Department of Mechanical Engineering

M.Tech. Thermal Engineering
Curriculum and Syllabus

(Applicable to the students admitted during AY: 2022-23)

School of Engineering and Sciences

SRM University *AP*, Andhra Pradesh

Department Vision

To become distinct and renowned globally by graduating high-quality professionals through rigorous coursework and cutting-edge research.

Department Mission

1. Emerge as a world class mechanical engineering department in exploring and providing knowledge through high quality academic programs and experiential learning.
2. Create an ambience for impactful research aligning to the national mission and addressing the societal needs.
3. Create entrepreneurs and leaders of the future imparted with knowledge, global awareness, and strategic thinking.
4. Promote high standards of integrity, and ethical behaviour among faculty members, staff, and students.

Program Educational Objectives (PEO)

1. Prepare graduates with sound fundamental knowledge and advanced research knowledge in the field of thermal engineering especially in the field of electronic cooling and to make them capable of effectively analyzing and solving the problems associated with cooling challenges of electronic components.
2. Prepare the graduates with core competency to be successful in industry or academia or research laboratories with a strong understanding and ability to analyze problems, understand the technical requirements, design, create and deliver effective engineering solutions.
3. Prepare graduates to Inculcate Teamwork, Communication and Interpersonal Skills adapting to Changing Environments of Technology, leadership qualities, professional and ethical values.
4. Prepare graduates for excellent careers in Thermal Engineering with specialization in electronic cooling or related fields by utilizing their knowledge and contributing as exceptional professionals, as well as encouraging a sense of entrepreneurship

Mission of the Department to Program Educational Objectives (PEO) Mapping

	PEO 1	PEO 2	PEO 3	PEO 4
Mission Statement 1	3	2	3	2
Mission Statement 2	3	3	3	2
Mission Statement 3	2	1	3	3
Mission Statement 4	3	2	2	3

Program Specific Outcomes (PSO)

1. Apply knowledge of maths, science, and engineering with a multidisciplinary approach to identify, formulate, and solve the problems facing the electronic cooling industry to realize its hardware design potential.
2. Ability to perform research with the application of advanced knowledge in thermal management of electronic components to develop novel cooling solutions which address the cooling challenges of electronic components.
3. Work effectively in a team to design components, systems, and processes to meet desired goals within realistic economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability constraints using advanced digital/simulation tools like ANSYS ICEPAK.

Mapping Program Educational Objectives (PEO) to Program Learning Outcomes (PLO)

	Program Learning Outcomes (PLO)												
PEOs	POs										PSOs		
	Engineering Knowledge	Design Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Lifelong Learning	PSO 1	PSO 2	PSO 3
PEO 1	3	3	3	3	2	2	3	2	2	2	3	3	2
PEO 2	3	3	3	3	3	2	3	1	2	2	3	3	3
PEO 3	3	3	3	3	2	3	3	3	3	3	2	2	3
PEO 4	3	3	2	3	2	3	3	1	2	2	3	2	2

Category Wise Credit Distribution

Course Sub-Category	Sub-Category Credits	Category Credits	Learning Hours
Ability Enhancement Courses (AEC)		1	30
University AEC	0		
School AEC	1		
Value Added Courses (VAC)		0	0
University VAC	0		
School VAC	0		
Skill Enhancement Courses (SEC)		0	0
School SEC	0		
Department SEC	0		
SEC Elective	0		
Foundation / Interdisciplinary courses (FIC)		0	0
School FIC	0		
Department FIC	0		
Core + Core Elective including Specialization (CC)		34	1020
Core	34		
Core Elective (Inc Specialization)	0		
Minor (MC) + Open Elective (OE)	0	0	0
Research / Design / Internship/ Project (RDIP)		34	1020
Internship / Design Project / Startup / NGO	17		
Internship / Research / Thesis	17		
Total		**69**	**2070**

Semester wise Course Credit Distribution Under Various Categories						
Category	**Semester**					
	I	**II**	**III**	**IV**	**Total**	**%**
Ability Enhancement Courses - AEC	1	0	0	0	1	1
Value Added Courses - VAC	0	0	0	0	0	0
Skill Enhancement Courses - SEC	0	0	0	0	0	0
Foundation / Interdisciplinary Courses - FIC	0	0	0	0	0	0
CC / SE / CE / TE / DE / HSS	17	17	0	0	34	49
Minor / Open Elective - OE	0	0	0	0	0	0
(Research / Design / Industrial Practice / Project / Thesis / Internship) - RDIP	0	2	15	17	34	49
Grand Total	**18**	**19**	**15**	**17**	**69**	**100**

Note: L-T/D-P/Pr and the class allocation is as follows.

a) Learning Hours : 30 learning hours are equal to 1 credit.

b) Lecture/Tutorial : 15 contact hours (60 minutes each) per semester are equal to 1 credit.

c) Discussion : 30 contact hours (60 minutes each) per semester are equal to 1 credit.

d) Practical : 30 contact hours (60 minutes each) per semester are equal to 1 credit.

e) Project : 30 project hours (60 minutes each) per semester are equal to 1 credit.

SEMESTER - I								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	AEC	S AEC	EGL 501	English for Research Paper Writing	1	0	0	1
2	Core	CC	METE 551	Advanced Heat & Mass Transfer	3	0	0	3
3	Core	CC	METE 552	Advanced Fluid Dynamics	3	0	0	3
4	Core	CC	METE 553	Computational Fluid Dynamics	3	0	0	3
5	Core	CC	METE 553L	Computational Fluid Dynamics Lab	0	0	1	1
6	Core	CC	METE 554	Numerical methods in Thermal Engineering	3	0	0	3
7	Core	CC	METE 554L	Numerical methods in Thermal Engineering Lab	0	0	1	1
8	Core	CC	METE 555	Measurements in Thermal Engineering	3	0	0	3
				Semester Total	**16**	**0**	**2**	**18**

SEMESTER - II								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	TE	TE	TE	Technical Elective	3	0	0	3
2	TE	TE	TE	Technical Elective	0	0	1	1
3	TE	TE	TE	Technical Elective	3	0	0	3
4	TE	TE	TE	Technical Elective	3	0	0	3
5	TE	TE	TE	Technical Elective	0	0	1	1
6	TE	TE	TE	Technical Elective	3	0	0	3
7	TE	TE	TE	Technical Elective	3	0	0	3
8	RDIP	RDIP	RM 101	Research Methodology for IPR	2	0	0	2
				Semester Total	**17**	**0**	**2**	**19**

SEMESTER - III								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	RDIP	RDIP	METE 575	Project Phase - I	0	0	15	15
				Semester Total	**0**	**0**	**15**	**15**

SEMESTER - IV								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	RDIP	RDIP	METE 576	Final project	0	0	15	15
2	RDIP	RDIP	METE 571	Seminar - II	0	0	2	2
				Semester Total	**0**	**0**	**17**	**17**

Technical Electives								
S. No	**Category**	**Sub-Category**	**Course Code**	**Course Title**	**L**	**T/D**	**P/Pr**	**C**
1	TE	TE	TE 561	Advanced CFD	3	0	0	3
2	TE	TE	TE 561L	Advanced CFD Lab	0	0	1	1
3	TE	TE	TE 562	Turbulence and Shear Flows	3	0	0	3
4	TE	TE	TE 563	Thermal Design for Electronics Equipment	3	0	0	3
5	TE	TE	TE 563L	Thermal Design for Electronics Equipment Lab	0	0	1	1
6	TE	TE	TE 564	Introduction to Multiphase Flows	3	0	0	3
7	TE	TE	TE 565	Micro and Nanoscale Heat Transfer	3	0	0	3
8	TE	TE	TE 567	Design of Heat Exchange equipment	3	0	0	3
9	TE	TE	TE 568	Transport in Porous Media	3	0	0	3

English for Research Paper Writing

				L	T	P	C
Course Code	EGL 501	**Course Category**	AEC	1	0	0	1
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**			
Course Offering Department	English	**Professional / Licensing Standards**					

Course Objectives / Course Learning Rationales (CLRs)

1. Understand the Structure of a Research Paper
2. Familiarize students with the different types of research & methodologies.
3. Develop fundamental proofreading skills to identify and correct common grammatical errors.
4. Guide students in creating clear thesis statements and research questions to shape their papers.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Identify and recall the key components of a research paper, including abstracts, introductions, methods, results, discussions, and conclusions.	1,2	75%	75%
Outcome 2	Interpret the structure and organization of research papers, recognizing the role each section plays in conveying information.	2	75%	75%
Outcome 3	Analyze the effectiveness of thesis statements and research questions in guiding the development of a research paper.	3	75%	75%
Outcome 4	Generate clear and concise sentences, paragraphs, and sections that conform to academic writing standards.	3	75%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)											
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1		1				3	3	3	3				
Outcome 2		1				3	3	3	3				
Outcome 3		1				3	3	3	3				
Outcome 4		1				3	3	3	3				
Average		1				3	3	3	3				

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1	**Planning & Preparation**	**3**		
	What is research & the need for research	1	1,2	1,2
	Planning a manuscript	2	1,2	1,2
			1	1,2
Unit 2	**The Key to Good Writing**	**3**		
	Structuring a paragraph	2	1,2	1,2
	Sequencing a paragraph	1	1,2	1,2
Unit 3	**Being Concise**	**3**	1,2	1,2
	The steps to being concise	2	1,2	1,2
	Redundancy Vs Conciseness	1	1,2	1,2
Unit 4	**The Basic Components**	**3**		
	Abstract & Introduction	2	3	1,2
	Basic Formats	1	1,2	1,2
			1,3	1,2
Unit 5	**Practical Implementation**	**3**		
	Presentation of a paper	3	1,2,3,4	1,2
Total Contact Hours		**15**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA -2 (10%)		CLA-3 (20%)		Mid-1 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember Understand	30%		20%		30%		50%		50%	
Level 2	Apply Analyse	70%		80%		70%		50%		50%	
Level 3	Evaluate Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Recommended Resources

1. Wallwork Adrian. (2016). English for Writing Research Papers. New York: Springer.
2. Dudley Evans, T. (1998). Developments in English for Specific Purposes: A multidisciplinary approach. U.K: Cambridge University Press

Other Resources

1. Hutchinson, T., & Waters, A. (1987). English for Specific Purposes: A learner-centered approach. U.K: Cambridge University Press
2. Raman, Meenakshi, and Sangeetha Sharma. (2008). Technical Communication: English Skills for Engineers. New Delhi: Oxford University Press
3. Trimble, Louis. English for Science and Technology - A Discourse Approach. (1985). Cambridge: Cambridge University Press
4. Williams, Phil. Advanced Writing Skills for Students of English. (2018). Brighton: Rumian Publishing.
5. Wilson, Paige and Teresa Ferster Glazier. (2013). The Least You Should Know About English: Writing Skills, Form C (11th Edition). Boston: Cengage Learning.

