

Programme Core (PC)

MCD810	Major Project Part 1 (Thermal Engineering) (OR)	0-0-24	12
MCD811	Major Project Part 1 (Thermal Engineering)	0-0-12	6
MCD812	Major Project Part 2 (Thermal Engineering)	0-0-24	12
MCL701	Advanced Thermodynamics	3-0-0	3
MCL702	Advanced Fluid Mechanics	3-0-0	3
MCL703	Advanced Heat and Mass Transfer	3-0-0	3
MCL704	Applied Mathematics for Thermofluids	3-0-0	3
MCL705	Experimental Methods	3-0-2	4
MCD800	Professional Project Activity		0

Total PC

15-0-38 34

Programme Electives (PE)

MCL811	Advanced Power Generation Systems	3	0	0	3
MCL812	Combustion	3	0	0	3
MCL813	Computational Heat Transfer	3	0	2	4
MCL814	Convective Heat Transfer	3	0	0	3
MCL815	Fire Dynamics and Engineering	2	0	4	4
MCL816	Gas Dynamics	3	0	2	4
MCL817	Heat Exchangers	3	0	0	3
MCL818	Heating, Ventilating and Air-conditioning	3	0	0	3
MCL819	Lattice Boltzmann method	3	0	0	3
MCL820	Micro/nano scale heat transfer	3	0	2	4
MCL821	Radiative Heat Transfer	3	0	0	3
MCL822	Steam and Gas Turbines	3	0	2	4
MCL823	Thermal Design	3	0	2	4
MCL824	Turbocompressors	3	0	0	3
MCL825	Design of Wind Power Farms	3	0	2	4

Master of Technology in Thermal Engineering

The overall credits structure

Category	PC	PE	OE	Total
Credits	34	12	3	49

M.Tech. in Thermal Engineering

MET

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
	L	T	P	Total									
I	MCL 701 Adv Thermodynamics (3 - 0 - 0) 3	MCL 702 Adv Fluid Mechanics (3 - 0 - 0) 3	MCL 703 Adv Heat & Mass Transfer (3 - 0 - 0) 3	MCL 704 Applied Math. (3 - 0 - 0) 3				4	12	0	0	12	12
II	MCL705 Exptl Methods (3 - 0 - 2) 4	PE-1 (3 -0- 0) 3/ (3-0-2)4	PE-2 (3 -0- 0) 3/ (3-0-2)4	PE-3 (3 -0- 0) 3/ (3-0-2)4				4	12	0	2/8	14/20	13/16
Summer	Professional Project Activity (compulsory audit)							0					0
III	MED811 Maj Proj Part 1 (MET) (0 - 0 - 12) 6	PE-4 (3 -0- 0) 3/ (3-0-2)4	OE-1 (3 -0- 0) 3/ (3-0-2)4					2	6	0	12/16	18/22	12/14
IV	MED812 Maj Proj Part 2 (MET) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 49/54

M Tech in Thermal and Fluids Engineering

DRC recommended that for students who need to carry out their projects off-site (e.g., at an industry) the following program structure can be used:

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
	L	T	P	Total									
I	MCL 701 Adv Thermodynamics (3 - 0 - 0) 3	MCL 702 Adv Fluid Mechanics (3 - 0 - 0) 3	MCL 703 Adv Heat & Mass Transfer (3 - 0 - 0) 3	MCL 704 Applied Math. (3 - 0 - 0) 3				4	12	0	0	12	12
II	MCL705 Exptl Methods (3 - 0 - 2) 4	PE-1 (3 -0- 0) 3/ (3-0-2)4	PE-2 (3 -0- 0) 3/ (3-0-2)4	PE-3 (3 -0- 0) 3/ (3-0-2)4				4	12	0	2/8	14/20	13/16
Summer	Professional Project Activity (compulsory audit)							0					0
III	MED810 Maj Proj Part 1 (MET) (0 - 0 - 24) 12							0	0	0	24	24	12
IV	MED812 Maj Proj Part 2 (MET) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 49/52

For such students, PE4 and OE-1 will not be required. They would do a total of 24 credits for the project.

COURSE TEMPLATE

1.	Department/Centre proposing the course	Department of Mechanical Engineering
2.	Course Title (< 45 characters)	ADVANCED THERMODYNAMICS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MCL701
6.	Status (category for program)	Core

7.	Pre-requisites (course no./title)	None
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8.	Status vis-à-vis other courses (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supercedes any existing course	MEL 703

9.	Not allowed for (indicate program names)	ME1 and ME2 students
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10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course All faculty from thermal engineering	
12.	Will the course require any visiting faculty?	No

13.	Course objective <i>(about 50 words):</i> The course is meant to present an advanced level treatment of thermodynamics for post-graduate students of thermal engineering. Advanced topics such as thermodynamic potentials, Maxwell's relations, multicomponent systems, reactive mixtures etc. will be covered.
14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Review of basic fundamentals, closed system and open system formulations, laws of thermodynamics, the maximum entropy principle, concept of equations of state, ideal gas, van der Waals equations and other variants, compressibility, maximum work theorem, exergy, energy minimum principle, thermodynamic potentials and relationships for compressible, elastic, electric and magnetic systems, stability conditions of potentials, multicomponent systems, entropy of mixing, chemical potential, mixtures, conditions of equilibrium and stability of multicomponent systems, thermodynamics of reactive mixtures.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Basic concepts and definitions	2
2	A generalized approach to Laws of thermodynamics for closed and open systems, equilibrium states, maximum entropy principle, exergy	8
3	Equations of state for simple compressible systems, ideal gas equation, van der Waals equation, other variants, generalized compressibility chart	6
4	Thermodynamic potentials and relationships for simple systems (compressible, elastic, electric, magnetic, etc.), systems with multiple modes of work. Maxwell's relations, stability conditions for thermodynamic potentials, physical consequences	10
5	Multicomponent systems, Gibbs-Duhem relation, mixing, chemical potential and fugacity, gas mixtures, ideal and non-ideal solutions	6
6	Conditions of equilibrium (including phase and chemical equilibrium), stability of multicomponent systems, applications	6
7	Thermodynamics of reactive mixtures, chemical equilibrium, equilibrium composition	4
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Dhar, P.L. , Engineering Thermodynamics - A Generalized Approach, 2008, Elsevier
 Borgnakke, C. and Sonntag, R.E., Fundamentals of Thermodynamics, 7th ed., 2009, Wiley
 Moran, M.J. and Shapiro, H.N., Fundamentals of Engineering Thermodynamics, 4th ed., 2000, John Wiley & Sons.
 Cengel, Y.A. and Boles, M.A., Thermodynamics - An Engineering Approach, 7th ed., 2011, Tata McGraw Hill.
 Callen, H. B., Thermodynamics and an introduction to thermostatics, 2nd ed., 1985, John Wiley & Sons.
 Fermi, E., Thermodynamics, 1956, Dover Publications.
 Annamalai, K., and Puri, I. K., Advanced Thermodynamics Engineering, 2001, CRC press.

