth, and critical evaluation of sources.

3. **CO3: Implement the proposed methodology and analyze results (25 marks)**

- Involves defining a clear and specific problem, along with formulating objectives and methodology, requiring planning and technical understanding.
- Assessment: Clarity, specificity, and significance of the problem statement.

4. **CO4: Communicate the project outcomes effectively (25 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 Committee - Programme Coordinator, One Senior faculty and Guide.

Sl. No	Type of evaluations	Marks	Evaluation criteria
1	Interim evaluation I	30	Problem identification, literature base, clarity of objectives
2	Interim evaluation II	30	Methodology, progress achieved, depth of knowledge
3	Final evaluation by a committee	25	Completion level and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	10	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	5	Initiative, regularity, involvement
Total Marks		**100**	

Rubrics for Interim Evaluation I (30 Marks)

Parameter	Excellent	Good	Average	Poor
Problem Identification (CO1) (10 marks)	Clearly defined, relevant, innovative, aligned with real-world issues	Relevant but limited innovation	Basic problem, limited relevance	Problem unclear or irrelevant
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Literature Review (CO2) (10 marks)	Comprehensive, recent sources, critical analysis, gap identified	Adequate review with some analysis	Limited sources, mostly descriptive	Very poor or no literature review
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Clarity of Objectives (CO3) (10 marks)	Well-defined, measurable and achievable	Clear but partially measurable	Vague or broad objectives	Objectives not defined
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)

Rubrics for Interim Evaluation II (30 Marks)

Parameter	Excellent	Good	Average	Poor
Problem statement (CO1) (5 marks)	Clearly defined, relevant, innovative, aligned with real-world issues	Relevant but limited innovation	Basic problem, limited relevance	Problem unclear or irrelevant
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Literature Review (CO2) (5 marks)	Comprehensive, recent sources, critical analysis, gap identified	Adequate review with some analysis	Limited sources, mostly descriptive	Very poor or no literature review
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Methodology (CO3) (5 marks)	Well-structured, appropriate tools/techniques, justified	Suitable methodology with minor gaps	Basic methodology, limited justification	Inappropriate or unclear methodology
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Depth of Knowledge (CO2) (10 marks)	Strong conceptual and technical understanding	Good understanding with minor gaps	Basic understanding	Poor understanding
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Progress Achieved (CO3) (5 marks)	Significant progress with validated results	Moderate progress with partial results	Limited progress	Minimal or no progress
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Final Evaluation (25 Marks)

Parameter	Excellent	Good	Average	Poor
Relevance of problem statement (CO1) (5 marks)	Clearly defined, relevant, innovative, aligned with real-world issues	Relevant but limited innovation	Basic problem, limited relevance	Problem unclear or irrelevant
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Implementation of methodology (CO3) (5 marks)	Well-structured, appropriate tools/techniques, justified	Methodology implemented with minor gaps	Basic methodology, limited justification	Inappropriate or unclear methodology
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Knowledge & Involvement (CO4) (10 marks)	Demonstrates good understanding and active involvement throughout the project	Good understanding with consistent involvement	Basic understanding with moderate involvement	Poor understanding; minimal involvement
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Presentation & Viva (CO4) (5 marks)	Clear, confident, logical, excellent responses	Good presentation, answers most questions	Less communication, limited clarity	Poor communication, unable to answer
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Miniproject Report (10 Marks)

Parameter	Excellent	Good	Average	Poor
Technical Depth (CO4) (5 marks)	Comprehensive, well-analyzed content	Good technical content	Basic description	Poor/incomplete
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Organization & Format (CO4) (5 marks)	Well-structured, follows guidelines	Minor deviations	Inconsistent format	Poor structure
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Semester - 3

CODE	COURSE NAME	CATEGORY	L	T	P	S	CREDIT
M26ME1M301	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. **Gas Turbines and Jet Engines**

   Duration: 12 weeks

   Provider: NPTEL

   Course Content: This course consists of two parts – (a) Analysis of industrial gas turbines (b) Analysis of different types of jet engines. The first part starts from the basics of industrial gas turbines, thermodynamic processes involved, improvements such as regeneration, intercooling, reheating, and additional analysis needed for real cycles. This will be followed by system level analysis of turbojet, turbofan, turboprop, ramjet & scramjet engines. The students will analyze the effect of design parameters on the performance characteristics for each engine along with important components such as diffusers and nozzles.

