JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

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JECRC Campus, Shri Ram ki Nangal, Via-Vatika, Tonk Road, Jaipur

Department of Mechanical Engineering

Name of Subject: Heat Transfer

Subject Code: 5ME4-02

Year:3rd Year, 5th Semester

Jaipur Engineering College and Research Center, Jaipur

Department of Mechanical Engineering

(Rajasthan Technical University, KOTA)

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Department of Mechanical Engineering

Vision and Mission of Institute:

VISION:

To become a renowned centre of outcome based learning, and work towards academic, professional, cultural and social enrichment of the lives of individuals and communities.

MISION:

- Focus on evaluation of learning outcomes and motivate students to inculcate research aptitude by project based learning.
- Identify, based on informed perception of Indian, regional and global needs, areas of focus and provide platform to gain knowledge and solutions.
- Offer opportunities for interaction between academia and industry.
- Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

Vision and Mission of Department:

Vision:

The Mechanical Engineering Department strives to be recognized globally for outcome based technical knowledge and to produce quality human resource, who can manage the advance technologies and contribute to society.

Mission:

M1:To impart quality technical knowledge to the learners to make them globally competitive mechanical engineers.

M2:To provide the learners ethical guidelines along with excellent academic environment for a long productive career.

M3:To promote industry-institute relationship.

PROGRAMEDUCATIONAL OBJECTIVES(PEOS)

PEO1: To equip graduates with a strong foundation in engineering sciences, with an emphasis on mechanical engineering principles, enabling them to analyze, design, and solve real-world engineering challenges.

PEO2: To prepare graduates with sound scientific and engineering fundamentals to innovate and deliver effective solutions addressing practical challenges in mechanical engineering

PEO3: To inculcate in graduates a professional and ethical attitude, effective communication and teamwork skills, a multidisciplinary approach, entrepreneurial mindset, and the ability to connect engineering solutions with societal and environmental concerns.

PEO4: To provide students with an academic environment that fosters excellence, leadership, adherence to ethical standards, and encourages self-motivated lifelong learning essential for a successful professional career in mechanical

PEO5: To prepare students to excel in industry and higher education by providing quality education grounded in strong technical knowledge and high moral values

Program Specific Outcomes (PSOs)

PSO1: Graduates will be able to design, analyze, and fabricate electric and hybrid vehicles using modern engineering tools and sustainable practices.

PSO2: Graduates will be able to apply design principles and computational techniques, including programming and data structures, to analyze and solve mechanical engineering problems.

Program Outcomes (POs)

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4:Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7:Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8:Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10:Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary

environments.

PO11:Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

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SYLLABUS

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Syllabus

3rd Year - V Semester: B.Tech. : Mechanical Engineering

5ME4-02: HEAT TRANSFER

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	CONTENTS	HOURS
1	Introduction: Objective, scope and outcome of the course.	1
2	Introduction: Heat transfer processes, conduction and radiation. Fourier's law of heat conduction, thermal conductivity, thermal conductivity of solids, liquids and gases, effect of temperature on thermal conductivity. Newton's law of cooling, definition of overall heat transfer coefficient. General parameters influence the value of heat transfer coefficient.	4
	Conduction: General 3-Dimensoinal conduction equation in Cartesian, cylindrical and spherical coordinates; different kinds of boundary conditions; nature of differential equations; one dimensional heat conduction with and without heat generation; electrical analogy; heat conduction through composite walls; critical thickness of insulation	3
3	Heat transfer from extended surfaces: Governing differential equation of fin, fin efficiency and effectiveness for different boundary conditions.	3
	Unsteady state heat conduction for slab, cylinder and sphere, Heisler chart.	2
	Convection: Review of Navier – Stokes and energy equation, hydrodynamic and thermal boundary layers; laminar boundary layer equations; forced convection appropriate non dimensional members; effect of Prandtl number; empirical relations for flow over a flat plate and flow through pipes.	4
4	Natural convection: Dimensional analysis, Grashoff number, boundary layers in external flows (flow over a flat plate only), boundary layer equations and their solutions, heat transfer correlations.	4
	Heat transfer with change of phase: Nature of vaporization phenomena; different regimes of boiling heat transfer; correlations for saturated liquid vaporization; condensation on flat plates; correlation of experimental results, drop wise condensation.	4
5	Heat exchanger: Types of heat exchangers, arithmetic and logarithmic mean temperature differences, heat transfer coefficient for parallel, counter and cross flow type heat exchanger; effectiveness of heat exchanger, N.T.U. method, fouling factor. Constructional and manufacturing aspects of Heat Exchangers.	8
6	Thermal Radiation: Plank distribution law, Krichoff's law; radiation properties, diffuse radiations; Lambert's law. Radiation intensity, heat exchange between two black bodies heat exchanger between gray bodies. Shape factor; electrical analogy; reradiating surfaces heat transfer in presence of reradiating surfaces.	8
	TOTAL	**41**