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19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	Blackboard and LCD projector
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (< 45 characters)	ADVANCED FLUID MECHANICS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MCL702
6.	Status (category for program)	

7.	Pre-requisites (course no./title)	
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8.	Status vis-à-vis other courses (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supercedes any existing course	

9.	Not allowed for (indicate program names)	ME1 and ME2 students
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10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course All thermal engineering faculty.	
12.	Will the course require any visiting faculty?	No

13.	Course objective <i>(about 50 words):</i> To acquire competence in modelling engineering problems that involve fluid flow, obtaining analytical solutions and deducing engineering design parameters in the continuum mechanics framework.
14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Formulation of Navier-Stokes equations. Exact solutions of the Navier-Stokes equations for select unsteady/steady flows, potential flows, boundary layer theory and its applications, turbulent flows; special topics in fluid mechanics such as capillary and electrokinetic flows.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction. Field theory, tensor algebra and calculus.	4
2	Reynolds transport theorem. Derivation of mass, momentum and energy equations.	4
3	Constitutive relations and the Navier Stokes equation for Newtonian fluids.	3
4	Inviscid flows, applications of Bernoulli/Euler equations, irrotational incompressible flows using complex variables	4
5	Analytical solutions of the transient and steady Navier Stokes equations for incompressible viscous flows: e.g. Stokes first problem or Rayleigh problem, Stokes second problem, pulsatile Poiseuille flow, steady flow through pipes of various cross-sections, Hiemenz's solution to stagnation point flow, Oseen vortices.	7
6	Boundary layer theory (zero/non-zero pressure gradient) and its applications to laminar boundary layers, jets, wakes and stagnation regions in external (e.g. airfoil) and internal flows (e.g. nozzles, developing flows).	6
7	Stability and transition to turbulence	2
8	Derivation of RANS equations; turbulent shear flows.	7
9	Special topics: 2-3 topics from lubrication theory, flows with surface tension, zero Reynolds number flow, compressible flow, introduction to non-Newtonian flows.	5
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Kundu, P. K., Cohen, I. M. and Dowling, D.R. Fluid Mechanics, 5 ed. Academic Press, 2012.
2. Panton, Ronald L. Incompressible flow. 4 ed. John Wiley & Sons, 2013.
3. Schlichting, H., Gersten, K., 8th ed., Springer, 2000.
4. Yuan Shao-Wen, Foundations of Fluid Mechanics, Student International edition, Prentice Hall, 1970
5. White, F. W. Viscous Fluid Flow, 3 ed., McGraw Hill, 2005

6. An Album of Fluid Motion, Van Dyke M., 1982.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	LCD Projector
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (<i>< 45 characters</i>)	ADVANCED HEAT AND MASS TRANSFER
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MCL 703
6.	Status (<i>category for program</i>)	Compulsory course for M Tech in Thermal Engineering

7.	Pre-requisites (<i>course no./title</i>)	Fluid Mechanics
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supercedes any existing course	

9.	Not allowed for (<i>indicate program names</i>)	ME1 and ME2
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course All thermal Engineering Faculty	
12.	Will the course require any visiting faculty?	No

13.	Course objective <i>(about 50 words):</i> To introduce students to advanced fundamentals of heat and mass transfer processes.
14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Derivation of governing equation for three dimensional transient heat conduction problems. Two-dimensional steady state heat conduction. Transient one-dimensional heat conduction in finite length bodies. Diffusive Mass Transfer – Fick's law and governing equation. Melting and solidification. Newton's law of cooling-Derivation of energy equation- Self-similar solution for laminar boundary flow over a flat plate – energy integral method for laminar boundary layer flow over a flat surface-Laminar internal flows-thermally fully developed flows-Graetz problem - Natural convection over a vertical flat plate: similarity solutions and energy integral method- natural convection in enclosures-mixed convection-Turbulent flow and heat transfer: Reynolds averaged equations-Turbulent boundary layer flows – The law of wall-integral solutions. Convective mass transfer. Convection with phase change: Pool boiling regimes- Condensation: drop-wise condensation-Laminar film condensation over a vertical surface. Radiative heat transfer: Black body radiation-radiative properties of non-black bodies-surface radiation heat transfer in enclosures with gray diffused walls and non-gray surfaces.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Background and context of the course with examples: importance of fundamentals and modeling. Macroscopic viewpoint. Introduction to micro/ nanoscale transport phenomena. An overview of limitations of macroscopic formulations, Size effect, Energy carriers - electrons & phonons.	. 3
2	Generalized governing equations for transport phenomena and constitutive relations.	3
3	Radiative heat transfer: surface properties - emissivity, absorptivity, reflectivity - directional, spectral, hemispherical, total. Spectrally selective surfaces. Radiative properties of non-black bodies-surface radiation heat transfer in enclosures with gray diffused walls and non-gray surfaces	6
4	Bouguer's law and introduction to engineering treatment of gas radiation in an enclosure.	6
5		
6	Similarity and Energy integral methods for heat and mass transfer in laminar boundary layers.	5
7	Laminar internal flows, heat and mass transfer: uniform wall temperature and uniform wall heat flux - fully developed solution. Developing flow and heat transfer for laminar situation	4
8	Natural convection over a vertical flat plate: Boussinesq approximation and its limitation. Similarity solution.	2
9	Turbulent heat transfer: Reynolds averaged energy equation – The law of wall - integral solutions	4
10	Stationary and moving heat source problems	3

11	Phase change problems: Melting and solidification - introduction and formulation. Analytical solution to phase change problems. Boiling and condensation.	6
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Suggested self study topics:	
2	Derivation of semi-infinite medium heat conduction equation and its solution	
3	Similarity solution for laminar Boundary layer over a flat plate - fluid flow and heat transfer. Also the corresponding numerical solution	
4	fin of variable cross section; optimal design of fins	
5	transient and steady state conduction in multiple dimensions	
6	Determination of thermal conductivity - theoretical background and experimental method of measurement	
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Fundamentals of Heat and Mass Transfer, Incropera and Dewitt, Sixth Edition, John Wiley.
 2. Convection Heat Transfer, A Bejan, John Wiley.
 3. Convective Heat and Mass Transfer, W M Kays and M E Crawford, McGraw-Hill publishing Company.
 4. Thermal Radiation Heat Transfer, J Siegel and R Howell, Elsevier.
- Ozisik
Poulikakos
Modest
Carslaw and Jaegar

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	10%
20.2	Open-ended problems	

20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	DEPARTMENT OF MECHANICAL ENGINEERING
2.	Course Title (<i>< 45 characters</i>)	APPLIED MATHEMATICS FOR THERMOFLUIDS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MCL704
6.	Status (<i>category for program</i>)	Core Course

7.	Pre-requisites (<i>course no./title</i>)	MAL110, MAL120
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8.	Status vis-à-vis other courses <i>(give course number/title)</i>	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supercedes any existing course	None

9.	Not allowed for (indicate program names)	None
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10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Thermal engineering faculty	
12.	Will the course require any visiting faculty?	None