Course Designers

1. Dr. Srabani Basu

SRM University *AP*, Andhra Pradesh
Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Advanced Heat and Mass Transfer

Course Code	METE551	**Course Category**	CC		**L**	**T**	**P**	**C**
					3	0	0	3
Pre-Requisite Course(s)	Fluid Mechanics, Heat Transfer, Thermodynamics, Calculus	**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. To enhance the understanding of heat transfer processes and their relevance to industrial problems.
2. To understand the derivations and physical meaning of governing equations of energy transfer.
3. To strengthen analytical and numerical abilities to solve complex heat transfer problems.
4. To provide experience in treating multimode heat transfer effects and in solving realistic engineering problems.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Identify the various heat transfer phenomena in real life situations.	2	70%	80%
Outcome 2	Apply the in depth understanding of conduction, convection and phase change processes of energy transfer.	3	70%	80%
Outcome 3	Interpret and solve the complex heat transfer problems and be able to compute their contributions to the energy exchange process.	4	70%	80%
Outcome 4	Analyse multi-mode heat transfer effects and situations for given applications	4	70%	80%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**										-		
	Engineering Knowledge	Design / Developmen	Conduct Investigation s of	Modern Tool	The Engineer and	Environment and	Ethics	Individual and Team	Communicat ion	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	2	2	2	-	-	2	-	2	3	2	2
Outcome 2	3	3	2	3	3	-	-	3	-	3	2	3	2
Outcome 3	3	3	3	3	3	-	-	3	-	3	2	3	3
Outcome 4	2	3	2	3	3	-	-	3	-	3	3	3	3
Course Average	**3**	**3**	**2**	**3**	**3**	-	-	**3**	-	**3**	**3**	**3**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Review of Heat Transfer Fundamentals: Brief review of Conduction: Transient conduction and extended surface	1.5	1	1, 6, 8
	Steady Laminar and Turbulent Heat Transfer in External and Internal Flows, Free and Forced convection	2.0	1	4, 5, 6, 8
	Brief review of radiation basics and mass transfer, Heat conduction - basic law,	0.5	1	1, 2, 6, 8
	governing equations in differential form including enthalpy basis, solution methods	3	2, 4	6, 7, 8, 12
Unit No. 2	Steady state conduction , Unsteady state problems-fins and moving fins problem	2.5	1, 2, 4	6, 7, 8, 12
	Moving boundaries/ interface problems in heat transfer Convective heat transfer	3.5	1, 2, 4	8, 12
	Conservation equations, boundary layer approximations Forced convective laminar and turbulent flow solutions.	03	2, 3	3, 4, 5, 6
	Natural convection solutions, correlations. Thermodynamics and physics of phase change	3.5	2, 3	3, 4, 5, 6
Unit No. 3	Vapor-liquid equilibrium for pure and multicomponent miscible fluids. Clasius-Clapeyron equation,	02	2, 3	3, 4, 5, 6
	Young-Laplace equation, capillary and Bond number. Contact angle and its hysteresis,	02	2, 3	3, 4, 5, 6
	Cassie-Baxter equation, surface wettability, super hydrophobic surface	1.5	2, 3	3, 4, 5, 6
	Bubble dynamics-Rayleigh equation, bubble deformation and collapse, breakup and coalescence Pool boiling-Nukiyama curve,	02	2, 3	3, 4, 5, 6
Unit No. 4	Boiling hysteresis, homogeneous and wall nucleation , liquid superheat, bubble departure, release frequency, nucleation site density, heat transfer mechanism, pool boiling correlation-Rohsenow equation, VDI correlation	04	2, 3, 4	3, 4, 5, 6, 8 9
	Effect of system pressure, heater geometry, surface wettability, dissolved gases and liquid sub cooling, boiling	02	2, 3, 4	3, 4, 9, 10, 11
	Critical heat flux in pool boiling-vapor jet Taylor and Kelvin-Helmholtz instability model	01	2, 3, 4	3, 4, 9, 10, 11
	correlation for CHF, film boiling – role of radiation, the Brombley model.	02	2, 3, 4	3, 4, 9, 10, 11
Unit No. 5	Two phase flow and flow boiling – flow maps, homogeneous model, Lockhart-Martinelli and Martinelli- Nelson model, Chisolm Model , drift flux model	03	2, 3, 4	3, 4, 9, 10, 11
	Flow boiling – onset of nucleate boiling, convective boiling, Chen's correlation, subcooled and saturated flow boiling, DNB and dry out, post dry out heat transfer.	02	2, 3, 4	3, 4, 9, 10, 11
	Mass Transfer- governing laws, transfer coefficients; applications	1.5	1, 2, 4	2, 6, 8
	Convective Mass Transfer – Combined Heat and Mass Transfer	2.5	1, 2, 4	2, 6, 8

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (5%)		Mid Term (25%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember Understand	30	-	20	-	20	-	40	-	30	-
Level 2	Apply Analyse	70	-	70	-	70	-	60	-	70	-
Level 3	Evaluate Create	-	-	10	-	10	-		-	-	-
Total		100%	-	100%	-	100%	-	100 %	-	100 %	-

Recommended Resources

1. E. R. G. Eckert and R. M. Drake Jr, Analysis of Heat Transfer, McGraw-Hill, 1972
2. W. M. Roshenow and P. Choi, Heat, Mass and Momentum Transfer, Prentice - Hall, 1961
3. Karl Stephan, Heat Transfer in Condensation and boiling, Springer- Verlag,1992
4. John G. Collier, John R. Thome, Convective boiling and condensation, Oxford University Press, 1996
5. P. B. Whalley, Two Phase flow and heat transfer, Oxford University Press, 1996
6. F. P. Incropera, D. P. Dewitt, T. L. Bergman and A. S. Lavine, "Fundamentals of Heat and Mass Transfer", 7th Ed., John Wiley and Sons, 2011.
7. J. P. Holman, "Heat Transfer", 10th Ed., McGraw Hill, 2009.
8. Yunus A. Çengel, Afshin J. Ghajar, "Heat and mass transfer: fundamentals and applications", McGraw-Hill Education, 2015.
9. L. S. Tong and Y. S. Tang, Boiling Heat Transfer and Two-Phase Flow, Taylor and Francis, 1997
10. S. G. Kandlikar, Hand book of phase change: Boiling and Condensation, Taylor and Francis, 1999
11. Mamoru Ishii, Takashi Hibiki, Thermo-Fluid Dynamics of Two-Phase Flow, Springer-Verlag, 2011
12. Latif M. Jiji, Heat Conduction: Third Edition, Springer-Verlag Berlin Heidelberg, 2009

Other Resources

1. **Lectures by Prof. C. Balaji on Conduction& Radiaiton:**
   https://www.youtube.com/watch?v=aLwJKZ1Gf3g&list=PL42D75EB85932E7D3
2. **Boiling phenomena: https://www.youtube.com/watch?v=Py0GEByCke4**

Course Designers

ADVANCED FLUID DYNAMICS

Course Code	**METE 552**	**Course Category**	CC		**L** 3	**T** 0	**P** 0	**C** 3
Pre-Requisite Course(s)	Basic Fluid Mechanics	**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Enhanced understanding on fluid dynamics to analyse practical fluid flow problems by applying advanced solutions of fluid mechanics and to Interpret and apply exact solutions of the Navier- Stokes equation to practical problems
2. To impart knowledge on low velocity flows-Stokesian flows.
3. To Understand and apply Boundary layer theory to engineering problems in case of both external flows and internal flows
4. To impart knowledge on the origin and nature of turbulence.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Solve and evaluate fluid velocity in the flow field and compute the rate of deformation of the fluid element	2	70%	65%
Outcome 2	Employ Navier Stokes Equation to solve real time engineering problems of high, low Reynolds number flows and boundary layer flows.	3	70%	65%
Outcome 3	Calculate the total drag and lift forces associated with structures immersed in the fluid and computing the flow rate and pumping power of the fluid.	4	70%	65%
Outcome 4	Predict the length scale of eddies and Reynolds stress	4	70%	65%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)											
	Engineering Knowledge	**Design and Development**	**Conduct Investigations of Complex Problems**	**Modern Tool and ICT Usage**	**The Engineer and Society**	**Environment and Sustainability**	**Moral, and Ethical Awareness**	**Individual and Teamwork Skills**	**Communication Skills**	**Self-Directed and Lifelong Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	**3**	**2**	**2**	**2**	**2**	1	-	**2**	**1**	3	3	2	2
Outcome 2	3	**3**	**3**	**3**	**3**	1	**-**	**2**	**1**	3	3	2	2
Outcome 3	**3**	**3**	**3**	**3**	**3**	2	**-**	**2**	**1**	3	3	2	3
Outcome 4	3	**3**	**3**	**3**	**3**	2	**-**	**2**	**1**	3	3	3	2
Course Average	**3**	**3**	**3**	**3**	**3**	**1**	**-**	**2**	**1**	**3**	3	2	2