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Subject: Heat Transfer **Code:5ME4-02**

COURSE OUTCOME

CO1: Understand the fundamental principles and modes of heat transfer.
CO2: Analyze steady-state and transient conduction in various geometries.
CO3: Evaluate convective heat transfer in internal and external flows.
CO4: Apply principles of radiation heat transfer to real-world problems.
CO5: Analyze heat exchangers and thermal systems.
CO6: Develop solutions for heat transfer applications in engineering

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	1	1	1	1	2	1	2	1	3	2
CO2	3	2	3	2	1	2	1	2	2	1	2	3	2
CO3	3	3	3	3	2	3	1	3	2	2	2	3	3
CO4	2	3	3	3	2	3	2	3	2	2	3	3	3
CO5	2	3	2	3	3	3	2	3	3	3	3	3	3
CO6	2	3	3	3	3	3	3	3	3	3	3	3	3

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Course Plan

Name of the Course: Heat Transfer

Code: 5ME4-02

Faculty: Dr.Bhuvnesh Bhardwaj

Basic Concepts of Heat Transfer

Lec	Topic	CO	Specific Objectives	Expected Outcomes	Reference
1	Explain course objectives and syllabus	CO1	To introduce course structure and evaluation scheme	Students will understand course structure and syllabus	Course File
1	Applications of heat transfer	CO1	To discuss industrial applications of heat transfer	Students will relate heat transfer to engineering applications	Notes
1	Modes of heat transfer	CO1	To explain conduction, convection and radiation	Students will identify modes of heat transfer	D.S. Kumar Ch.1 p.1-8
2	Basic heat transfer laws	CO1	To introduce Fourier law, Newton law and Stefan law	Students will apply heat transfer laws	Holman Ch.1 p.1-10
2	Thermal properties of materials	CO1	To explain thermal properties of materials	Students will calculate thermal properties	D.S. Kumar p.8-15
3	PYQ / Numerical Problems	CO1	To solve basic numerical problems	Students will solve basic heat transfer problems	GATE/PYQ

Heat Conduction

Lec	Topic	CO	Specific Objectives	Expected Outcomes	Reference
4	Fourier law of conduction	CO2	To derive Fourier law of conduction	Students will apply Fourier law	Holman Ch.2 p.30-40
4	Steady state conduction plane wall	CO2	To analyze plane wall conduction	Students will calculate heat transfer	D.S. Kumar p.20-30
5	Composite wall conduction	CO2	To explain composite wall conduction	Students will solve composite wall problems	D.S. Kumar p.30-40
6	Radial conduction cylinder	CO2	To analyze cylindrical conduction	Students will calculate radial heat transfer	Holman p.40-50
7	Radial conduction	CO2	To analyze	Students will solve	Holman p.50-

	sphere		spherical conduction	spherical problems	60
8	Critical thickness of insulation	CO2	To explain critical thickness	Students will design insulation systems	D.S. Kumar p.45-55
9	Heat generation in solids	CO2	To analyze heat generation	Students will calculate temperature distribution	Holman p.60-70
10	Fins and extended surfaces	CO2	To explain fins	Students will calculate fin efficiency	D.S. Kumar p.60-75
11-12	PYQ / Numerical Problems	CO2	To solve conduction problems	Students will solve advanced problems	GATE/PYQ