   Relevance: Gas turbines play a vital role in power generation and industries, and jet engine technology is advancing through organizations like ISRO and DRDO. It equips students with the skills to analyze and improve propulsion and energy systems, supporting India's growth in aviation, defense, and sustainable energy sectors.

2. **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.

3. **Applied Thermodynamics**

Duration: 12 weeks

Provider: NPTEL

Course Content: Analysis of practical devices/applications using first and second law; applications such a steam and gas turbine power plants, vapor compression refrigeration devices, spark ignition and compression ignition IC engines, psychrometry, combustion of fuels and compressible flow through nozzles.

Relevance: his course is highly relevant as it enables students to apply thermodynamic principles to real engineering systems such as power plants, refrigeration, and IC engines, which are widely used in industry. In the Indian context, it supports the development of efficient energy systems, sustainable cooling technologies, and improved automotive performance, aligning with the country's growing energy and industrial demands.

4. **Fundamentals of Compressible Flow**

Duration: 12 weeks

Provider: NPTEL

Course Content: It pertains the basic theory of compressible flow, formation of shock waves and expansion waves, nozzle flows. The contents of the course start with fluid and thermodynamic fundamentals followed by governing theories of compressible flow phenomena. Many aerodynamic high-speed facilities and their measurement diagnostics governed by these theories, are also covered in this course.

Relevance: This course is highly relevant as it bridges the fundamentals of fluid mechanics and thermodynamics to analyze compressible flow phenomena essential for high-speed aerodynamics. It equips students with the theoretical and practical knowledge required for the design and analysis of high-speed vehicles and advanced aerodynamic testing facilities.

5. **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.

6. **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.

7. **Finite Element Methods in Thermal Engineering**

   Duration: 12 weeks

   Provider: NPTEL

   Course Content: This course emphasises on illustrating the usefulness of FEM as a highly accurate discretization method for handling heat transfer/fluid dynamics problems. This course provides a simple approach for element level assembly and implementation of boundary conditions, that is handier for implementation in computer coding.

   Relevance: students will be familiar with contrasting implementation issues of FEM in solid mechanics vis a vis fluid mechanics. They will be able to generate the global matrix equation system via manual calculations as well as solve it for heat conduction/convection-diffusion problems and compare FEM solutions with corresponding FDM solutions.

8. **Fundamentals of Combustion**

   Duration: 12 weeks

   Provider: NPTEL

Course Content: Emphasize on the basics of fuels, stoichiometry, chemical kinetics and equilibrium, mass transfer, and different types of combustion process. Mathematics involved in transport processes of a reactive flow, simplifications involved and the parameters affecting different types of combustion processes.

Relevance: This course is highly relevant as it provides a strong foundation in combustion principles essential for understanding energy conversion in engines, power plants, and industrial processes. In the Indian context, it supports advancements in efficient fuel utilization, emission control, and sustainable energy technologies.

9. **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.

10. **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.

11. **Energy and the Climate Crisis: The Path to Net-Zero Emissions**

Duration: 12 weeks

Provider: NPTEL

Course Content: The course will provide an overview of climate change: the underlying science, the threat posed by global temperature rise, the proposed policy solutions, and international climate negotiations. A detailed understanding of energy uses in different sectors and the urgent need for energy efficiency and low consumption patterns will be provided.

Relevance: This course provides critical understanding of climate change, energy use, and strategies for achieving net-zero emissions in response to global environmental challenges. It supports informed decision-making and policy awareness for sustainable development, energy efficiency, and transition to clean energy systems.