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Properties of fluid, application of fluid mechanics and introduction to fluid statics.	2	1	2,4
	Introduction to basic principles such as Eulerian and Lagrangian approaches	2	1	2,4
	Types of flows, characterisation of fluid flows by covering the topic of streamline, path line and streak line also the concept of acceleration.	3	1	2,4
	Deformation of fluid elements and the concept of conservation of mass and various non dimensional numbers.	3	1	2,5
Unit No. 2	Introduction to Euler equations and Bernoulli equations.	2	1,2	1, 3, 4
	Navier-Stokes equations	3	1,2	1, 3, 4
	Application of simplified Navier-stokes equations for Parallel flows, Couette flow, Plane Poiseuille flow, Hagen-Poiseuille flow, flow in a convergent divergent channel	4	1,2	1, 3, 4
	Low Reynolds number flows Stokes first problem and second problem	3	1,2	1, 3, 4
Unit No. 3	Boundary layer formation in case both internal flows and external flows	4	2,3	1, 3
	Non dimensional form of the Navier stokes equations, the concept of order of magnitude analysis	2	2,3	1, 3
	Displacement and momentum thickness for external flow	2	2,3	1, 3
	Exact solutions of boundary layer equations for a flat plate	2	2,3	1, 3
Unit No. 4	The concept of boundary layer separation	3	2,3,4	1, 2, 3,4
	Potential flows, concept of lift and drag and its applications	2	2,3,4	1, 2, 3, 4
	Compressible flows and significance of mach number.	2	2,3,4	1, 2, 3,4
Unit No. 5	Introduction to turbulent flows, eddy's formation, statistical description of turbulent flows	3	4	1, 3,4
	Introduction to Reynolds stresses	3	4	1, 3,4

Learning Assessment

<table>
<tr><th colspan="2" rowspan="2">Bloom's Level of Cognitive Task</th><th colspan="4">Continuous Learning Assessments (__%)</th><th rowspan="2">End Semester Exam (50%)</th></tr>
<tr><th>CLA-1 (10%)</th><th>CLA-2 (10%)</th><th>CLA-3 (5%)</th><th>Mid Term (25%)</th></tr>
<tr><th colspan="2"></th><th>Th</th><th>Th</th><th>Th</th><th>Th</th><th>Th</th></tr>
<tr><td rowspan="2">Level 1</td><td>Remember</td><td rowspan="2">30%</td><td rowspan="2">20%</td><td rowspan="2">20%</td><td rowspan="2">30%</td><td rowspan="2">30%</td></tr>
<tr><td>Understand</td></tr>
<tr><td rowspan="2">Level 2</td><td>Apply</td><td rowspan="2">70%</td><td rowspan="2">80%</td><td rowspan="2">80%</td><td rowspan="2">70%</td><td rowspan="2">70%</td></tr>
<tr><td>Analyse</td></tr>
<tr><td rowspan="2">Level 3</td><td>Evaluate</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Create</td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td></tr>
</table>

Recommended Resources

1. K Muralidhar and G Biswas, "Advanced Engineering Fluid Mechanics", 3/e,Narosa Publishing House.,2001.
2. Yunus A Cengel& John Cimbala, "Fluid Mechanics: Fundamentals and Applications", 3/e McGraw Hill., 2017
3. Ronald L. Panton, "Incompressible Flow", 4/e, John Wiley & Sons Inc., 2011.
4. Robert W. Fox, Alan T. McDonald, &Philip J., "Fluid Mechanics", 8/e, John Wiley & Sons Inc., 2017

Course Designers

1. Dr. Lakshmi Sirisha Maganti, Assistant Professor, Department of Mechanical Engineering, SRM University-AP, Andhra Pradesh.

Computational Fluid Dynamics

Course Code	METE 553	**Course Category**	CC		**L**	**T**	**P**	**C**
					3	0	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Predict and derive the solution methodologies.
2. Identify advantages and disadvantages of various methods to solve a particular problem.
3. Apply the knowledge of the methods to engineering applications.
4. Study the computational implementation of the methods.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Derive the equations of fluid motion	2	80%	75%
Outcome 2	Derive the discretised equations	2	70%	65%
Outcome 3	Demonstrate the discretisation techniques for fluid flow equations	3	70%	65%
Outcome 4	Demonstrate Transformation of the governing equations and grid generation	3,4	60%	55%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)											
	Engineering Knowledge	Design / Developmen	Conduct Investigatio	Modern Tool Usage	The Engineer	Environmen t and	Ethics	Individual and Team	Communica tion	Life-long Learnin	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	1	2	2	-	-	-	-	3	3	2	3
Outcome 2	3	3	2	3	2	-	-	-	-	3	3	2	3
Outcome 3	3	3	3	3	2	-	-	-	-	3	3	2	3
Outcome 4	3	3	3	3	3	-	-	-	-	3	3	3	3
Course Average	**3**	**3**	**3**	**3**	**3**	-	-	-	-	**3**	**3**	**2**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Introduction to computational fluid dynamics	0.5	1	1, 2,3, 4
	Types of flow	1	1	1
	Material derivative, divergence	1.5	1	1, 3
	Continuity, momentum and energy equations differential form	5	1	1
	Integral form of governing equations	2	1	2,3
Unit No. 2	Finite difference methods	1	2	1
	Discretisation of wave equation	2	2	1, 2
	Numerical error, stability	1	2	1, 3
	Transient heat conduction equation	1	2	1, 3
	Explicit, Crank Nickolson and Pure implicit schemes	3	2	1, 2
	Grid independence	1	2	1
Unit No. 3	Lax wendroff and Maccormack technique	3	2	1, 3
	Relaxation, its significance and TDMA	2	2	1, 2
	ADI, Pressure correction methods	2	2	1, 3
	Staggered grid and its importance	1	2	1, 3
	Semi Implicit Method for Pressure linked equations (SIMPLE)	3	2	1, 3
	Stream function and vorticity	2	2	1
Unit No. 4	FVM basics	2	3	2, 3
	Central, upwind biased and hybrid schemes	1	3	2, 3
	One dimensional conduction problem	0.5	3	2, 4
	One dimensional convection and convection-diffusion	1	3	2, 3
	Boundary conditions	1	3	1, 2, 3, 4
Unit No. 5	Steady and transient problems	0.5	3	4
	Grid transformation	1	4	1
	Jacobian and Metrics of transformation	1	4	1
	Transforming governing equations	2	4	1
	Stretched, compressed and adaptive grids	1	4	1, 2,3
	Body fitted and unstructured grid	2	4	1, 3
Total Contact Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (55%)								End Semester Exam (45%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (20%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	40%		30%				40%		30%	
	Understand										
Level 2	Apply	60%		50%				60%		70%	
	Analyse										
Level 3	Evaluate			20%							
	Create										
	Total	**100%**		**100%**				**100%**		**100%**	

Recommended Resources

1. Anderson J.D., "Computational Fluid dynamics", McGraw Hill Int., New York, 2010.
2. Computational Fluid Dynamics, An Open-Source Approach. Brian C. Vermeire, Carlos A.Pereira and

Other Resources

1. Hamidreza Karbasian. https://users.encs.concordia.ca/~bvermeir/files/CFD%20-%20An%20Open-Source%20Approach.pdf
2. Versteeg H.K., and Malalasekera W., "An introduction to computational fluid dynamics, The finite volume method", Longman, 2007. ANSYS© guide.

Course Designers

1. Dr Satya Pramod Jammy, Associate Professor, Department of Mechanical Engineering, SRM University.

Computational Fluid Dynamics- Lab

Course Code	METE 553 L	**Course Category**	**Core**	**L**	**T**	**P**	**C**
				0	0	1	1
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**			
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**					

Course Objectives / Course Learning Rationales (CLRs)

1. Numerical solution steps.
2. Study about the limits of Numerical techniques and how to utilize them in actual situations.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Advanced Simulation Techniques	4	80%	75%
Outcome 2	CFD simulations of Complex Engineering Problems	2,3,4	70%	65%
Outcome 3	Basic fluid and heat transfer simulations	3	70%	65%
Outcome 4	Simulation steps	1	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**											
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life-long Learnin	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	1	2	2	-	-	-	-	3	3	2	3
Outcome 2	3	3	2	3	2	-	-	-	-	3	3	2	3
Outcome 3	3	3	3	3	2	-	-	-	-	3	3	2	3
Outcome 4	3	3	3	3	3	-	-	-	-	3	3	3	3
Course Average	**3**	**3**	**3**	**3**	**3**	-	-	-	-	**3**	**3**	**2**	**3**

Course Unitization Plan

Exp No	Experiment Name	Required Contact Hours	CLOs Addressed	References Used
1.	Introduction to ANSYS and CFD Basics	2	1	3
2.	Mesh Generation using ANSYS	4	4	1, 3,4
3.	Flow Simulation through a Pipe	4	3,4	3, 4
4.	Heat Transfer Analysis using ANSYS	4	3,4	3, 4
5.	Turbulence Modelling in CFD	6	2,3,4	3, 4
6.	Case study of an Engineering applications	10	3,4	3, 4
Total Contact Hours		**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)		End Semester Exam (50%)
		Experiments (30%)	Record / Observation Note (20%)	
Level 1	Remember	40%	40%	40%
	Understand			
Level 2	Apply	60%	60%	60%
	Analyse			
Level 3	Evaluate			
	Create			
Total		**100%**	**100%**	**100%**

Recommended Resources

1. Anderson J.D., "Computational Fluid dynamics", McGraw Hill Int., New York, 2010.
2. Computational Fluid Dynamics, An Open-Source Approach. Brian C. Vermeire, Carlos A.Pereira and

Other Resources

1. HamidrezaKarbasian.https://users.encs.concordia.ca/~bvermeir/files/CFD%20-%20An%20Open-Source%20Approach.pdf
2. Versteeg H.K., and Malalasekera W., "An introduction to computational fluid dynamics, The finite volume method", Longman, 2007.
3. ANSYS© guide.