Transient Heat Conduction

Lec	Topic	CO	Specific Objectives	Expected Outcomes	Reference
13	Introduction to transient conduction	CO2	To explain transient conduction	Students will understand transient heat transfer	D.S. Kumar Ch.3
13	Lumped system analysis	CO2	To apply lumped system analysis	Students will solve transient problems	Holman p.90-100
14	Biot and Fourier number	CO2	To define dimensionless numbers	Students will apply Biot and Fourier number	D.S. Kumar p.100-110
14	Heisler charts	CO2	To apply Heisler charts	Students will solve transient problems	Holman p.110-120
15	Semi infinite solids	CO2	To analyze semi infinite solids	Students will solve semi infinite problems	D.S. Kumar p.120-130
16	PYQ / Numerical Problems	CO2	To solve transient problems	Students will solve advanced problems	GATE/PYQ

Convection Heat Transfer

Lec	Topic	CO	Specific Objectives	Expected Outcomes	Reference
17	Introduction to convection	CO3	To explain convection mechanism	Students will understand convection heat transfer	Holman Ch.4
18	Boundary layer theory	CO3	To explain boundary layer	Students will analyze boundary layer	D.S. Kumar p.140-150
19	Dimensionless numbers	CO3	To define Reynolds, Prandtl, Nusselt	Students will apply dimensionless numbers	Holman p.150-160

			number		
20	Forced convection	CO3	To analyze forced convection	Students will solve forced convection problems	D.S. Kumar p.160-175
20	Natural convection	CO3	To explain natural convection	Students will calculate natural convection	Holman p.175-185
21	Internal flow convection	CO3	To analyze internal flow	Students will solve pipe flow problems	D.S. Kumar p.185-200
21	External flow convection	CO3	To analyze external flow	Students will calculate heat transfer	Holman p.200-215
22-23	PYQ / Numerical Problems	CO3	To solve convection problems	Students will solve advanced problems	GATE/PYQ

Radiation Heat Transfer

Lec	Topic	CO	Specific Objectives	Expected Outcomes	Reference
24	Introduction to radiation	CO4	To explain radiation heat transfer	Students will understand radiation	D.S. Kumar Ch.5
24	Black body radiation	CO4	To explain black body radiation	Students will calculate radiation heat transfer	Holman p.240-250
24	Stefan Boltzmann law	CO4	To apply Stefan Boltzmann law	Students will solve radiation problems	D.S. Kumar p.250-260
25	Kirchhoff law	CO4	To explain Kirchhoff law	Students will solve radiation problems	Holman p.260-270
25	Shape factor	CO4	To calculate view factors	Students will analyze radiation exchange	D.S. Kumar p.270-285
26	Radiation between surfaces	CO4	To analyze radiation exchange	Students will solve radiation problems	Holman p.285-300
27-28	PYQ / Numerical Problems	CO4	To solve radiation problems	Students will solve advanced problems	GATE/PYQ

Lec	Topic	CO	Specific Objectives	Expected Outcomes	Reference
29	Heat exchanger types	CO5	Classify heat exchangers	Identify applications	D.S. Kumar Ch.6
30	LMTD method	CO5	Apply LMTD method	Solve problems	Holman p.320-330
31	Effectiveness NTU method	CO5	Apply NTU method	Design exchanger	D.S. Kumar p.330-345
32	Case studies	CO6	Solve real world problems	Apply knowledge	Research paper
33-	PYQ / Competitive Questions	CO1-CO6	Apply knowledge	Solve numericals	GATE/PYQ

Advanced Topics

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34	Introduction to 2-D heat conduction	CO6	To introduce two dimensional heat conduction concept	Students will understand 2-D conduction problems	D.S. Kumar
35	Introduction to Mass Transfer	CO6	To introduce mass transfer and Fick's law	Students will understand basic mass transfer	D.S. Kumar
36	Industrial Applications & Advanced Topics	CO6	To discuss advanced heat transfer applications	Students will apply heat transfer in real engineering systems	Holman

Reference Books

1. D.S. Kumar — Heat and Mass Transfer, S.K. Kataria & Sons
2. J.P. Holman — Heat Transfer, McGraw Hill