13.	Course objective <i>(about 50 words):</i> Purpose of this course is to present and explain the mathematical methods related to thermofluids. Objective of this course is to help students to build necessary skills to solve and/or analyze the equations that they encounter in their courses related to thermofluids. Mathematical methods discussed in this course will include equations that can be solved exactly and methods which cannot be solved exactly. Students will be taught to be able to analyze the equations which cannot be solved exactly to obtain approximate solutions for the equations.
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14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Initial-boundary value problems, Linear and Non-linear systems; Theory of linear homogeneous and nonhomogeneous equations; Non-linear systems; Series solutions of linear ordinary differential equations; special functions; 1 st order PDEs, classification of PDEs: 2 nd order PDE - Planar, cylindrical and spherical geometries, Homogeneous and nonhomogeneous PDEs, Sturm-Liouville theory; Stability and instability of regular system
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Examples of physical differential problems	1
2	Review of analytic functions: fundamentals of complex theory integration of Cauchy's theorem; Special functions; Integral representations	4
3	1st order PDEs: solutions of quasi-linear and non-linear equations using method of characteristics	3
4	Fourier series, Fourier integrals and transforms, DFT and FFT, Gibbs phenomenon	3
5	Classification of 2nd order PDEs, solutions of 2nd order PDEs in planar coordinates: separation of variables for parabolic, hyperbolic and elliptical PDEs	4
6	Sturm-Liouville theory, properties of eigenvalues and eigenfunctions, Self-adjoint operators, Lagrange's identity, Green's formula	2
7	Higher order homogeneous PDEs in planar, circular, cylindrical and spherical coordinates: multiple Fourier series	3
8	Nonhomogeneous PDEs: change of variable, eigenfunction expansion method for homogeneous BCs, eigenfunction expansion method with nonhomogeneous BCs	4
9		
10	Linear algebra; system of linear algebraic and differential equations, ill-conditioned matrices, pivoting	7
11	Numerical solution of system of ODEs using Runge-Kutta. Numerical quadrature.	5
12	Introduction to optimization techniques.	6
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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4		
5		
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COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Richard Habermann, Applied Partial Differential Equations: With Fourier Series and Boundary Value Problems, 4th Edition, Prentice Hall, 2003
 Walter A Strauss, Partial Differential Equations: An Introduction, Wiley; 2 edition, 2007
 HF Weinberger, A First Course in Partial Differential Equations: with Complex Variables and Transform Methods, Dover Publications, 1995
 Ronald B. Guenther, John W. Lee , Partial Differential Equations of Mathematical Physics and Integral Equations , Dover Publications, 2012

MN Ozisik, Heat conduction, A Wiley-Interscience Publications, 2nd edition, 1993
 IH Herron, MR Foster, Partial Differential Equations in Fluid Dynamics, Cambridge University Press; 1st edition, 2008
 Chapra, S., C., and Canale, R. P., Numerical Methods for Engineers, McGraw-Hill, 7th Edition, 2015.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Department of Mechanical Engineering
2.	Course Title (<i>< 45 characters</i>)	EXPERIMENTAL METHODS
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	MCL 705
6.	Status (<i>category for program</i>)	PG Core of M.Tech Thermal and any other interested M.Tech Programme

7.	Pre-requisites (<i>course no./title</i>)	Undergraduate fluid mechanics and heat transfer
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supercedes any existing course	None

9.	Not allowed for (<i>indicate program names</i>)	ME1 and ME2
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10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
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11.	Faculty who will teach the course Faculty from Thermofluids Group of Department of Mechanical Engineering	
12.	Will the course require any visiting faculty?	No

13.	Course objective <i>(about 50 words):</i> To teach the methodology of designing experiments, interfacing of laboratory instruments, acquisition of data, performing data analysis and reporting of experimental results. Students will be taught how to design and plan an experiment keeping in mind the required uncertainty in measurements. For this purpose, statistical basis of uncertainty analysis and design of experiments will be taught. Characteristics of various instruments will be discussed. Also, data acquisition and sampling strategies will be discussed for interfacing of instruments.
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14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Methodology and planning of experimental work and reporting results. Types of errors, uncertainty propagation and statistical basis of uncertainty. Statics and data interpretation: population and sample, mean and standard deviation, standard deviation of mean, probability distributions and sample size selection. Design of experiments. Instruments: specifications, characteristics, and sources of error. Data acquisition and signal processing: analog to digital conversion, Fourier series and transform, sampling, aliasing, and filtering. Cross-correlation and autocorrelation. Digital image analysis.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Purpose and methodology of experimental work. Planning and professional practices in experimental work; documentation, reporting, and presenting experimental work.	2
2	Uncertainty analysis: Types of errors and uncertainties, statistical basis of uncertainty, propagation of uncertainties. Codes for uncertainty analysis by ASME, ISO, NASA etc.	5
3	Statistics and data interpretation: Population and samples, mean and standard deviation, standard deviation of mean. Estimators of population mean and standard deviation. Normal distribution, Student's t-distribution, Chi-squared distribution. Confidence levels and sample size selection. Outlier treatment. Regression analysis.	10
4	Introduction to design of experiments (DOE): concepts, methodology, examples.	6
5	Instruments: specifications and characteristics; range, resolution, accuracy, precision, calibration traceability, time/frequency response. Selection of instruments for measurements of physical quantities such as temperature, pressure, flow rate. Sources of error.	6
6	Data acquisition and signal processing: Basics of digital data. analog to digital conversion, number of bits, sampling, sampling rate, conversion rate, single and multiple channels. Fourier series, fourier transform. Convolution, Filtering, aliasing, Nyquist sampling theorem, amplifier, signal-to-noise ratio. Cross-correlation, autocorrelation. Introduction to optical diagnostics. Image analysis and its applications in particle tracking techniques.	10
7	Introduction to optical diagnostics. Image analysis and its applications in particle tracking techniques.	3
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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Familiarization and calibration of various laboratory equipment: Example: welding thermocouples and their calibration.	6
2	Interfacing of equipment with computer using Labview/Adamview/Matlab.	8
3	Operation of wind/water tunnel and flow visualization.	4
4	Experiments in heat conduction, convection, and mass transfer.	6
5	Experiment on compressible fluid flow in converging-diverging channel.	2
6	Presentation of consolidation report.	2
7	NOTE: Experiments can be made interdisciplinary based on the interest from other M.Tech. programmes.	
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10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Doebelin, E.O., Measurement Systems-Application and Design, Tata McGraw Hill, New Delhi, 2004.
 Holman, J. P. Experimental Methods for Engineers, Tata McGraw-Hill, New Delhi, 2004.
 Bowker, A.H., and Lieberman, G.J., Engineering Statistics, Prentice Hall, New Jersey, 1972.
 Kale, S.R., Notes on Introduction to Statistics, IIT Delhi, New Delhi, 2007
 Osgood, B., The Fourier Transform and its Applications, Stanford University, Stanford, 2007
 ASME, Test Uncertainty, PTC 19.1, ASME, New York, 2005
 ISO, Guide to Expression of Uncertainty in Measurement, 2008
 NASA Handbook: Measurement Uncertainty Analysis Principles and Methods, Washington DC, 2010.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	DMATLAB, LabView, Adamview, MS Excel.
19.2	Hardware	Desktop computers, Data acquisition cards, instrumentation.
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	PG Teaching Laboratory
19.5	Equipment	Custom designed experimental setups
19.6	Classroom infrastructure	LCD and blackboard
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	

20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (< 45 characters)	ADVANCED POWER GENERATION SYSTEMS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MCL 811
6.	Status (category for program)	DE for PG programmes in Mechanical Engg. and OC for other programmes

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	NA
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course P M V Subbarao, Premachandran& other interested faculty.	
12.	Will the course require any visiting faculty?	No

13.	Course objective <i>(about 50 words):</i> The objective of this course is to introduce recent and upcoming technologies in the area of power generation. The course is focused on thermo-fluid analysis of a power generation system. Major part of this course deals with thermal power systems, however some time will be spent on hydro power systems and direct power systems.
14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> General Introduction to current power generation technology and need for advances systems. Analysis of Advanced Ultra super-critical power plants, Organic Rankine Cycle based systems, Power systems using mixtures as working fluids. Sizing of components for the selected systems. Design of power systems for solar, biomass and geothermal sources. Thermo-fluid analysis of solar PV systems. Hybrid solar PV-thermal systems. Recent developments in hydro power systems.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	General Introduction to current power generation technologies	5
2	Thermodynamics of supercritical cycles	3
3	Advanced and ultra supercritical power systems	3
4	Thermo-fluid design of super critical steam generators.	3
5	Design and analysis of turbines for super critical steam.	4
6	Thermodynamics of organic working fluids	3
7	Analysis of organic Rankine cycles	5
8	Simulation of cycles using mixtures	5
9	Development of solar thermal, geothermal and Bio-thermal ORCs	5
10	Thermofluid analysis of solar PV systems and Hybrid systems	2
11	Advance hydro power systems	2
12	Special designs for micro & pico power systems	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		

2		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Papers collected from international journals.
2. Technical reports by DoE and other international organizations.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Slides/ photos of applications
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	PC and projection system.