Course Designers

1. Dr Satya Pramod Jammy*, Associate Professor, Department of Mechanical Engineering, SRM University*

Numerical methods in Thermal Engineering

Course Code	METE 554	**Course Category**	CC		**L**	**T**	**P**	**C**
					3	0	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Predict and derive the solution methodologies.
2. Identify advantages and disadvantages of various methods to solve a particular problem.
3. Apply the knowledge of the methods to engineering applications.
4. Study the computational implementation of the methods.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1	Classify the numerical methods	2	80%	75%
Outcome 2	Solve given engineering problems based on numerical methods such as Gauss elimination, bisection, least squares regression and differential equations	3	70%	65%
Outcome 3	Solve given engineering problems using numerical techniques and Python programming	3	70%	65%
Outcome 4	Demonstrate index notation methods for given equations using Python	3	60%	55%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	1	2	2	-	-	-	-	3	3	2	3
Outcome 2	3	3	2	3	2	-	-	-	-	3	3	2	3
Outcome 3	3	3	3	3	2	-	-	-	-	3	3	2	3
Outcome 4	3	3	3	3	3	-	-	-	-	3	3	3	3
Course Average	**3**	**3**	**3**	**3**	**3**	-	-	-	-	**3**	**3**	**2**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Numerical methods	0.5	1	1, 3
	Algorithms	1	1	1, 3
	Scientific notation, Precision effects, Error's	1	1	1, 3
	Syntax	0.5	1	1, 3
Unit No. 2	Linear algebraic systems	1	2	1, 2
	Gauss elimination method	1	2	1, 2,3
	LU decomposition, Tri diagonal Matrices, Thomas algorithm	3	2	1, 2
	Iterative solvers (Jacobi, Gauss-Siedel)	2	2	1, 2
	Convergence acceleration and stability using relaxation	2	2	1, 2
	Nonlinear equations solution using Bisection and Newton Raphson Nonlinear systems	3	2	1, 2, 4
Unit No. 3	Interpolation, extrapolation	1	2	1, 2, 3
	Linear, quadratic, and cubic interpolation -- Direct methods	1	2	1, 2
	Newton divided differences interpolation	2	2	1, 2
	Lagrange interpolation	1	2	1, 2
	Curve fitting and its applications	1	2	1, 2
	Regression analysis, error definitions	1	2	1, 2
	Linear least squares regression single variable, multi variable	1	2	1, 2
	Polynomial regression	2	2,4	1,2
Unit No. 4	Ordinary differential equations integration using Euler and Runge Kutta methods	2	2,4	1,2, 3
	Ordinary differential equations Predictor corrector methods, boundary, and initial value problems	3	2,4	1,2
	Discretisation, grid and boundaries	2	2,4	1,2
	Finite differences (forward, backward, and central) formulas up to 6th order derivations	3	2,4	1, 2
	Order of accuracy	2	2,4	1, 2
	Classification of partial differential equations (PDE)	1	2,4	1, 2
	Solution of elliptic, hyperbolic, and parabolic PDE using finite differences	3	2,4	1, 2
Unit No. 5	Steady and transient problems	0.5	3	4
	Grid transformation	1	4	1
	Application of linear and nonlinear system solutions to various engineering problems	1	4	1, 2, 3
	Application of Curve fitting and interpolation in Mechanical engineering	1	4	1, 2
	ODE and PDE applications specific to mechanical engineering	2	4	1, 2
Total number of lecture hours - Theory		**45**		

Learning Assessment

<table>
<tr><th colspan="2" rowspan="3">Bloom's Level of Cognitive Task</th><th colspan="3">Continuous Learning Assessments (55%)</th><th rowspan="2">End Semester Exam (45%)</th></tr>
<tr><th>CLA-1 (20%)</th><th>Mid-1 (15%)</th><th>CLA-2 (20%)</th></tr>
<tr><th>Th</th><th>Th</th><th>Th</th><th>Th</th></tr>
<tr><td rowspan="2">Level 1</td><td>Remember</td><td rowspan="2">30%</td><td rowspan="2">35%</td><td rowspan="2">40%</td><td rowspan="2">40%</td></tr>
<tr><td>Understand</td></tr>
<tr><td rowspan="2">Level 2</td><td>Apply</td><td rowspan="2">70%</td><td rowspan="2">65%</td><td rowspan="2">60%</td><td rowspan="2">60%</td></tr>
<tr><td>Analyse</td></tr>
<tr><td rowspan="2">Level 3</td><td>Evaluate</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Create</td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td></tr>
</table>

Recommended Resources

1. Numerical methods for engineers by Steven C. Chapra and Raymond P. Canalem McGrawhill Publications
2. Numerical Methods with worked examples, Chris H. Woodford and Christopher Phillips, Springer
3. Numerical Methods in Engineering with Python, John Kiusalaas.

Other Resources

1. Numerical Methods using Matlab, John H Mathews
2. Matlab Workspace online

Course Designers

1. Dr Satya Pramod Jammy, Associate Professor, Department of Mechanical Engineering, SRM University AP

Numerical Methods Lab

				L	T	P	C
Course Code	METE 554 L	**Course Category**	CC	0	0	1	1
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**			
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**					

Course Objectives / Course Learning Rationales (CLRs)

1. Predict and derive the solution methodologies.
2. Identify advantages and disadvantages of various methods to solve a particular problem.
3. Apply the knowledge of the methods to engineering applications.
4. Study the computational implementation of the methods

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Classify the numerical methods	2	80%	75%
Outcome 2	Solve given engineering problems based on numerical methods such as Gauss elimination, bisection, least squares regression and differential equations	3	70%	65%
Outcome 3	Solve given engineering problems using numerical techniques and Python programming	3	70%	65%
Outcome 4	Demonstrate index notation methods for given equations using Python	3	60%	55%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)											
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	1	2	2	-	-	-	-	3	3	2	3
Outcome 2	3	3	2	3	2	-	-	-	-	3	3	2	3
Outcome 3	3	3	3	3	2	-	-	-	-	3	3	2	3
Outcome 4	3	3	3	3	3	-	-	-	-	3	3	3	3
Course Average	**3**	**3**	**3**	**3**	**3**	-	-	-	-	**3**	**3**	**2**	**3**

Course Unitization Plan—Lab

Exp No	Experiment Name	Required Contact Hours	CLOs Addressed	References Used
1.	Plotting using Matplotlib	2	1	3
2.	Solution of linear algebraic equations using direct methods	4	2, 3,4	1, 3,4
3.	Linear algebraic equations using iterative methods	4	3,4	3, 4
4.	Non linear equations, using Newton Raphson and Bisection	4	2, 3,4	2, 3, 4
5.	Regression implementation	6	2, 3,4	3, 4
6.	Euler, Runge Kutta 2nd and fourth order methods	4	3,4	3, 4
7.	Finite differences	2	2, 3,4	3, 4
8.	Partial differential equations	4	3,4	1, 3
Total Contact Hours		**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)	End Semester Exam (50%)
		Experiments and performance (50%)	
Level 1	Remember	40%	40%
	Understand		
Level 2	Apply	60%	60%
	Analyse		
Level 3	Evaluate		
	Create		
Total		**100%**	**100%**

Recommended Resources

1. Numerical methods for engineers by Steven C. Chapra and Raymond P. Canalem McGrawhill Publications
2. Numerical Methods with worked examples, Chris H. Woodford and Christopher Phillips, Springer
3. Numerical Methods in Engineering with Python, John Kiusalaas
4. Numerical Methods using Matlab, John H Mathews.

Other Resources

Course Designers

1. Dr Satya Pramod Jammy, Associate Professor, Department of Mechanical Engineering, SRM University AP

SRM University *AP*, Andhra Pradesh

Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Measurements in Thermal Engineering

Course Code	METE555	**Course Category**	CC		**L**	**T**	**P**	**C**
					3	0	0	3
Pre-Requisite Course(s)	Fluid Mechanics, Heat transfer, Calculus	**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. To enhance the understanding of measurement systems, mathematical modelling and system responses both static and dynamic behaviour.
2. To have an improved understanding of measurement errors, statistical data analysis and their interpretation.
3. To learn different techniques of instrumentation involved in measurement of thermal quantities.
4. To provide understanding and exposure in planning of experimental work and choice of instrumentation in realistic engineering problems.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Identify the various measurement systems and their modelling in real life situations.	2	70%	80%
Outcome 2	Apply the in depth understanding of errors in measurements and statistical analysis.	3	70%	80%
Outcome 3	Identify and interpret measurements process for pressure, flow and temperature in real life.	4	70%	80%
Outcome 4	Analyse measured and acquired data for different measurement processes for given applications.	4	70%	80%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)										-		
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	2	2	2	-	-	2	-	2	3	2	2
Outcome 2	3	3	2	3	3	-	-	3	-	3	2	3	2
Outcome 3	3	3	3	3	3	-	-	3	-	3	2	3	3
Outcome 4	2	3	2	3	3	-	-	3	-	3	3	3	3
Course Average	**3**	**3**	**2**	**3**	**3**	-	-	**3**	-	**3**	**3**	**3**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Methodology and planning of experimental work	1	1	1, 3, 4, 5
	Introduction to measurements, Measurement categories-primary and derived quantities, intrusive and non-intrusive methods	2.0	1	1, 3, 4, 5
	Static and dynamic characteristics	1.5	1, 4	1, 3, 4, 5
	System response- first and second order systems and analysis	1.5	1, 4	1, 3, 4, 5
Unit No. 2	Analysis of experimental data- types of errors Uncertainty analysis, propagation of uncertainty	3	2	2, 3, 4
	Statistical analysis of experimental data- normal error distributions (confidence interval and level of significance, Chauvenet's criterion)	3	2	2, 3, 4
	Chi-square test of goodness of fit, method of least squares (regression analysis, correlation coefficient),	2	2	2, 3, 4
	Multivariable regression, Students' t-distribution, graphical analysis and curve fitting.	2	2	2, 3, 4
Unit No. 3	Measurement of temperature- thermoelectric thermometry, resistance thermometry, pyrometry	04	3	1, 3, 5
	Liquid in glass, bimetallic and liquid crystal thermometer	02	3	1, 3, 5
	Temperature sensors for measurement of transient temperature.	02	3	1, 3, 5
	Measurement of pressure-U-tube manometer, Bourdon gage, pressure transducers,	04	3	1, 3, 5
Unit No. 4	Measurement of transient and vacuum pressures	02	3	1, 3, 5
	Measurement of volume flow rate- variable area type flow meter-orifice plate meter, flow nozzle, venture meter, rotameter	04	3, 4	1, 2, 5
	Measurement of velocity-Pitot static and impact probes	03	3, 4	1, 2, 5
	Velocity measurement based on thermal effect	01	3, 4	1, 2, 5
Unit No. 5	Doppler velocimetry, Time of flight velocimetry	03	3, 4	1, 2, 5
	Analog to digital conversion Fourier series and transform, sampling, aliasing, and filtering	2.5	3, 4	1, 2, 3
	Cross-correlation and autocorrelation. Digital image analysis.	1.5	3, 4	1, 2, 3