12. Oil Hydraulics and Pneumatics

Duration: 12 weeks

Provider: NPTEL

Course Content: The course will provide an overview of hydraulic pumps and its working and constructional features, pneumatic power sources, its pressure drops, control elements and other sub systems. Along with this, it explains the hydraulic circuit design, servo and proportional valves and certain elements of modelling and simulation.

Relevance: Revolutionary changes are taking place in the field of fluid power technology due to the integration of electronics as a control medium for fluid power components and systems. Increased sophistication of fluid power and allied fields of engineering, the fluid power-driven machines are now able to generate more power and higher accuracy in speed, force, and position control.

INTERNSHIP

Slot	Course Code	Course	Marks		L-T-P-S	Hours	Credit
C	M26ME1302	Internship	50	50	--	-	10

Internship - Mandatory internship of minimum 16 weeks duration

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 totheir specialization after the second semester for a minimum duration of 16 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 theclassroom 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 subjectarea of training.
- Create conducive conditions with quest for knowledge and its applicabilityon 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 afull-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 andprojects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer 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 16 weeks.
- Students can take mini projects, assignments, case studies by discussing it with 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 other document from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid by the 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) Internal evaluation & Student's diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

Continuous Internal Evaluation: 50 marks

Internal evaluation & Student's diary - 25 Marks

Evaluation done by the industry - 25 Marks

Internal evaluation committee comprises of Programme coordinator, Project coordinator and a senior faculty.

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 shouldrecord 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 dailytraining 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 ofhis 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 processand 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*

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*

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 notremove 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. Absentshould 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 following parameters:

Parameters	**Marks** Rating (0-10 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	
Is punctual	
Uses time effectively	

Overall performance of student:
Intern (Tick one): Needs improvement (0 – 1 mark) / Satisfactory (2 mark) / Good (3 mark) / Very Good (4 mark) / Excellent (5 mark)

Additional comments, if any:

Signature of Industry Supervisor *Signature of Section Head/HRManager*

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 taught in the course

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

Rubrics for Students diary and Internal Evaluation (25 Marks)

Parameter	Excellent	Good	Average	Poor
Regularity & Completeness (5 marks)	Diary maintained regularly with complete and consistent entries	Mostly regular with minor gaps	Irregular entries; some missing records	Rarely maintained; major gaps
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Application of Concepts (5 marks)	Strong real-world application	Moderate application	Limited application	No application
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Understanding of Work (5 marks)	Thorough understanding, confident	Good understanding	Basic knowledge	Poor understanding
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Organization & Clarity (5 marks)	Well-structured, clear and logical	Minor issues in organization	Poor structure	Disorganized
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Presentation skills (5 marks)	Clear and well structured	Good presentation	Average clarity	Poor communication
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for External Evaluation (Viva Voce) (25 Marks)

Parameter	Excellent	Good	Average	Poor
Understanding of Work (10 marks)	Thorough understanding, confident	Good understanding	Basic knowledge	Poor understanding
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Integration with theory (5 marks)	Strong linkage with academic concepts	Moderate linkage	Weak linkage	No linkage
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Application of Concepts (5 marks)	Strong real-world application	Moderate application	Limited application	No application
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Presentation skills (5 marks)	Clear and well structured	Good presentation	Average clarity	Poor communication
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Internship report (25 Marks)

Parameter	Excellent	Good	Average	Poor
Technical Depth (10 marks)	Comprehensive, well-analyzed, industry relevance	Good technical content	Basic description	Poor/ incomplete
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Organization & Format (10 marks)	Well-structured, follows guidelines	Minor deviations	Inconsistent format	Poor structure
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Originality (5 marks)	Highly original work	Some originality	Limited originality	Copied/ plagiarized
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

DISSERTATION PHASE I

Slot	Course Code	Course	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
P	M26ME1P303	Dissertation Phase I	100	--	0-0-12-18	12	8

Dissertation Phase I may be undertaken either in the college or in the industry. Dissertation Phase I can be linked with internship. Such students are expected to have the following skills: Technical Skills, Research Skills, Communication Skills, Critical Thinking Skills, and Problem-Solving Skills.