19.7	Site visits	
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20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	60
20.2	Open-ended problems	30
20.3	Project-type activity	10
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title <i>(< 45 characters)</i>	COMBUSTION
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MCL812

6.	Status (category for program)	Elective
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7.	Pre-requisites (course no./title)	Advanced Heat and Mass Transfer
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8.	Status vis-à-vis other courses (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	MEL812

9.	Not allowed for (indicate program names)	ME1 and ME2
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Anjan Ray, M R Ravi, S R Kale, S Kohli and any other interested thermal engineering faculty	
12.	Will the course require any visiting faculty?	No

13.	Course objective (about 50 words): To introduce students to fundamentals of combustion of solids, liquids and gases with examples from a spectrum of application areas.	
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14.	Course contents (about 100 words) (Include laboratory/design activities): Introduction - importance of combustion. Chemical thermodynamics and chemical	
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	kinetics. Important chemical mechanisms. Coupling chemical and thermal analysis of reacting systems. Premixed systems: detonation and deflagration, laminar flames, burning velocity, flammability limits, quenching and ignition. Turbulent premixed flames. Non-premixed systems: laminar diffusion flame jet, droplet burning. Combustion of solids: drying, devolatilization and char combustion. Practical aspects of coal combustion, woodstove combustion.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction: importance of combustion. Applications and role of combustion engineer. Premixed and non-premixed combustion. Solid, liquid and gaseous fuel combustion. Heterogeneous and homogeneous combustion.	2
2	Chemical thermodynamics: stoichiometry, enthalpy of formation, enthalpy and heat of combustion, adiabatic flame temperature, chemical equilibrium.	2
3	Chemical kinetics: elementary and global reactions, law of mass action, reaction order, rate expressions. Opposing, concurrent and consecutive reactions, steady state and partial equilibrium assumptions, mechanism of H ₂ -O ₂ , CO-oxidation, hydrocarbon oxidation and NO _x formation.	6
4	Constant volume reactor, constant pressure reactor, well-stirred reactor, plug flow reactor	3
5	Conservation equations: Mass, momentum, energy and species conservation equations, Shvab-Zeldovich formulation.	4
6	Detonation and deflagration: Rankine-Hugoniot relation, calculation of detonation velocity, ZND structure of detonation wave.	3
7	Premixed flames: Derivation of expression for laminar burning velocity. Minimum ignition energy, quenching distance, flammability limits, flashback, lift-off and blow-off. Turbulent premixed flames - phenomenological description, various regimes.	10
8	Non-premixed systems: analysis of laminar diffusion flame jet, mixture fraction formulation. Flame length calculation. Droplet burning - problem formulation and d ₂ -law.	8
9	Combustion of solids: mechanisms of solid fuel combustion - drying, devolatilization and char combustion. Simplified analysis of particle combustion to calculate char burning time under diffusion and kinetic control. Some aspects of pulverized fuel combustion in a boiler. Woodstove combustion.	3

10	Closure: review of course and some aspects of industrial combustion - latest trends.	1
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Turns, Stephen R, An Introduction to Combustion, McGraw-Hill, 2012.
 Kuo, Kenneth K, Principles of Combustion, John Wiley, 2000.
 Poinso, T and Veynante, D Theoretical and Numerical Combustion, RT Edwards, 2005.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	CHEMKIN, COSILAB.
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Freely available videos on youtube etc.
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (<i>< 45 characters</i>)	COMPUTATIONAL HEAT TRANSFER
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	MCL 813
6.	Status (<i>category for program</i>)	DE for PG programmes in Mechanical Engg. and OC for other programmes

7.	Pre-requisites (<i>course no./title</i>)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Drs. Prabal Talukdar, Premachandran Balachandran, Sanjeev Jain, Amit Gupta, MR Ravi and other interested faculty	
12.	Will the course require any visiting faculty?	No

13.	Course objective <i>(about 50 words):</i> To introduce students to general forms of governing equations and their discretization and numerical solutions for heat transfer problems.
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14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Mathematical Description of the Physical Phenomena- Governing equations—mass, momentum, energy, species, General form of the scalar transport equation, Elliptic, parabolic and hyperbolic equations Discretization Methods- Introduction to finite difference and finite volume method, Consistency, stability and convergence Diffusion Equation- 1D-2D steady diffusion, Source terms, non-linearity, Boundary conditions, interface diffusion coefficient, Under-relaxation, Solution of linear equations (preliminary), Unsteady diffusion, Explicit, Implicit and Crank-Nicolson scheme Convection and Diffusion- Steady one-dimensional convection and diffusion, Upwind, exponential, hybrid, power, QUICK scheme, Two-dimensional convection-diffusion Flow Field Calculation- Incompressibility issues and pressure-velocity coupling, Primitive variable versus other methods, Vorticity-stream function formulation, Staggered grid, SIMPLE family of algorithms Radiative heat transfer - Computation of surface radiation using zone method, Solution of radiative transfer equation using discrete transfer, discrete ordinates and finite volume methods
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Mathematical Description of the Physical Phenomena- Governing equations—mass, momentum, energy, species, General form of the scalar transport equation, Elliptic, parabolic and hyperbolic equations, Behavior of the scalar transport equation with respect to these equation type	3
2	Discretization Methods- Methods for deriving discretization equations- Introduction to finite difference, finite volume and finite element methods, Method for solving discretization equations - iterative methods, Consistency, stability and convergence - Von-Neumann stability analysis	5
3	Diffusion Equation- 1D-2D steady diffusion, Treatment of source terms, non-linearity, Boundary conditions, interface diffusion coefficient, Under-relaxation, Unsteady diffusion, Explicit, Implicit and Crank-Nicolson scheme, Two dimensional conduction, Boundedness, accuracy, stability and convergence for diffusion problems	10
4	Convection and Diffusion- Steady one-dimensional convection and diffusion, Upwind, exponential, hybrid, power, QUICK scheme, Two-dimensional convection-diffusion, Accuracy of Upwind scheme; false diffusion and dispersion, Boundary conditions	7
5	Flow Field Calculation- Incompressibility issues and pressure-velocity coupling, Primitive variable versus other methods, Vorticity-stream function formulation, Staggered grid, SIMPLE family of algorithms	8
6	Introduction to Grid generation	3
7	Radiative heat transfer calculation -calculation of surface radiation exchange using zone method, coupling of surface radiation with energy equation,	2
8	Calculation for participating media, Radiation model - Flux method, Discrete ordinates method, finite volume method, Radiation coupled with conduction and convection	4
9		