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (05%)		Mid Term (25%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember Understand	30	-	20	-	20	-	30	-	30	-
Level 2	Apply Analyse	60	-	70	-	70	-	70	-	70	-
Level 3	Evaluate Create	10	-	10	-	10	-	-	-	-	-
	Total	100%	-	100%	-	100%	-	100%	-	100%	-

Recommended Resources

1. S. P. Venkateshan, Mechanical Measurements, Anne Books Pvt. Ltd., 2015
2. J. P. Holman, Experimental Methods for Engineers, McGraw-Hill, 2011
3. Ernest O. Doeblin and Dhanesh N. Manik, Measurement and Systems: Application and Design, 6th edition, McGraw-Hill, 2011
4. John R. Taylor, An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements, University Science Books, 1997
5. Thomas G. Beckwith and Roy D. Marangoni, Mechanical Measurements, Pearson, 6th edition, 2007

Other Resources

1. **Fourier Series & Transforms:** **https://www.youtube.com/watch?v=mgXSevZmjPc**

Course Designers

SRM University *AP*, Andhra Pradesh

Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Research Methodology and IPR

						L	T	P	C
Course Code	RM 101	**Course Category**	RDIP			2	0	0	2
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**					
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**							

<u>Course Objectives / Course Learning Rationales (CLRs)</u>

1. Developing Research Skills
2. Understanding Intellectual Property Rights (IPR)
3. Enhancing Ethical Research Practices
4. Promoting Effective Communication of Research Results

<u>Course Outcomes / Course Learning Outcomes (CLOs)</u>

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Understand research problem formulation	2	80%	75%
Outcome 2	Analyse research-related information and understand research ethics	2	70%	65%
Outcome 3	Understanding that when IPR would take such an important place in the growth of individuals & nations.	3	80%	70%
Outcome 4	Understand that IPR protection provides an incentive to inventors for further research work and investment in R&D.	3	70%	65%

<u>Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)</u>

CLOs	**Program Learning Outcomes (PLO)**												
	Engineering Knowledge	**Design / Development of Solutions**	**Conduct Investigations of Complex Problems**	**Modern Tools and ICT Usage**	**The Engineer and Society**	**Environment and Sustainability**	**Ethics**	**Individual and Teamwork Skills**	**Communication Skills**	**Life-long Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	2	1	2	2				1		3	2	2	3
Outcome 2	3	2	3	3				2		3	3	2	3
Outcome 3	3	3	3	2				1		3	2	2	3
Outcome 4	3	2	3	2				2		3	3	3	3
Average	3	2	3	2				2		3	3	2	3

Course Unitization Plan

Session	Description of Topic	Contact hours	CLOs Addressed	Reference
1	**Unit I**	**6**		
2	Meaning of research problem, Sources of research problem	2	1	1,3
3	Criteria Characteristics of a good research problem,	2	1	1,2,3
4	Errors in selecting a research problem, scope, and objectives of research problem.	2	1	1,2,3
5	**Unit II**	**6**		
6	Approaches of investigation of solutions for research problem, data collection,	2	1,2	1,2,3
7	Analysis, interpretation, Necessary instrumentations.	2	1,2	1,2,3
8	Effective literature studies approaches, analysis Plagiarism, Research ethics.	2	1,2	1,2,3
9	**Unit III**	**6**		
10	Effective technical writing,	2	1,2	1,2
11	how to write report, Paper Developing a Research Proposal,	2	1,2	1,2
12	Format of research proposal, a presentation and assessment by a review committee.	2	1,2	1,2
13	**Unit IV**	**6**		
14	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research,	2	1,2	1,2,3
15	innovation, patenting, development. International Scenario: International cooperation on Intellectual Property.	2	1,2	1,2,3
16	Procedure for grants of patents, Patenting under PCT.\	1	1,2	1,2,3
17	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	1	1,2	1,2,3
18	**Unit V**	**6**		
19	New Developments in IPR: Administration of Patent System.	2	3,4	4,5
20	New developments in IPR; IPR of Biological Systems,	2	3,4	4,5
21	Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	2	3,4	4,5
22				
	Total Contact Hours	**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)				End Semester Exam (50%)
		CLA-1 (10%)	Mid-1 (15%)	CLA-2 (10%)	Mid-2 (15%)	
		Th	Th	Th	Th	Th
Level 1	Remember Understand	40%	50%	30%	20%	30%
Level 2	Apply Analyse	60%	50%	70%	80%	70%
Level 3	Evaluate Create					
Total		**100%**	**100%**	**100%**	**100%**	**100%**

Recommended Resources

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’ “Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
2. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step-by-Step Guide for beginners” Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
3. Mayall, “Industrial Design”, McGraw Hill, 1992.
4. Niebel, “Product Design”, McGraw Hill, 1974.
5. Asimov, “Introduction to Design”, Prentice Hall, 1962.

Other Resources

Course Designers

1. Dr. Manjesh Kumar, Department of Mechanical Engineering, SRM University-AP, Andhra Pradesh.
2. Dr. Manas Das, Department of Mechanical Engineering, IIT Guwahati

Project Phase -1

Course Code	METE575	**Course Category**	RDIP			**L** 0	**T** 0	**P** 15	**C** 15
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**					
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**							

Course Objectives / Course Learning Rationales (CLRs)

1. To learn how to define the research objective.
2. To acquire skills to solve the problem statement.
3. To learn how to prepare scientific presentations.
4. To develop skills for project management and writing scientific reports.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Formulate research objective	2	80%	80%
Outcome 2	Describe the method (experiments or simulation to attain objective)	2	65%	60%
Outcome 3	Describe the research outcome through presentation	3	65%	60%
Outcome 4	Find out how to write thesis	2	60%	65%
Outcome 5	Study about various instrumentation techniques used during presentations.	3	80%	75%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)													
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and CT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and Finance	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	2	-	2	3	2	1	-	-	3	3	2	3	1	2	2
Outcome 2	2	-	2	3	2	1	-	-	3	3	2	3	2	2	1
Outcome 3	2	-	2	3	2	1	-	-	3	3	2	3	2	2	1
Outcome 4	2	-	2	3	2	1	-	-	3	3	2	3	2	2	2
Outcome 5	2	-	2	3	2	3	-	3	3	3	2	3	2	3	2
Average	2	-	2	3	2	1	-	3	3	3	2	3	2	2	2

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Clearly articulating the problem that the project aims to solve, Describing the current state of affairs and why a solution is necessary	3	1	1,5
Unit No. 2	Application of various methods and approaches to ensure successful execution of Project	3	2	1,5
Unit No. 3	The obtained results must be interpreted utilising appropriate software, tools, and techniques. Validation of results with standard data base	4	3	2,3,5
Unit No. 4	Making a scientific presentation of the results obtained with appropriate reasoning.	2	3	2,3
Unit No. 5	Obtained results is summarized in the form thesis/manuscript/report	3	4	4,5

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)		End Semester Exam (50%)
		Project Review 1 (25%)	Project Review 2 (25%)	
Level 1	Remember	-	-	-
	Understand			
Level 2	Apply	50%	50%	50%
	Analyse			
Level 3	Evaluate	50%	50%	50%
	Create			
Total		**100%**	**100%**	**100%**

Recommended Resources

1. Problem Solving for Engineers and Scientists: A Creative Approach (https://doi.org/10.1007/978-1-4615-3906-3)
2. Matt Carter Designing Science Presentations: A Visual Guide to Figures, Papers, Slides, Posters, and More (ISBN: 0123859697)
3. Garr Reynolds Presentation Zen: Simple Ideas on Presentation Design and Delivery (ISBN: 0321811984)
4. Article, how to write consistently boring scientific literature by Kaj Sand-Jensen. doi/10.1111/j.0030-1299.2007. 15674.x
5. Keshav S. How to read a paper. ACM SIGCOMM Computer Communication Review. 2007 Jul 20;37(3):83-4.

Course Designers

Final project

Course Code	METE 576	**Course Category**		**L**	**T**	**P**	**C**
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**			
Course Offering Department		**Professional / Licensing Standards**					

Course Objectives / Course Learning Rationales (CLRs)

- Enter Data

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1				
Outcome 2				
Outcome 3				
Outcome 4				

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and CT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and Finance	Self-Directed and Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1															
Outcome 2															
Outcome 3															
Average															

<u>Course Unitization Plan</u>

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1				
Unit 2				
Unit 3				
Unit 4				
Unit 5				

Learning Assessment

<table>
<tr><th colspan="2" rowspan="2">Bloom's Level of Cognitive Task</th><th colspan="4">Continuous Learning Assessments (50%)</th><th rowspan="2">End Semester Exam (50%)</th></tr>
<tr><th>CLA-1 20%</th><th>Mid-1 20%</th><th>CLA-2 20%</th><th>CLA-3 20%</th></tr>
<tr><td rowspan="2">Level 1</td><td>Remember</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Understand</td></tr>
<tr><td rowspan="2">Level 2</td><td>Apply</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Analyse</td></tr>
<tr><td rowspan="2">Level 3</td><td>Evaluate</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Create</td></tr>
<tr><td colspan="2">Total</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Recommended Resources

1. Enter Data

Other Resources

1. Enter Data

Course Designers

1. Enter Data

Seminar - II

Course Code	METE 571	**Course Category**			L	T	P	C
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department		**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	**Bloom's Level**	**Expected Proficiency Percentage**	**Expected Attainment Percentage**
Outcome 1				
Outcome 2				
Outcome 3				
Outcome 4				

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**														
	Engineering Knowledge	Problem Analysis	Design and Development	Analysis, Design and Research	Modern Tool and CT Usage	Society and Multicultural Skills	Environment and Sustainability	Moral, and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Project Management and Finance	Self-Directed and Lifelong Learning	PSO 1	PSO 2	PSO 3
Outcome 1															
Outcome 2															
Outcome 3															
Average															

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References Used
Unit 1				
Unit 2				
Unit 3				
Unit 4				
Unit 5				