Objectives

The objectives of Phase I of an M.Tech dissertation typically focus on laying a strong foundation for the research work to be conducted in subsequent phases. While specific objectives can vary depending on the institution, discipline, and project, the following are common goals for Phase 1:

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

M Tech in Thermal Power Engineering

After completing dissertation phase 1 student should be able to

CO1: 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.

CO2: 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.

CO3: Define **a Clear Research Problem , formulate objectives and methodology**: 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.

CO4: 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.

Course Outcome (CO)	Mapped Program Outcome (PO)	Justification
CO1: Demonstrate Research Topic Selection Skills	PO1: Ability to independently carry out research/investigation and development work	Selecting a research topic requires independent exploration and judgment, aligning with research skills.
	PO3: Demonstrate mastery over the specialization area	Topic selection reflects an understanding of advanced concepts beyond undergraduate level.
CO2: Conduct Effective Literature Analysis	PO1: Ability to independently carry out research/investigation and development work	Literature analysis is a core research skill, requiring independent critical thinking.
	PO3: Demonstrate mastery over the specialization area	Analyzing literature demonstrates depth of knowledge in the chosen field.
CO3: Define a Research Problem, formulate objectives and methodology	PO1: Ability to independently carry out research/investigation and development work	Defining a research problem is a fundamental step in independent research.
	PO4: Apply stream knowledge to design or develop solutions for real-world problems	A well-defined problem often addresses real-world challenges using specialized knowledge.
	PO5: Identify, select, and apply appropriate techniques, resources, and tools	Outlining methodology involves selecting suitable techniques and tools for the research.
CO4: Prepare a Comprehensive Research Proposal	PO2: Ability to communicate effectively, write and present technical reports	Writing a proposal requires clear communication and presentation skills for technical audiences.
	PO6: Engage in life-long learning with consideration of sustainability, societal aspects	A proposal often reflects awareness of broader impacts, fostering

Continuous Internal Evaluation

Evaluation committee comprises of

1. Project coordinator
2. A senior faculty
3. Project supervisor / Industry mentor

Course Outcome (CO)	Marks Allocated	Justification
CO1: Demonstrate Research Topic Selection Skills	25	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; formulate objectives and Methodology	25	Defining the problem is a pivotal step, requiring clarity and alignment with research goals; formulating objectives and methodology demands detailed planning and technical understanding
CO4: Prepare a Comprehensive Research Proposal	25	Proposal preparation integrates all prior work into a concise document, focusing on communication
Total	**100**	

Detailed Breakdown and Rationale:

1. **CO1: Demonstrate Research Topic Selection Skills (25 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.
2. **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.
3. **CO3: Define a Clear Research Problem, formulate objectives and methodology (25 marks)**
   - Involves defining a clear and specific research problem and formulating objectives and methodology, requiring critical thinking, planning, and technical understanding as it sets the direction for the dissertation.
   - Assessment: Clarity, specificity, and significance of the problem statement.
4. **CO4: Prepare a Comprehensive Research Proposal (25 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.

M. Tech Dissertation Phase 1 (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).

Evaluation Process

- **Industry Mentor Involvement**: The industry mentor (from the internship or dissertation site) provides feedback and assesses feasibility.
- **Academic Supervisor**: Ensures academic rigor and alignment with M.Tech standards.
- **Expert Committee Review**: Evaluates the final proposal.
- **Deliverables**:
    - Interim report (literature review, problem statement) – Mid-Phase 1.
    - Final proposal (synopsis) – End of Phase 1.