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12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Computer assignment with finite difference method for 2D diffusion equation	4
2	Computer assignment with finite volume method for steady and unsteady 2D diffusion equation - explicit, implicit and crank - Nicholson scheme	4
3	Computer assignment on 2D convection-diffusion equation - implementation of various schemes of discretization	6
4	Computer assignment on fluid flow calculations with stream function vorticity formulation	4
5	Computer assignment on fluid flow calculations - primitive variable approach - Simple family	6
6	Assignment on Grid generation	4
7		
8		
9		

10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow,
2. Jr. Anderson, Computational Fluid Dynamics - The basics with applications, TATA McGraw Hill
3. Ferziger and Peric , Computational Methods for Fluid dynamics, Springer
4. H. Versteeg, W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	Lab with computers
19.5	Equipment	Computers
19.6	Classroom infrastructure	PC and projection system.
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	

20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (<i>< 45 characters</i>)	CONVECTIVE HEAT TRANSFER
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MCL 814
6.	Status (<i>category for program</i>)	

7.	Pre-requisites (<i>course no./title</i>)	MCL 703 Advanced Heat and Mass Transfer
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	Nil

8.2	Overlap with any UG/PG course of other Dept./Centre	Nil
8.3	Supercedes any existing course	MEL 802

9.	Not allowed for (indicate program names)	ME1 and ME2
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course B.Premachandran, Anjan Ray and any other faculty members of thermal group	
12.	Will the course require any visiting faculty?	No

13.	Course objective <i>(about 50 words):</i> To introduce advanced fundamentals of convective heat transfer.
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14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Derivation of energy equation- Similarity solutions for laminar external flows - Laminar internal flows- Transition flow-Heat transfer in transition flow- Reynolds averaged equations of motion, Averaged energy equations-Turbulent flow and heat transfer over a flat plate - Turbulent flow and heat transfer in pipes and channels-Laminar and turbulent natural convection-laminar and turbulent mixed convection-Pool boiling:nucleate boiling-film boiling, flow boiling-condensation:dropwise condensation-film condensation Nusselt theory-Special topics-Convective heat transfer in rotating systems, Microscale convective heat transfer, Convective heat transfer with nano-fluids,Combined convection and radiation,Double diffusive convection
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to convection, Newton's law of cooling, derivation of energy equations	2
2	External flows: Laminar boundary layer flows-Similarity solutions, Energy integral method	3
3	Laminar Internal flows - entry length solutions, non-circular ducts	4
4	Transition to turbulence, Structure of transition boundary layer, Heat Transfer in transition boundary layer, Transition of pipe flow.	2
5	Turbulent convection from external wall flows, Analogy between Momentum and heat transfer; Effects of Prandtl number, wall roughness, free stream turbulence intensity on heat transfer, Flow - heat transfer with pressure gradient	6
6	Turbulent convection in internal flows: Velocity distribution, pressure drop, Fully developed flow and heat transfer in circular pipes and channels- constant wall temperature and constant wall heat flux, Effect of Prandtl number surface roughness, free stream turbulence intensity,	6
7	Natural and mixed convection: Governing equations - Boussinesq approximation and its limitations Laminar Natural convection over flat surface-similarity solutions. Laminar natural and mixed convection in channels and open cavities. Heat transfer in transition natural and mixed convection, internal and external natural convection, Effects of buoyancy on turbulent transport of heat and momentum on flow over flat plate, flow through channels and cavities	6
8	Turbulence modeling for forced and natural convection flows	3
9	Pool Boiling, The Pool Boiling Curve, Heterogeneous Bubble Nucleation and Ebullition, Heat Transfer Mechanisms in Nucleate Boiling, film boiling over a horizontal surface, Critical Heat Flux, Flow boiling: forced flow boiling regimes, onset of nucleate boiling, Critical Heat Flux and Post-CHF Heat Transfer in Flow Boiling	6
10	Condensation-dropwise condensation-Film condensation over a	4

	vertical surface and horizontal tubes, effect of non-condensable gases on film condensation	
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Effect of fluid properties on heat transfer calculations	
2	Special topics: Convective heat transfer in rotating systems, Microscale convective heat transfer, Convective heat transfer with nano-fluids, Combined convection and radiation, Double diffusive convection	
3	Heat transfer in high speed flows	
4	Heat transfer in rotating flows	
5	Film cooling	
6	Heat transfer in low gravity	
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- 1.W.Kays, M.Crawford and B.Weigand, Convective Heat and Mass Transfer, 4th Edition, McGraw Hill, 2005.
- 2.V.S.Arpaçi and P.S.Larsen, Convective Heat Transfer, Prantice Hall Inc., 1984.
- 3.A.Bejan, Convective Heat Transfer, 4th Edition, Wiley, 2013
- 4.P. H. Oosthuizen, David Naylor, An Introduction to Convective Heat Transfer Analysis, First Edition, WCB/McGraw Hill, 1999
- 5.M.Favre-Marinet, S.Tardu, Convective Heat Transfer, First Edition, ISTE/Wiley 2013
- 6.L.C. Burmeister, Convective Heat Transfer, 2nd Edition, John Wiley 1993.

References:

- 1.H.Tennekes and J.L.Lumley, A first course in Turbulence, The MIT Press, 1972.
- 2.G.Biswas and V.Eswaran, Turbulent flows, Narosa, 2001.
- 3.S.B.Pope, Turbulent Flows, Cambridge University Press, 2000.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course		Mechanical Engineering Department	
2.	Course Title	Fire Dynamics and Engineering		
3.	L-T-P structure	2-0-4		
4.	Credits	4	Non-graded Units	Please fill appropriate details in S. No. 21
5.	Course number	MCL 815		
6.	Course Status (Course Category for Program) Program elective for MET Program			
Institute Core for all UG programs			(Yes / No) No	

Programme Linked Core for:	List of B.Tech. / Dual Degree Programs
Departmental Core for:	List of B.Tech. / Dual Degree Programs
Departmental Elective for:	List of B.Tech. / Dual Degree Programs
Minor Area / Interdisciplinary Specialization Core for:	Name of Minor Area / Specialization
Minor Area / Interdisciplinary Specialization Elective for:	Name of Minor Area / Specialization
Programme Core for:	List of M.Tech. / Dual Degree Programs
Programme Elective for:	M Tech Thermal Engineering
Open category Elective for all other programs (No if Institute Core)	(Yes / No) Yes

7.	Pre-requisite(s)	Advanced Thermodynamics, Advanced Heat and Mass Transfer
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8.	Status vis-à-vis other courses	
8.1	List of courses precluded by taking this course (significant overlap)	None
(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	
(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	
8.2	Supersedes any existing course	None