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)				End Semester Exam (50%)
		CLA-1 20%	Mid-1 20%	CLA-2 20%	CLA-3 20%	
Level 1	Remember					
	Understand					
Level 2	Apply					
	Analyse					
Level 3	Evaluate					
	Create					
Total						

Recommended Resources

1. Enter Data

Other Resources

1. Enter Data

Course Designers

1. Enter Data

SRM University *AP*, Andhra Pradesh

Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Advanced CFD

Course Code	TE 561	**Course Category**	**TE**		**L**	**T**	**P**	**C**
					3	0	0	3
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Predict and derive the solution methodologies.
2. Identify advantages and disadvantages of various methods to solve a particular problem.
3. Apply the knowledge of the methods to engineering applications.
4. Study the computational implementation of the methods

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Derive the equations of fluid motion	2	80%	75%
Outcome 2	Derive the discretised equations	2	70%	65%
Outcome 3	Demonstrate the discretisation techniques for fluid flow equations	3	70%	65%
Outcome 4	Demonstrate Transformation of the governing equations and grid generation	3	60%	55%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)											
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tool Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life-long Learnin	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	1	2	2	-	-	-	-	3	3	2	3
Outcome 2	3	3	2	3	2	-	-	-	-	3	3	2	3
Outcome 3	3	3	3	3	2	-	-	-	-	3	3	2	3
Outcome 4	3	3	3	3	3	-	-	-	-	3	3	3	3
Course Average	**3**	**3**	**3**	**3**	**3**	-	-	-	-	**3**	**3**	**2**	**3**

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Flow properties	0.5	1	1, 2,3, 4
	Types of flow	1	1	1
	FDM and FVM	1.5	1	1, 3, 4
	Classification of Navier Stokes equations	5	1	1
	Integral form of equations suitable of FVM	2	1	2,3
Unit No. 2	Incompressible flow solutions	5	2	1
	Order of accuracy in FVM	2	2	1, 2
	SIMPLE, PIMPLE and PISO algorithms	5	2	1, 3
Unit No. 3	Different methods for gradient evaluation	5	2	1, 3
	Methods to find the node values	4	2	1, 2
	Solution of TDMA	4	2	1, 3
Unit No. 4	Higher order schemes	2	3	2, 3
	Compact differences	1	3	2, 3
	Spectral methods for Pressure solution	3	3	2, 4
Unit No. 5	Basics of multiphase flows	1	4	1
	Eulerian and Larangian approaches	1	4	1
	Volume of Fluid (VOF) method	2	4	1
	Multiphase flow simulations: bubbles, droplets	1	4	1, 2,3
	Application to multi-phase flows	2	4	1, 3
	Total Contact Hours	**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (55%)								End Semester Exam (45%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (20%)			
		Th	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**	**Th**	**Prac**
Level 1	Remember	40%		30%				40%		30%	
	Understand										
Level 2	Apply	60%		50%				60%		70%	
	Analyse										
Level 3	Evaluate			20%							
	Create										
Total		**100%**		**100%**				**100%**		**100%**	

Recommended Resources

1. High-Performance Computational Fluid Dynamics for Aerospace Engineering" by Wei Shyy, Yongsheng Lian, and Jianping Bai
2. Versteeg H.K., and Malalasekera W., "An introduction to computational fluid dynamics, The finite volume method", Longman, 2007.
3. Computational Fluid Dynamics: Principles and Applications" by Jiri Blazek.

Other Resources

1. Computational Fluid Dynamics: A Practical Approach" by Jiyuan Tu, Guan Heng Yeoh, and Chaoqun Liu https://users.encs.concordia.ca/~bvermeir/files/CFD%20-%20An%20Open-Source%20Approach.pdf

Course Designers

1. Dr Satya Pramod Jammy*, Associate Professor, Department of Mechanical Engineering, SRM University AP.*

Advanced CFD LAB

Course Code	TE 561 L	**Course Category**	**Core Course (CC)**	**L**	**T**	**P**	**C**
				0	0	1	1
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**			
Course Offering Department		**Professional / Licensing Standards**					

Course Objectives / Course Learning Rationales (CLRs)

1. Numerical solution steps.
2. Study about the limits of techniques and how to utilize them in actual situations.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Advanced Simulation Techniques	4	80%	75%
Outcome 2	CFD simulations of Complex Engineering Problems	2,3,4	70%	65%
Outcome 3	Basic fluid and heat transfer simulations	3	70%	65%
Outcome 4	Simulation steps	1	80%	70%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)											
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	1	2	2					3	2	3	3	2
Outcome 2	3	2	3	2					3	2	3	3	3
Outcome 3	3	3	3	2					3	2	3	3	3
Outcome 4	3	3	3	2					3	2	3	3	3
Average	3		3						3	2	3	3	3

Course Unitization Plan

Exp No	Experiment Name	Required Contact Hours	CLOs Addressed	References Used
1.	CFD simulation basic	2	1	3
2.	Turbulence modelling	4	4	1, 3,4
3.	Laminar/Turbulent flow over a flat plate	4	3,4	3, 4
4.	Effect of numerical methods on solution	4	3,4	3, 4
5.	Project/case study	16	2,3,4	3, 4
Total Contact Hours		**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)		End Semester Exam (50%)
		Experiments (30%)	Record / Observation Note (20%)	
Level 1	Remember Understand	40%	40%	40%
Level 2	Apply Analyse	60%	60%	60%
Level 3	Evaluate Create			
Total		**100%**	**100%**	**100%**

Recommended Resources

1. Anderson J.D., "Computational Fluid dynamics", McGraw Hill Int., New York, 2010.
2. Computational Fluid Dynamics, An Open-Source Approach. Brian C. Vermeire, Carlos A.Pereira and.

Other Resources

1. Hamidreza Karbasian. https://users.encs.concordia.ca/~bvermeir/files/CFD%20-%20An%20Open-Source%20Approach.pdf
2. Versteeg H.K., and Malalasekera W., "An introduction to computational fluid dynamics, The finite volume method", Longman, 2007.
3. ANSYS© guide

Course Designers

1. Dr Satya Pramod Jammy, *Associate Professor, Department of Mechanical Engineering, SRM University*

Turbulence and Shear flows

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">TE562</td><td rowspan="2">Course Category</td><td rowspan="2" colspan="2">TE</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Pre-Requisite Course(s)</td><td></td><td>Co-Requisite Course(s)</td><td></td><td>Progressive Course(s)</td><td colspan="4"></td></tr>
<tr><td>Course Offering Department</td><td>Mechanical Engineering</td><td>Professional / Licensing Standards</td><td colspan="6"></td></tr>
</table>

Course Objectives / Course Learning Rationales (CLRs)

1. Predict and derive the solution methodologies.
2. Identify advantages and disadvantages of various methods to solve a particular problem.
3. Apply the knowledge of the methods to engineering applications.
4. Study the computational implementation of the methods

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Derive the equations of fluid motion	2	80%	75%
Outcome 2	Derive the discretised equations	2	70%	65%
Outcome 3	Demonstrate the discretisation techniques for fluid flow equations	3	70%	65%
Outcome 4	Demonstrate Transformation of the governing equations and grid generation	3	60%	55%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)												
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	2	2					3	2	3	3	2
Outcome 2	3	3	3	2					3	2	3	3	3
Outcome 3	3	3	3	2					3	2	3	3	3
Outcome 4	3	3	3	3					3	3	3	3	3
Average	3	3	3	3					3	2	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Nature of turbulent flows	1	1	1, 2,3, 4
	Irregularity, diffusivity	1	1	1
	three dimensional motions	1	1	1, 3
	dissipation, wide spectrum, origin of turbulence,	1	1	1
	eddy motions and length scales.	1	1	2,3
Unit No. 2	Random nature of turbulence, distribution function, probability density, moments, correlations	5	2	1
	Taylor's hypothesis, integral micro scales, homogeneous and isotropic turbulence	2	2	1, 2
	Kolmogorov hypothesis, scales of turbulence, energy cascade, turbulence spectra.	3	2	1, 3
Unit No. 3	Reynolds decomposition, turbulent stresses, vortex stretching	4	2	1, 3
	Reynolds equations, mixing-length model, Reynolds' analogy, dynamics of turbulence.	4	2	1, 2
	Free Shear flows: Mixing Layer, Turbulent Wakes and Jets, Grid Turbulence	4	2	1, 3
Unit No. 4	Channel and pipe flows, Reynolds stresses, turbulent boundary layer equations, logarithmic law of walls, turbulent structures.	5	3	2, 3
	Experimental methods: Introduction, hot wire anemometry	2	3	2, 3
	uncertainty analysis and laser doppler anemometry.	3	3	2, 4
Unit No. 5	Introduction, eddy-viscosity hypothesis, algebraic model	2	4	1
	k-ε and k-ω model	2	4	1
	Reynolds-stress model	2	4	1
	Near-wall treatment	1	4	1, 2,3
	Introduction to LES and DNS.	2	4	1, 3
Total Contact Hours		**45**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (55%)								End Semester Exam (45%)	
		CLA-1 (10%)		CLA-2 (10%)		CLA-3 (15%)		Mid Term (20%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	40%		30%						30%	
	Understand										
Level 2	Apply	60%		50%						70%	
	Analyse										
Level 3	Evaluate			20%							
	Create										
Total		100%		100%						100%	

Recommended Resources

1. Anderson J.D., "Computational Fluid dynamics", McGraw Hill Int., New York, 2010.
2. Versteeg H.K., and Malalasekera W., "An introduction to computational fluid dynamics, The finite volume method", Longman, 2007.

Other Resources

1. Computational Fluid Dynamics, An Open-Source Approach. Brian C. Vermeire, Carlos A.Pereira and Hamidreza Karbasian. https://users.encs.concordia.ca/~bvermeir/files/CFD%20-%20An%20Open-Source%20Approach.pdf
2. Suhas.V. Patankar, "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2009.