Evaluation of Dissertation Phase I
Rubrics for Zeroth presentation (30 Marks)

Parameter	Excellent	Good	Average	Poor
Topic Selection (10 marks) (CO1)	Relevant to current research/industry, strong SDG alignment	Relevant with some novelty	Limited relevance	Irrelevant/unclear
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Literature Review & Analysis (10 marks) (CO2)	Comprehensive, recent, critically analyzed; clear research gap	Adequate review with some analysis	Limited, descriptive	Poor/no review
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Problem Definition (5 marks) (CO3)	Clearly defined, specific, research-worthy	Defined but lacks depth	Vague or broad	Not defined
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Presentation & Communication (5 marks) (CO4)	Highly clear, logical, confident delivery	Good clarity	Basic clarity	Poor communication
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Interim presentation (30 Marks)

Parameter	Excellent	Good	Average	Poor
Relevance of Topic (5 marks) (CO1)	Highly innovative, relevant to current research/industry, strong SDG alignment	Relevant with some novelty	Limited relevance	Irrelevant/unclear
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Literature Review & Analysis (10 marks) (CO2)	Comprehensive, recent, critically analyzed; clear research gap	Adequate review with some analysis	Limited, descriptive	Poor/no review
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Objectives & Methodology (10 marks) (CO3)	Well-defined objectives; robust, feasible, justified methodology	Suitable with minor gaps	Basic methodology	Inappropriate/ missing
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Progress Achieved (5 marks) (CO4)	Significant progress with validated results	Moderate progress with partial results	Limited progress	Minimal or no progress
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Final presentation (College based) (40 Marks)

Parameter	Excellent	Good	Average	Poor
Topic Selection & Novelty (10 marks) (CO1)	Topic is highly relevant, innovative, and aligned with current research/ industry needs; clear demonstration of originality	Topic is relevant with some degree of novelty; partial alignment with current trends	Topic is basic with limited originality; minimal relevance to current trends	Topic is outdated, irrelevant, or lacks clarity; no evidence of novelty
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Literature Review & Analysis (5 marks) (CO2)	Comprehensive, recent, critically analyzed; clear research gap	Adequate review with some analysis	Limited, descriptive	Poor/no review
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Definition of Research Problem, Formulation of Research (10 marks) (CO3)	Problem is clearly defined, Objectives are clear, measurable, and research-worthy; well-justified with appropriate tools/techniques	Problem is defined and relevant, Objectives are clear; methodology is suitable with minor gaps in justification	Problem is vague, Objectives are basic or partially aligned; methodology is limited or lacks clarity	Problem and objectives are unclear, irrelevant, or not defined
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Report (10 marks) (CO4)	Well-structured, technically sound, excellent clarity, proper references	Good documentatio n with minor issues	Average documentation	Poor/ incomplete
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Presentation & Communicati on (5 marks) (CO4)	Highly clear, logical, confident delivery	Good clarity	Basic clarity	Poor communicati on
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Final presentation (Industry based) (40 Marks)

Parameter	Excellent	Good	Average	Poor
Topic Selection & Novelty (10 marks) (CO1)	Topic is highly relevant, innovative, and aligned with current research/ industry needs; clear demonstration of originality	Topic is relevant with some degree of novelty; partial alignment with current trends	Topic is basic with limited originality; minimal relevance to current trends	Topic is outdated, irrelevant, or lacks clarity; no evidence of novelty
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Literature Review & Analysis (5 marks) (CO2)	Comprehensive, recent, critically analyzed; clear research gap	Adequate review with some analysis	Limited, descriptive	Poor/no review
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Definition of Research Problem, Formulation of Objectives (5 marks) (CO3)	Problem is clearly defined, Objectives are clear, measurable, and research-worthy; well-justified with appropriate tools/techniques	Problem is defined and relevant, Objectives are clear; methodology is suitable with minor gaps in justification	Problem is vague, Objectives are basic or partially aligned; methodolog y is limited or lacks clarity	Problem and objectives are unclear, irrelevant, or not defined
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
*Feedback from industry (5 marks) CO3)	Excellent	Good	Satisfactory	Needs improvement
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Report (10 marks) (CO4)	Well-structured, technically sound, excellent clarity, proper references	Good documentatio n with minor issues	Average documentati on	Poor/ incomplete
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Presentation & Communication (5 marks) (CO4)	Highly clear, logical, confident delivery	Good clarity	Basic clarity	Poor communication
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

*Feedback from industry may be taken in 5-point scale

Feedback from 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 following parameters:

Parameters	**Marks** Rating (0-10 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	
Is punctual	
Uses time effectively	

Overall performance of student:

Intern (Tick one): Needs improvement (0 – 1 mark) / Satisfactory (2 mark) / Good (3 mark) / Very Good (4 mark) / Excellent (5 mark)

Additional comments, if any:

Signature of Industry Supervisor *Signature of Section Head/HRManager*

Semester - 4

DISSERTATION PHASE II

Slot	Course Code	Course Name	Marks		L-T-P-S	Hours	Credit
			CIE	ESE			
P	M26ME1P401	Dissertation Phase II	100	100	0-0-24-26	24	20
	Total		100	100		24	20

- **Duration**: Typically the final semester (e.g., fourth semester of M.Tech).
- **Focus**: Implementation, experimentation, analysis, and conclusion of the research initiated in Phase 1.
- **Common Objectives**:
    1. Execute the proposed methodology.
    2. Analyze results and draw meaningful conclusions.
    3. Demonstrate technical proficiency and problem-solving.
    4. Document and present findings effectively.

Scheme for Dissertation Phase II (College-Based)

Course Outcomes (COs)

1. **CO1**: Implement the research methodology proposed in Phase 1 using appropriate tools and techniques (Technical Skills, Problem-Solving Skills).
2. **CO2**: Conduct experiments or simulations to generate data or validate the approach (Research Skills, Critical Thinking Skills).
3. **CO3**: Analyze results and interpret findings to address the research problem (Critical Thinking Skills, Research Skills).
4. **CO4**: Prepare a comprehensive dissertation report that systematically documents the research process, outcomes, and effectively present the work (Communication Skills, Technical Skills).

Evaluation Scheme

1. **Continuous Internal Evaluation (CIE) – 100 Marks**
   - Assessed by the project coordinator throughout the semester.
   - Focus: Progress, effort, and intermediate deliverables.

Paper publication/acceptance (10 marks): Awarded only if at least one paper (authored by the student) is published or accepted in:

- A recognized national/international conference or,
- An indexed journal
- Proof required: Acceptance letter/publication link/DOI/conference proceedings page

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	25	CO3	Evaluates preliminary analysis and critical thinking during the semester.
Draft Report Submission, Presentation	25	CO4	Checks documentation quality and adherence to academic standards; assesses communication and ability to discuss progress with the supervisor.
Total	**100**		

Rubrics for Interim Presentation I (30 marks)

Parameter	Excellent	Good	Average	Poor
Implementation of Methodology (10 marks) (CO1)	Methodology implemented	Implementation initiated with good progress	Partial implementation with limited clarity	No meaningful progress
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Experimental/ Analytical Work (10 marks) (CO2)	Results are well-validated and critically analyzed	Results interpreted with some validation	Basic interpretation	No meaningful interpretation
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Validation & Interpretation of Results (5 marks) (CO3)	Strong validation with comparison and justification	Adequate validation	Limited validation	No validation

Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Presentation & Viva (5 marks) (CO4)	Excellent communication and defense	Good communication	Average	Poor
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Interim Presentation II (30 marks)

Parameter	Excellent	Good	Average	Poor
Execution of the Proposed Methodology (5 marks) (CO1)	Complete, accurate, well-executed	Minor gaps in execution/accuracy	Partially complete, limited accuracy	Incomplete, incorrect implementation
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Progress Achieved (5 marks) (CO2)	Significant progress with validated results	Moderate progress with partial results	Limited progress	Minimal or no progress
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Quality of Results/Data & Analysis (5 marks) (CO3)	Robust results, deep analysis, strong conclusions	Good results, adequate analysis	Basic results, limited analysis	Weak/invalid results, poor analysis
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Depth of Knowledge (5 marks) (CO3)	Strong conceptual and technical understanding	Good understanding with minor gaps	Basic understanding	Poor understanding
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)
Presentation Skills (5 marks) (CO4)	Highly professional and confident	Good	Average	Poor
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

Rubrics for Final Internal Presentation (40 marks)