9.	Not allowed for	ME1 and ME2
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10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☐ II sem ☐ Either semester
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11.	Faculty who will teach the course - Dr. S.R. Kale, Dr. Anjan Ray and any other interested faculty of the Department
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12.	Will the course require any visiting faculty?	No
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13.	Course objective This course will cover the Dynamics of Fires. Knowledge of combustion, Heat Transfer and Fluid Mechanics will be applied to understand initiation and propagation of a Fire in a variety of practical settings. Techniques of fire detection and suppression will be discussed with emphasis on the underlying physical phenomenon.
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14.	Course contents Basics of Conservation equations, Turbulence, radiation and thermochemistry. Ignition of solids- Burning and heat release rates. Properties of fire plumes- buoyant plumes and interactions with surfaces. Turbulent diffusion flames- structure, modeling, soot formation and radiation effects. Toxic products. Fire chemistry, thermal decomposition of bulk fuel, pyrolysis, nitrogen and halogen chemistry. Fire growth- ignition, initial conditions, flame and fire spread theory, feedback to fuel. Compartment zone models. Flashover, post-flashover and control. Fire detection, suppression methods, codes, standards and laws. Case studies of real fires- buildings, transport, industries, shamiana and jhuggi-jhonpdi etc.
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15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	COMBUSTION FUNDAMENTALS: Chemical Thermodynamics and kinetics, Pyrolysis, ignition and combustion, conservation equations for mass, momentum, energy and species.	2
2	SURVEY OF APPLICATIONS: Industrial settings, buildings, transport modes, forest, shamiana, jhuggi-jhonpdi, materials and their properties, inventory of combustible materials.	3
3	FIRE DYNAMICS: Flames and fire spread theory, buoyant plumes, interactions with surfaces, smoke spread, turbulent diffusion flames, soot formation and radiation effects, toxic products; feedback to fuel; fire chemistry, nitrogen and	10

	halogen thermochemistry, numerical techniques.	
4	COMPARTMENT ZONE FIRES: Flashover, post-flashover, control, applications, numerical techniques, plume and ceiling jet models.	6
5	FIRE DETECTION AND SUPPRESSION: Instruments and sensors, monitoring systems, halogen and water mist suppression. Automatic sprinkler systems and prediction of actuating time.	4
6	Codes, standards and laws; case studies of real fires – buildings, factories and godowns, automobiles, buses, trains and aircraft, oil spills, forest fires, tents, slums, residential spaces. Engineering evaluation of fire safety.	3
	Total Lecture hours (14 times 'L')	28

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	Total Tutorial hours (14 times 'T')	

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
1	COMBUSTION FUNDAMENTALS: Chemical Thermodynamics and kinetics, Pyrolysis, ignition and combustion, conservation equations for mass, momentum, energy and species, turbulence, radiation.	4

2	SURVEY OF APPLICATIONS: Industrial settings, buildings, transport modes, forest, shamiana, jhuggi-jhonpdi, materials and their properties, inventory of combustible materials.	8
3	FIRE DYNAMICS: Flames and fire spread theory, buoyant plumes, interactions with surfaces, smoke spread, turbulent diffusion flames, soot formation and radiation effects, toxic products; feedback to fuel; fire chemistry, nitrogen and halogen thermochemistry, numerical techniques.	16
4	COMPARTMENT ZONE FIRES: Flashover, post-flashover, control, applications, numerical techniques, plume and ceiling jet models.	12
5	FIRE DETECTION AND SUPPRESSION: Instruments and sensors, monitoring systems, halogen and water mist suppression. Automatic sprinkler systems and prediction of actuating time.	8
6	Codes, standards and laws; case studies of real fires – buildings, factories and godowns, automobiles, buses, trains and aircraft, oil spills, forest fires, tents, slums, residential spaces. Engineering evaluation of fire safety.	8
Total Practical / Practice hours (14 times 'P')		56

18. Brief description of module-wise activities pertaining to self-learning component

(Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
Beyond the fundamentals introduced in lectures, students are expected to read the reference texts in order to be able to solve the assignments, some of which could require use of software packages.	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Drysdale, D.D., An Introduction to Fire Dynamics, Wiley, New York, 1999.
2. Lyons, J.W., Fire, Scientific American Books, New York.
3. Karlsson, B., and Quintiere, J.G., Enclosure Fire Dynamics, CRC Press.
4. Cox, G., Combustion Fundamentals of Fire, Academic Press, London, 1995.

5. Haessler, W.M., Fire: Fundamentals and Control, Marcel Dekker, 1988.
6. SFPE, Handbook of Fire Protection Engineering, NFPA, Quincy, Mass.
7. Quintiere, J.G., Principles of Fire Behavior, Delmar, 1985.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Fire Dynamics Simulator (FDS)
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date:

(Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
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The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course		Mechanical Engineering Department	
2.	Course Title	Gas Dynamics		
3.	L-T-P structure	3-0-2		
4.	Credits	4	Non-graded Units	Please fill appropriate details in S. No. 21
5.	Course number	MCL816		
6.	Course Status (Course Category for Program) Program Elective for MET Program			
Institute Core for all UG programs			(Yes / No)No	
Programme Linked Core for:			List of B.Tech. / Dual Degree Programs	
Departmental Core for:			List of B.Tech. / Dual Degree Programs	
Departmental Elective for:			List of B.Tech. / Dual Degree Programs	

Minor Area / Interdisciplinary Specialization Core for:	Name of Minor Area / Specialization
Minor Area / Interdisciplinary Specialization Elective for:	Name of Minor Area / Specialization
Programme Core for:	List of M.Tech. / Dual Degree Programs
Programme Elective for:	M Tech Thermal Engineering
Open category Elective for all other programs (No if Institute	(Yes / No)

7.	Pre-requisite(s)	PG Students Only
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8.	Status vis-à-vis other courses	
8.1	List of courses precluded by taking this course (significant overlap)	(course number)
(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	
(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	(course number)
8.2	Supersedes any existing course	(course number)

9.	Not allowed for	ME1 and ME2
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10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☐ II sem ☐ Either semester
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11.	Faculty who will teach the course Prof P M V Subbarao, Dr S Datta, Dr S Bahga, Dr A Gupta and other interested faculty
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12.	Will the course require any visiting faculty?	No
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13.	Course objectives :
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	To acquaint the students with the elements of compressible flow and its applications.
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14.	Course contents: Introduction, properties of the atmosphere, speed of sound, Mach number, Isentropic flow relations, Isentropic flow through nozzles and diffusers, pressure waves- infinitesimal and finite waves, Introduction to numerical analysis of compressible flow. Normal and oblique shocks, compression and expansion waves, Prandtl Meyer expansion, interaction of shock waves, shock-boundary layer interaction, Flow with friction. Flow with Heat Transfer. Introduction to 2-D compressible flow. Application in measurement of subsonic and supersonic flows, wind tunnels and aircraft and rocket propulsion.
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15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Introduction and recapitulation: properties of the atmosphere, pressure waves, speed of sound, Mach number, isentropic flow relations.	5
2	Isentropic and adiabatic flow through nozzles and diffusers.	3
3	Normal shocks, flow through variable area passages with shocks.	4
4	Oblique shocks, expansion waves, Prandtl Meyer expansion, interaction and reflection of shocks and expansion waves.	6
5	Shock-boundary layer interactions	4
6	Flow with friction and heat transfer in variable area passages	6
7	Introduction to 2-D compressible flow and method of characteristics.	4
8	Introduction to numerical analysis of compressible flows	3
9	Applications of gas dynamics: measurements in subsonic and supersonic flows, wind tunnels, aircraft and rocket propulsion.	4

10	Special topics: Analysis of hypersonic flows, transient compressible flows	Page 30 3
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
1	Introduction and recapitulation: properties of the atmosphere, pressure waves, speed of sound, Mach number, isentropic flow relations.	2
2	Isentropic and adiabatic flow through nozzles and diffusers.	2

3	Normal shocks, flow through variable area passages with shocks.	4
4	Oblique shocks, expansion waves, Prandtl Meyer expansion, interaction and reflection of shocks and expansion waves.	4
5	Shock-boundary layer interactions	4
6	Flow with friction and heat transfer in variable area passages	4
7	Introduction to 2-D compressible flow and method of characteristics.	2
8	Introduction to numerical analysis of compressible flows	2
9	Applications of gas dynamics: measurements in subsonic and supersonic flows, wind tunnels, aircraft and rocket propulsion.	2
10	Special topics: Analysis of hypersonic flows, transient compressible flows	2
Total Practical / Practice hours (14 times 'P')		28

18. Brief description of module-wise activities pertaining to self-learning component

(Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
	Recapitulation
	Literature survey on selected topics
	Problem solving, some involving computers, to better understand the lectures

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Oosthuizen, P.H., and Carscallen, W.E., Compressible Fluid Flow, McGraw-Hill, 1992
2. Zucker, R.D., Fundamentals of Gas Dynamics, Matrix Publishers, 1977.