Course Designers

1. Dr Satya Pramod Jammy, Associate Professor, Department of Mechanical Engineering, SRM University AP.

Thermal Design for Electronics Equipment-TDEE

Course Code	TE563	**Course Category**	TE		L	T	P	C
					3	0	0	3
Pre-Requisite Course(s)	Fluid Mechanics, Heat transfer, Thermodynamics, Calculus	**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. To enhance the overview of the introduction of thermal design for electronics devices.
2. To understand the relevance of cooling technologies for electronics devices.
3. To enhance the understanding and utility of heat transfer mechanisms and thermos-physical properties in different electronics systems.
4. To implement the fundamental knowledge of heat transfer, fluid mechanics and thermodynamics laws to thermal design of electronics applications and perform analysis.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Identify the fluid mechanics and heat transfer laws, modes of heat transfer and applications of these modes to electronics engineering systems.	2	70%	80%
Outcome 2	Apply the in depth understanding of fundamentals of electronics packaging and data centres, Conjugate heat conduction and thermal spreading.	3	70%	80%
Outcome 3	Apply different cooling techniques for thermal management of electronics.	4	70%	80%
Outcome 4	Analyse and design primitive thermal management for electronics packaging.	4	70%	80%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)											
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	2	2			2		3	2	2	3	2
Outcome 2	3	2	3	3			3		3	3	2	3	3
Outcome 3	3	3	3	3			3		3	3	3	3	3
Outcome 4	2	2	3	3			3		3	3	3	2	3
Average	3	2	3	3			3		3	3	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Fundamentals of Heat Transfer: Review of Conduction, Convection and Radiation heat transfer.	2	1	1,2,5
	Introduction to electronics packaging	1	1	1,4
	Basic definitions of electronics packaging,	1	1	1,4
	classification of electronics packaging and self- heating in electronics packaging.	1	1	1,4
Unit No. 2	Introduction to thermal management of electronics packages and datacentres: Basic definitions of thermal management, classification of thermal management of electronics packages and datacentres	2	2, 4	1, 2, 3, 4
	Concept of Contact resistance elastic-elastic contacts and elastic plastic contacts.	3	2, 5	1, 2, 3, 8
	Conjugate heat conduction and thermal spreading: Derivation of analytical solution of heat spreading in heat sink base.	4	2, 5	1, 2, 3, 8
	Fin analysis and heat sink design: Derivation of general thermal resistance network.	4	2, 5	1, 2, 3, 4,7,8
Unit No. 3	Natural convection in electronics packaging, Radiation in electronic packages. Forced convection in electronics,	4	1,3,4	1, 2, 3, 5, 6
	Liquid cold plates for electronics, Jet impingement analytical solution derivation,	3	3,4,5	1, 2, 3, 5, 6
	Boiling and Condensation, Immersion cooling of electronics, design considerations.	3	3,4,5	1, 2, 3, 5, 6
	Introduction to heat pipes, Phase change energy storage with PCM's. Microchannel heat exchangers, Piezoelectric fans and synthetic jets.	2	3,4,5	1, 2, 3, 5, 6, 8
Unit No. 4	Thermoelectric modules, derivation of analytical solution, Acoustic challenges,	2	3, 4	1, 2, 3, 6, 8
	thermal modelling of electronics packages and printed circuits	2	3, 4	1, 2, 3, 6, 8
	Thermal design of fan heat sinks: fan/blower curves, parallel plate fins,	3	3, 4	1, 2, 3, 6, 8
	manufacturing processes, design for manufacturability.	3	3, 4	1, 2, 3, 6, 8
Unit No. 5	Thermal design of smartphones and tablets: case studies	1	4	1, 2, 4, 8
	Thermal design of IT data centers Part 1 (IT equipment loop).	1	4	1, 2, 4, 8
	Thermal design of IT data centers Part 2 (IT facilities loop) chip to cooling tower Thermal design.	2	3, 4, 5	1, 2, 4, 6, 8
	Thermal design of IT data centers Part 2 (IT facilities loop) chip to cooling tower Thermal design.	1	3, 4, 5	1, 2, 4, 6, 8

Learning Assessment

<table>
<tr><th rowspan="3" colspan="2">Bloom's Level of Cognitive Task</th><th colspan="8">Continuous Learning Assessments (50%)</th><th colspan="2" rowspan="2">End Semester Exam (50%)</th></tr>
<tr><th colspan="2">CLA-1 (10%)</th><th colspan="2">CLA-2 (10%)</th><th colspan="2">CLA-3 (10%)</th><th colspan="2">Mid Term (20%)</th></tr>
<tr><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th><th>Th</th><th>Prac</th></tr>
<tr><td rowspan="2">Level 1</td><td>Remember</td><td rowspan="2">30</td><td rowspan="2">-</td><td rowspan="2">20</td><td rowspan="2"></td><td rowspan="2">20</td><td rowspan="2"></td><td rowspan="2">40</td><td rowspan="2">-</td><td rowspan="2">30</td><td rowspan="2">-</td></tr>
<tr><td>Understand</td></tr>
<tr><td rowspan="2">Level 2</td><td>Apply</td><td rowspan="2">70</td><td rowspan="2">-</td><td rowspan="2">70</td><td rowspan="2"></td><td rowspan="2">70</td><td rowspan="2"></td><td rowspan="2">60</td><td rowspan="2">-</td><td rowspan="2">70</td><td rowspan="2">-</td></tr>
<tr><td>Analyse</td></tr>
<tr><td rowspan="2">Level 3</td><td>Evaluate</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">10</td><td rowspan="2"></td><td rowspan="2">10</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">-</td></tr>
<tr><td>Create</td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td>-</td><td>100%</td><td></td><td>100%</td><td></td><td>100%</td><td>-</td><td>100%</td><td>-</td></tr>
</table>

Recommended Resources

1. Lian-Tuu Yeh, Richard C. Chu, Dereje Agonafer, "Thermal management of microelectronic equipment heat transfer theory, analysis methods and design practices", ASME press, 2002
2. F. P. Incropera, D. P. Dewitt, T. L. Bergman and A. S. Lavine, "Fundamentals of Heat and Mass Transfer", 7th Ed., John Wiley and Sons, 2011.
3. Allen D. Kraus and Avram Bar Cohen, "Design and Analysis of Heat Sinks", Wiley-Interscience, 2008
4. Tummala Rao R., "Fundamentals of Microsystems packaging", McGrawHill, 2004
5. Yunus A. Çengel, Afshin J. Ghajar, "Heat and mass transfer: fundamentals and applications", McGraw-Hill Education, 2015
6. Ho Sung Lee, "Thermal Design: Heat Sinks, Thermo-electrics, Heat Pipes, Compact Heat Exchangers, and Solar Cells", John Wiley and Sons, 2010
7. Adrian Bejan, Allan D. Kraus, "Heat Transfer Handbook", Wiley-Interscience, 2003
8. Ralph Remsburg, "Thermal Design of Electronic Equipment", CRC Press LLC, 2001

Other Resources

1. Moore's Law: https://www.visualcapitalist.com/visualizing-moores-law-in-action-1971-2019
2. Property data: http://www.mhtlab.uwaterloo.ca
3. Packaging: https://www.intel.com/content/www/us/en/silicon-innovations/silicon-innovations-technology.html
4. Prof. Yovanovich site for Analytical solitions: http://www mhtl uwaterloo ca/RScalculators html#SpreadingResistance

Course Designers

SRM University *AP*, Andhra Pradesh

Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Thermal Design For Electronic Equipments Laboratory

Course Code	**TE 563L**	**Course Category**	TE		**L**	**T**	**P**	**C**
					0	0	2	1
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	**Mechanical Engineering**	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Objective 1: To enhance the overview of introduction of thermal design for electronics devices.
2. Objective 2: To understand the relevance of cooling technologies for electronics devices.
3. Objective 3: To enhance the understanding and utility of heat transfer mechanisms and thermos-physical properties in different electronics systems.
4. Objective 4: To implement the fundamental knowledge of heat transfer, fluid mechanics and thermodynamics laws to thermal design of electronics applications and perform analysis.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Identify the fluid mechanics and heat transfer laws, modes of heat transfer and applications of these modes to electronics engineering systems.	2	70%	80%
Outcome 2	Apply the in depth understanding of fundamentals of electronics packaging and data centres, Conjugate heat conduction and thermal spreading.	3	70%	80%
Outcome 3	Apply different cooling techniques for thermal management of electronics.	4	70%	80%
Outcome 4	Analyse and design primitive thermal management for electronics packaging.	4	70%	80%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	**Program Learning Outcomes (PLO)**										**-**		
	Engineering Knowledge	**Design / Development of Solutions**	**Conduct Investigations of Complex Problems**	**Modern Tool Usage**	**The Engineer and Society**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life-long Learning**	**PSO 1**	**PSO 2**	**PSO 3**
Outcome 1	3	2	2	2	2	-	-	2	-	3	3	2	2
Outcome 2	3	3	2	3	3	-	-	3	-	3	2	3	2
Outcome 3	3	3	3	3	3	-	-	3	-	3	2	3	3
Outcome 4	2	3	2	3	3	-	-	3	-	3	3	3	3
Course Average	3	3	2	3	3	-	-	3	-	3	3	3	3

Course Unitization Plan- Laboratory

S.No.	Experiment Name	Required Contact Hours	CLOs addressed	References Used
1.	Simulate an external flow over a cylinder of diameter D = 10 mm and length L = 60mm with fluids (a) Water (b) Air.	6	1, 2, 3	1, 2, 5
2.	Simulate an internal flow in a backward facing step of dimensions mentioned in the Biswas et al. 2004 Journal of Fluids Engineering paper.	6	1, 2, 3	1, 2, 3, 5
3.	Simulate heat transfer phenomena across extended surfaces inline and staggered rods for the given geometry.	6	2, 3, 4	1, 2, 3, 5
4.	A research paper was allocated to each student and was asked to reproduce the simulation results	12	1, 2, 3, 4	1, 2, 4, 5, 6
Total contact hours		**30**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)		End Semester Exam (50%)
		Lab performance (35%)	**Observation Notes (15%)**	
				Practical/Viva
Level 1	Remember	30%	30%	40%
	Understand			
Level 2	Apply	60%	60%	60%
	Analyse			
Level 3	Evaluate	10%	10%	-
	Create			
Total		**100%**	**100%**	**100%**

Recommended Resources

1. F. P. Incropera, D. P. Dewitt, T. L. Bergman and A. S. Lavine, "Fundamentals of Heat and Mass Transfer", 7th Ed., John Wiley and Sons, 2011.
2. Yunus A. Çengel, Afshin J. Ghajar, "Heat and mass transfer: fundamentals and applications", McGraw-Hill Education, 2015
3. Biswas G, Breuer M, Durst F. Backward-facing step flows for various expansion ratios at low and moderate Reynolds numbers. J. Fluids Eng.. 2004 May 1;126(3):362-74.
4. Sahoo LK, Roul MK. CFD analysis on heat transfer through different extended surfaces. Heat Transfer. 2020 Dec;49(8):4820-33.
5. ANSYS-FLUENT, manual 2019 version
6. ANSYS-ICEPAK, manual 2022 version

Other Resources

Course Designers

SRM University *AP*, Andhra Pradesh

Neerukonda, Mangalagiri Mandal,
Guntur District, Mangalagiri, Andhra Pradesh – 522240.