Parameter	Excellent	Good	Average	Poor
Proposed Methodology (10 marks) (CO1)	Complete, accurate, well-executed	Minor gaps in execution/ accuracy	Partially complete, limited accuracy	Incomplete, incorrect implementation
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)

Understanding of Work (10 marks) (CO2)	Thorough understanding, confident	Good understanding	Basic knowledge	Poor understanding
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Validation & Results (10 marks) (CO3)	Strong validation with comparison and justification	Adequate validation	Limited validation	No validation
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Report (10 marks) (CO4)	Excellent technical report with proper structure and references	Good clarity	Basic clarity	Poor communication
Range of marks	(9-10 marks)	(7-8 marks)	(5-6 marks)	(0-4 marks)
Presentation skill (5 marks) (CO4)	Clear& confident presentation	Good communication	Average	Poor
Range of marks	(5 marks)	(4 marks)	(3 marks)	(0-2 marks)

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	25	CO1	Evaluates completeness and technical accuracy of the implemented solution.
Quality of Results/Data, Depth of Analysis and Conclusions	30	CO2	Assesses the robustness and validity of experimental or simulation outcomes, examines the interpretation and significance of findings.
Final Dissertation Report	20	CO3	Judges the quality, structure, and clarity of the written report.
Viva Voce/Presentation	25	CO4	Tests ability to defend work and communicate findings to an academic panel.
Total	**100**		

Rubrics for End Semester Evaluation

Parameter	Excellent	Good	Average	Poor
Methodology Implementation (25 marks) (CO1)	Complete, accurate, well-executed	Minor gaps in execution/accuracy	Partially complete, limited accuracy	Incomplete, incorrect implementation
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)
Quality of Results/Data & Analysis (30 marks) (CO2)	Robust results, deep analysis, strong conclusions	Good results, adequate analysis	Basic results, limited analysis	Weak/invalid results, poor analysis
Range of marks	(25-30 marks)	(20-24 marks)	(10-19 marks)	(0-9 marks)
Dissertation Report (20 marks) (CO3)	Clear, well-structured, high quality	Good structure with minor issues	Adequate but lacks clarity/flow	Poorly written, unstructured
Range of marks	(15-20 marks)	(10-14 marks)	(5-9 marks)	(0-4 marks)
Viva Voce / Presentation (25 marks) (CO4)	Confident, clear, presentation with in-depth knowledge	Clear with minor gaps	Basic explanation, weak defense	Unclear, unable to defend
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)

Scheme for Dissertation Phase II (Industry-Based)

Course Outcomes (COs)

1. **CO1**: Implement the industry-oriented methodology proposed in Phase 1 using industry tools/resources (Technical Skills, Problem-Solving Skills).
2. **CO2**: Perform industry-relevant experiments, validations, or prototypes (Research Skills, Critical Thinking Skills).
3. **CO3**: Analyze results and draw conclusions applicable to the industry problem (Critical Thinking Skills, Research Skills).
4. **CO4:** Prepare a comprehensive dissertation report that systematically documents the research process and outcomes, and effectively present and defend the work before an academic audience (Communication Skills, Technical Skills). Evaluation Scheme

1. **Continuous Internal Evaluation (CIE) – 100 Marks**
   - Assessed jointly by the Project coordinator, supervisor / industry mentor during the semester.

- Focus: Industry collaboration, progress, and practical application.

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, result Analysis	30	CO2	Evaluates practical outputs (e.g., prototypes, tests) relevant to industry needs, assesses industry-applicable insights derived during the process.
Draft Report Submission	20	CO3	Ensures documentation meets both academic and industry standards.
Industry Feedback/Interaction	25	CO4	Gauges communication with industry mentor and progress updates.
Total	**100**		

Rubrics for Internal Evaluation (100 marks)