3. Shapiro, A.H., The Dynamics and Thermodynamics of Compressible Fluid Flow, Vol-1 and 2, Ronald, 1953.
4. Anderson, John D. Jr., Modern Compressible Flow: with historical perspective, McGraw-Hill, New York, 1982.
5. Anderson, John D. Jr., Fundamentals of Aerodynamics, McGraw-Hill, New York, 1988.
6. Liepmann, H.W., and Roshko, A., Elements of Gas Dynamics, John Wiley, New York, 1957

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	

21.5	Others (please specify)	
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Date:

(Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
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The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (<i>< 45 characters</i>)	HEAT EXCHANGERS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MCL 817
6.	Status (<i>category for program</i>)	DE for PG programmes in Mechanical Engg. and OC for other programmes

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses <i>(give course number/title)</i>	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	YES - MEL709

9.	Not allowed for (indicate program names)	-
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Sanjeev Jain, P.M.V.Subbarao, B.Premachandran& others	
12.	Will the course require any visiting faculty?	

13.	Course objective <i>(about 50 words):</i> The objective of this course is to understand the fundamentals, types, constructional features and design procedures of heat exchangers. This course would enable the students to design and carry out the performance analysis of various kinds of heat exchangers.
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14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Applications. Basic design methodologies – LMTD and effective-ness-NTU methods. Overall heat transfer coefficient, fouling. Correlations for heat transfer coefficient and friction factor. Classification and types of heat exchangers and construction details. Design and rating of double pipe heat exchangers, shell and tube heat exchangers, compact heat exchangers, plate and heat pipe type, condensers, cooling towers. Heat exchanger standards and testing, Heat transfer enhancement and efficient surfaces.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction-Applications. Basic design methodologies – LMTD and effectiveness-NTU methods. Overall heat transfer coefficient, fouling. Correlations for heat transfer coefficient and friction factor.	4
2	Classification and types of heat exchangers and construction details.	2
3	Design and rating of double pipe heat exchangers: pipes with and without fins, series and parallel configuration, multi-tube heat exchanger	4
4	Shell and tube heat exchangers: Delaware method, Streamline method	5
5	air cooled heat exchangers- equipment description, airside heat transfer coefficient and pressure drop, overall heat transfer coefficient, fan and motor sizing, heat pipe heat exchangers	5
6	Design of Compact heat exchangers - Tube-fin and Plate-fin	4
7	Plate heat exchangers, geometry, enhancement technique, design methods, rating and sizing	4
8	Condensers, Shell and tube condensers, surface condensers of power plants	4
9	Design of cooling towers: Natural draft cooling towers- wet and dry cooling towers; mechanical draft cooling towers, Meteorological effect, selection and optimization	4
10	Counter flow rotating regenerator - counterflow rotating regenerator: rating and sizing	2
11	Heat exchangers for cryogenic plant and nuclear power plant	2
12	Codes and standards related to heat exchangers	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Flow maldistribution in heat exchangers	
2	Spiral heat exchangers	
3	Microscale heat exchangers	
4	Material selection	
5	Design of selected heat exchangers	
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- | |
|---|
| 1.R.K. Shah and D.P.Sekulic, Fundamentals of heat exchanger design, John Wiley and Sons, 2003 A.L.A.
2.Air cooled heat exchangers and cooling towers, Vol. 1 and 2, Penwell publications, 2004
3.W.M.Kays, and A.L. London, Compact heat exchangers, McGraw-Hill, 1984
4. S.Kakaç, H.Liu, A.Pramuanjaroenkij, Heat Exchangers: Selection, Rating, and Thermal Design, Third edition, CRC Press, 2012
5.T.Kuppan, Heat Exchanger Design Handbook, Second Edition, CRC Press, 2013. |
|---|

6. A P Fraas : Heat Exchanger Design, Second Edition 1999, John Wiley and Sons.
3. Amir Faghri : Heat pipe science and technology, First Edition 1995, Taylor & Francis.
4. G.F. Hewitt, G.L. Shires and T.R. Bott : Process Heat Transfer, 1994, CRC Press.
6. E.K. Kalinin, G.A. Dreitser, I.Z.Kopp, A.S.Myakochin: Efficient Surfaces for Heat Exchangers, 2003, Jaico Publishing House.
9. D. Q. Kern : Process Heat Transfer, International Edition 1965, Mc Graw Hill.
10. D.Q. Kern and Allan D. Kraus : Extended Surface Heat Transfer, Mc Graw Hill.
11. G.P. Peterson: An Introduction to Heat Pipes, First Edition 1994, John Wiley and Sons.
12. E.M.Smith : Thermal Design of Heat Exchangers, First Edition 1997, John Wiley and Sons.
13. RK Shah, Subbarao and RA Mashelkar : Heat Transfer Equipment design, 1988 (HPC)
16. Tubular Exchangers Manufacturers Association Standards, 1988 (TEMA)
17. API 661, standard on air cooled HX's

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Slides/ photos of applications
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	PC and projection system.
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	

20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (<i>< 45 characters</i>)	HEATING, VENTILATING AND AIR-CONDITIONING
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	MCL 818
6.	Status (<i>category for program</i>)	Elective

7.	Pre-requisites (<i>course no./title</i>)	
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8.	Status vis-à-vis other courses <i>(give course number/title)</i>	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supercedes any existing course	

9.	Not allowed for (indicate program names)	ME1 and ME2
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr/Prof Sanjeev Jain and any other interested thermal engineering faculty	
12.	Will the course require any visiting faculty?	No

13.	Course objective <i>(about 50 words):</i> To introduce students to basics of heating, ventilation and airconditioning technology with necessary exposure to design calculations, equipment, instrumentation and control strategies.
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14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Introduction, psychrometry of airconditioning processes. HVAC technologies. Thermal comfort - factors influencing thermal comfort. Cooling and Heating load calculations. Room air distribution principles. Design of air duct systems. Indoor air quality. Ventilation - need, principles. Various types of air conditioning systems. Cooling, dehumidification and humidification equipment. Temperature, pressure and humidity controllers. Various types of controls and control strategies.
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction , Applications, Review of Psychrometry..	2
2	Psychrometry of air-conditioning processes, enthalpy potential, air-conditioning calculations	4
3	HVAC Technologies- VCS, VAS, Evaporative cooling, Desiccant cooling, adsorption cycles, aircraft cycles	5
4	Thermal comfort - Factors influencing comfort, mechanism of heat transfer from human body, comfort chart, PMV-PPD model	3
5	Outside design conditions - climatic data	2
6	Cooling and heating load calculations - Solar heat gain through glass. Heat and water vapour flow through structures, Sol-air temperature, Internal and system heat gains, Infiltration, ventilation, Heat balance and RTS methods.	5
7	Room air distribution principles: Inlets and outlets selection, Factors affecting grille performance, various types of grilles, ADPI, EDT. Noise considerations. Design of air duct systems, duct sizing.	4
8	Indoor air quality - Air Cleaning: Air cleaner performance & classification. Filter location. odour control.	2
9	Ventilation - need, principles, Tunnel ventilation	3
10	Various types of air-conditioning systems. All air systems. Air water systems. Water and DX systems; Thermal storage, Passive cooling concepts – earth tunnels, water walls etc.	3
11	Cooling, dehumidification and humidification equipment, Heat and Mass transfer during direct contact of air and water. Design of cooling tower, Spray washers, Cooling and dehumidifying coils.	5