Introduction to Multiphase Flow

					L	T	P	C
Course Code	TE 564	**Course Category**	TE		3	0	0	3
Pre-Requisite Course(s)	Fluid Mechanics, Heat Transfer	**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. To introduce the fundamental concepts, principles, and application of multiphase flow.
2. To learn various mathematical models for multiphase flow systems and hydrodynamic flow regimes maps.
3. To strengthen analytical and numerical abilities to solve complex two- and three-phase flow problems such as bubbly and slug flows.
4. Learning measurement techniques associated with multiphase flow.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	To have a general introduction to the theory of multiphase flow in connection with real-life examples and its importance in process industries.	2	70%	80%
Outcome 2	Develop a general understanding about the hydrodynamics of multiphase flows with various flow regimes, and flow regime maps.	3	70%	80%
Outcome 3	Students will learn various analytical models to develop a comprehensive understanding of numerical modelling of multiphase flow	4	70%	80%
Outcome 4	Exposure to measurement techniques employed in multiphase flow system.	4	70%	80%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)											
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	2	2	2	-		2	-	-	3	3		3
Outcome 2	3	2	3	3	-		2	-	-	3	3		3
Outcome 3	3	3	3	3	-		3	-	-	3	3		3
Outcome 4	2	2	3	3	-		2	-	-	3	3		2
Average	3	3		3	3		-	2	-	3	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Review of fundamentals of Fluid Mechanics	**1.5**	**1**	**1, 2**
	Introduction to multiphase flow Types and applications, common terminologies	**1.5**		
	Flow patterns and flow pattern maps	**2**		
Unit No. 2	One dimensional steady homogenous flow, Concept of choking, and critical flow phenomena	**4**	**2, 4**	**1, 2**
	One dimensional steady separated flow model in case the phases considered together with different velocities	**5**	**1, 2, 4**	
	1D steady separated flow in the case wherein phases are considered separately,	**3**		**1, 2**
Unit No. 3	The separated flow model for stratified and annular flow	**2**	**2, 3**	**1 ,2, 5**
	Flow in which inertia effects dominate, energy equations	**5**		
	The general theory of drift flux model. Application of drift flux model to bubbly and slug flow	**5**		
Unit No. 4	An introduction to three-phase flow with examples	**1.5**	**2, 3, 4**	**3, 4**
	Bubble departure, release frequency, nucleation site density	**2.5**		
	Heat transfer mechanism, pool boiling correlation equation, VDI correlation	**3**		
	Hydrodynamics of solid-liquid and gas-solid flow.	**4**		
Unit No. 5	Measurement techniques for multiphase flow: Flow regime identification	**2**	**1, 2, 4**	**4, 5**
	Measurement of pressure drop and void fraction	**1.5**		
	Flow rate measuring techniques in multiphase flow	**1.5**		

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)				End Semester Exam (50%)
		CLA-1 (10%)	Mid Term (25%)	CLA-2 (5%)	CLA-3 (10%)	
		Th	Th	Th	Th	Th
Level 1	Remember	30%	40%	40%	40%	30%
	Understand					
Level 2	Apply	70%	60%	60%	60%	70%
	Analyse					
Level 3	Evaluate					
	Create					
Total		100%	100%	100%	100%	100%

Recommended Resources

1. Wallis, Graham B. One-dimensional two-phase flow. Courier Dover Publications, 2020.
2. Brennen, Christopher E. Fundamentals of multiphase flow. 2005.
3. Crowe, Clayton T. Multiphase flow handbook. CRC press, 2005.
4. Bertola, Volfango, ed. Modelling and experimentation in two-phase flow. Vol. 450. Springer, 2014.
5. Butterworth, David, and Geoffrey Frederick Hewitt. Two-phase flow and heat transfer, 1977

Other Resources

1. https://youtube.com/playlist?list=PLyMtJ7HNLrEOIAkdIPfd3OTkDRHdDfUS5&si=cCR7SKA-do_LiNlF

Course Designers

Micro and Nanoscale Heat Transfer

Course Code	TE 565	**Course Category**	TE		**L** 3	**T** 0	**P** 0	**C** 3
Pre-Requisite Course(s)	METE 551	**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Mechanical Engineering	**Professional / Licensing Standards**						

Course Objectives / Course Learning Rationales (CLRs)

1. Enhanced understanding on modelling challenges of energy transport phenomena at different scales especially at micro and nano scale.
2. Fundamental understanding of micro and nanoscale transport in various fields of current interest especially in the field of electronic components.
3. Enhanced understanding on analysing the real time cooling challenges of electronic components and applying advanced methods to model heat transfer at small scale.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Illustrate the recent developments in thermal sciences and engineering related to micro/nanoscale energy transport and technologies.	3	70%	65%
Outcome 2	Investigate the microscopic descriptions and approaches in thermal science, like equilibrium statistics, Boltzmann transport equation.	3	70%	65%
Outcome 3	Investigate the nanoscale energy transport phenomena such as nanoscale heat conduction and radiation.	3	70%	65%
Outcome 4	Examine, evaluate and solving the real time engineering challenges in the area of electronic cooling using advanced knowledge of micro and nanoscale scale heat transfer concepts.	4	70%	65%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)											
	Engineering Knowledge	Design / Development of Solutions	Conduct Investigations of Complex Problems	Modern Tools and ICT Usage	The Engineer and Society	Environment and Sustainability	Ethics	Individual and Teamwork Skills	Communication Skills	Life-long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	3	3			2	1	3	3	3	3	3
Outcome 2	3	3	3	3			2	1	3	3	3	3	3
Outcome 3	3	3	3	3			2	1	3	3	3	3	3
Outcome 4	3	3	3	3			2	1	3	3	3	3	3
Average	3	3	3	3			2	1	3	3	3	3	3

Course Unitization Plan

Unit No.	Syllabus Topics	Required Contact Hours	CLOs Addressed	References Used
Unit No. 1	Ranges of scales, Limitations of Knudsen number.	2	1,2	1,2,3
	Advantage of Boltzmann equation for high Kn flows, Distinguished factors at high Kn numbers	2	1,2	1,2,3
	Advantages of microchannels in the context of energy transport, microelectronic devices and applications.	2	1,2,4	1,2,3
	Limitations of macroscopic laws for small length scales.	2	1,2,4	1,2,3
	Introduction to nanoscale energy transport.	2	1,2,3	1,2,3
Unit No. 2	Heat conduction equation for continuum energy transport and constitutive loss of heat transfer.	2	1,2	1,2,3
	Applicability of constitute laws for microscale energy transport, Energy or momentum possessed by energy carriers	2	1,2	1,2,3
	Basic wave characteristics: standing wave, travelling wave, derivation of energy possessed by a wave in a given distance. Schrodinger's wave equation.	3	1,2	1,2,3
	Different forms of wave functions. Heisenberg uncertainty, Particle in a 1D confinement.	2	1,2	1,2,3
Unit No. 3	Fundamentals of statistical thermodynamics	4	1,2	1,2,3
	Distribution of energy carriers	4	1,2	1,2,3
Unit No. 4	Fundamentals of nanoscale transport	4	1,3	1,2,3
Unit No. 5	Single phase heat transfer in microchannel	4	1,2,3,4	1,2,3
	Gas flows and heat transport in microchannels	2	1,2,3,4	1,2,3
	Applications of nanofluids in microchannels	4	1,2,3,4	1,2,3
	Applications of microfluidics and nanofluidic	4	1,2,3,4	1,2,3

Learning Assessment

<table>
<tr><th colspan="2" rowspan="2">Bloom's Level of Cognitive Task</th><th colspan="4">Continuous Learning Assessments (__%)</th><th rowspan="2">End Semester Exam (50%)</th></tr>
<tr><th>CLA-1 (10%)</th><th>CLA-2 (10%)</th><th>CLA-3 (5%)</th><th>Mid Term (25%)</th></tr>
<tr><th colspan="2"></th><th>Th</th><th>Th</th><th>Th</th><th>Th</th><th>Th</th></tr>
<tr><td rowspan="2">Level 1</td><td>Remember</td><td rowspan="2">20%</td><td rowspan="2">10%</td><td rowspan="2">10%</td><td rowspan="2">10%</td><td rowspan="2">20%</td></tr>
<tr><td>Understand</td></tr>
<tr><td rowspan="2">Level 2</td><td>Apply</td><td rowspan="2">80%</td><td rowspan="2">90%</td><td rowspan="2">90%</td><td rowspan="2">90%</td><td rowspan="2">80%</td></tr>
<tr><td>Analyse</td></tr>
<tr><td rowspan="2">Level 3</td><td>Evaluate</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Create</td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td><td>100%</td></tr>
</table>

Recommended Resources

1. Microscale and nanoscale heat transfer, “C.B Sobhan and G.P Peterson, CRC press, 2008.

2. Nanoscale energy transport and conversion, “Gang Chen, Oxford University press, 2005.

3. Nano/Microscale heat transfer, “ZhuominZhang, McGraw-Hill,2007.

Course Designers

1. *Dr. Lakshmi Sirisha Maganti,* Assistant Professor, *Department of Mechanical Engineering, SRM University-AP, Andhra Pradesh*