Parameter	Excellent	Good	Average	Poor
Methodology Implementation (25 marks) (CO1)	Systematic, on-time, effective use of tools	Good progress, minor gaps	Partial progress, some delays	Poor progress, inadequate execution
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)
Industry Validation / Prototype & Analysis (30 marks) (CO2)	High-quality validation, deep analysis, strong relevance	Good validation and analysis	Basic validation, limited analysis	No meaningful validation or analysis
Range of marks	(25-30 marks)	(20-24 marks)	(10-19 marks)	(0-9 marks)
Draft Report (20 marks) (CO3)	Clear, structured, comprehensive	Good with minor issues	Adequate, lacks depth/clarity	Poor, incomplete, unstructured
Range of marks	(15-20 marks)	(10-14 marks)	(5-9 marks)	(0-4 marks)
Industry Feedback / Interaction (25 marks) (CO4)	Proactive, regular updates, effective feedback use	Good interaction, periodic updates	Limited interaction, partial feedback use	Poor communication, no feedback use
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)

Feedback from 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 following parameters:

Parameters	**Marks** Rating (0-10 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	
Is punctual	
Uses time effectively	

Overall performance of student:

Intern (Tick one): Needs improvement (0 – 1 mark) / Satisfactory (2 mark) / Good (3 mark) / Very Good (4 mark) / Excellent (5 mark)

Additional comments, if any:

Signature of Industry Supervisor *Signature of Section Head/HRManager*

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	25	CO1	Evaluates the technical success of the industry-implemented solution.
Quality of Industry Outputs/Results, depth of Analysis and Industry Impact	30	CO2	Assesses the practical utility and quality of industry-specific deliverables, examines conclusions and their relevance to industry challenges.
Final Dissertation Report	20	CO3	Judges the report's ability to address academic rigor and industry needs.
Viva Voce/Presentation (Dual Audience)	25	CO4	Tests communication to both academic and industry evaluators.
Total	**100**		

Rubrics for End Semester Evaluation (100 marks)

Parameter	Excellent	Good	Average	Poor
Methodology Implementation (25 marks) (CO1)	Innovative, well-executed, validated	Appropriate, minor gaps	Acceptable, limited depth/validation	Poor, unclear, or irrelevant
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)
Results, Analysis & Industry Impact (30 marks) (CO2)	Highly relevant, deep analysis, strong impact	Relevant, good analysis	Limited relevance, basic analysis	Irrelevant, weak/no analysis
Range of marks	(25-30 marks)	(20-24 marks)	(10-19 marks)	(0-9 marks)
Final Dissertation Report (20 marks) (CO3)	Well-structured, clear, technically strong	Good structure, minor issues	Adequate, lacks clarity/depth	Poorly written, unstructured
Range of marks	(15-20 marks)	(10-14 marks)	(5-9 marks)	(0-4 marks)
Viva Voce / Presentation (25 marks) (CO4)	Confident, clear, presentation with in-depth knowledge	Clear with minor gaps	Basic, limited clarity	Unclear, unable to defend
Range of marks	(20-25 marks)	(15-19 marks)	(10-14 marks)	(0-9 marks)

EVALUATION COMMITTEES AT A GLANCE

MINI PROJECT (100 Marks) **Continuous Internal Evaluation (CIE) – 100 Marks** Evaluation committee comprises Project coordinator, senior faculty and Project supervisor. Final evaluation by a Committee of Project coordinator, Project supervisor and a senior faculty.
INTERNSHIP (100 Marks) **Internal evaluation committee (25 Marks)** comprises of Programme coordinator, Project coordinator and a senior faculty. **Viva Voce (25 Marks)** will be done by a committee comprising Programme Coordinator, Project coordinator and an external expert (from Industry or research/academic Institute)
DISSERTATION PHASE I (100 Marks) **Continuous Internal Evaluation (CIE) – 100 Marks** Evaluation committee comprises of Project coordinator, senior faculty and project supervisor / Industry mentor
DISSERTATION PHASE II (200 Marks) **Continuous Internal Evaluation (CIE) – 100 Marks** Assessed jointly by the Project coordinator, supervisor / industry mentor and senior faculty during the semester. **End Semester Evaluation (ESE) – 100 Marks** Assessed by a panel of Project coordinator, supervisor and external examiner at the semester end.