12	Temperature, pressure and humidity controllers. Various types of systems controls, building management systems, control strategies, energy monitoring	4
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Experiments in RAC lab.	
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- McQuiston, Faye C., J.D. Parker, J.D. Spitler, Heating Ventilating and Air conditioning Analysis and Design, John Wiley & Sons, Inc., 2000
- Jones, W.P., Air Conditioning Engineering, ELBS, 1985
- W.F. Stoecker, Principles of Air-conditioning
- ASHRAE Handbook of HVAC Applications, 2011
- ASHRAE Handbook of Systems and equipment, 2012
- ASHRAE Handbook of Fundamentals, 2013
- Arora, C.P., Refrigeration and Air-conditioning, Tata McGraw Hill, 2010.
- Arora, R.C., Refrigeration and Air-conditioning, , 2010
- Stoecker, W.F. and Jones, Refrigeration and Air-conditioning, Tata McGraw Hill, 1983

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	.
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Department of Mechanical Engineering
2.	Course Title (< 45 characters)	LATTICE BOLTZMANN METHOD
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MCL 819
6.	Status (category for program)	Elective of ME Thermal Program

7.	Pre-requisites (course no./title)	
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8.	Status vis-à-vis other courses (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Dr. Amit Gupta, Dr. Sasidhar Kondaraju or any other interested faculty from Department of Mechanical Engineering	
12.	Will the course require any visiting faculty?	No

13.	Course objective <i>(about 50 words):</i> To provide foundational concepts of lattice Boltzmann modeling and its applications in various fluid flow problems to postgraduate students. Computational exercises will enable students to develop their own codes, which will give them an opportunity to expand it into their research project/thesis.
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14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Introduction, Kinetic theory and statistical mechanics, Lattice gas cellular automata, LBM, Thermal LBM, Boundary conditions, Body forces, Multiple relaxation time model, Single component multiphase models, Multicomponent models single phase models, Applications of LBM
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction	1
2	Kinetic Theory: Atomistic model, Relaxation to local equilibrium, Chapmann-Enskog procedure, BGK model	4
3	Lattice Cellular Gas Automata: LGCA evolution, lattice tensors and isotropy, free streaming and collision, advantages, disadvantages	5
4	LBM: BGK model, derivation of weight functions, entropy and equilibrium distribution functions, 2D and 3D models hydrodynamic models, Equilibrium distribution functions - the Anasztz method	6
5	Hydrodynamic LBM with Energy Equation (2 distribution functions and Hybrid FDM-LBM methods)	4
6	Boundary Conditions: Wall conditions for regular and complex shapes, inlet and outlet BCs,	3
7	Body force implementations	2
8	Multiple relaxation methods	3
9	Single Component Multiphase Model - Non-ideal EOS, interparticle forces and incorporation into LBM, phase separation, homogeneous and heterogeneous cavitations, non isothermal multiphase model	7
10	Multi Component Multiphase Models - Pseudo potential model, two color gradient model, low and high density models	5
11	Applications of LBM - Complex fluids, electrohydrodynamics, fluid-structure interactions	2
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Succi S, The Lattice Boltzmann Equation - for fluid dynamics and beyond, Clarendon Press, Oxford, 2001
 Mohamad AA, Lattice Boltzmann Method - fundamentals and engineering applications with computer codes, Springer, 2011,
 Sukop MC, Thorne DT, Lattice Boltzmann Modeling- an introduction for geoscientist and engineers, Springer, 2007
 Wolf-Gladrow AD, Lattice-Gas Cellular Automata and Lattice Boltzmann Models - an introduction, Springer, 2005
 Farhat H et al., Accelerated Lattice Boltzmann for Colloidal Suspensions, Springer, 2014

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19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (<i>< 45 characters</i>)	MICRO/ NANO SCALE HEAT TRANSFER
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	MCL 820
6.	Status (<i>category for program</i>)	DE for UG/PG programmes in Mechanical Engg. and OC for other programmes

7.	Pre-requisites (<i>course no./title</i>)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (<i>indicate program names</i>)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Drs. Sanjeev Jain, Prabal Talukdar, Premachandran Balachandran, Subhra Datta, Amit Gupta and other interested faculty
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12.	Will the course require any visiting faculty?	No
13.	Course objective <i>(about 50 words):</i> The course will include fundamental approaches for experimental and numerical studies, along with the applications and developments in this area related to thermal sciences and engineering.	
14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Introduction to micro/ nano scale transport phenomena, size effect behaviour, overview of engg. applications, fundamentals of micro/nano scale fluid mechanics and heat transfer – kinetic theory, quantum mechanics considerations, Boltzmann transport equation, molecular dynamics modelling, microfluidics, Knudsen number, slip theory, micro/nano scale heat conduction - classical/ quantum size effects, thermal conductivity models, specific heat, thin films, convection in microtubes and channels, nanoparticles and nanofluids – preparation & transport properties, microfluidics - electrokinetic flows, microscale radiative heat transfer – modelling, properties, measurements at microscale	

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to micro/ nanoscale transport phenomena & its applications An overview of limitations of macroscopic formulations, size effect behaviour, microscopic view point, micro-scale engineering applications, microelectronics, micro channels, micro heat pipes, thin films, electronics cooling, two phase flow, radiation etc.	3
2	Fundamental approaches for micro/ nanoscale fluid mechanics & heat transfer Quantum mechanics considerations, Kinetic theory, Boltzmann transport equation, Maxwell's equations, molecular dynamics modelling, Knudsen number, Flow regimes, Maxwell's slip theory.	9
3	Micro-scale Heat conduction Classical and quantum size effects, acoustic/ optical phonons, Thermal conductivity models, specific heat of solids, Phonon transport, conduction in thin films, semiconductors, electronic devices.	8
4	Micro-scale Convection Gas flows - Slip flow, 1st & 2nd order boundary conditions, Burnett equations, Convective heat transfer in micro-tubes & channels - Governing equations, single phase forced convection, thermal creep Liquid flows – simple fluid, layering phenomena, apparent viscosity Nanoparticles & Nanofluids preparation, thermal conductivity, viscosity, transport phenomena in nano-scale suspensions	9
5	Microfluidics Fundamentals of Electrokinetics, Low inertia flows, Electrokinetic, pressure-driven and surface tension driven flows. Applications in heat transfer.	5
6	Micro-scale radiative heat transfer Spatial & temporal microscales, modelling of micro-scale radiation,	6

	gas radiation.	
7	Measurements at micro/nano scale - flow, temperature, concentration etc.& Engineering Applications	2
8		
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Visits to micro/nano manufacturing facilities, measurement facilities, computational facilities within and outside the institute	4
2	Exposure to commercial and open source codes,	2
3	MD simulation problem	4
4	Analytical solution of microscale gas flows - slip flows	4
5	Numerical solution of electrokinetic flows	6
6	Design of experimental facilities for heat transfer studies	4

7	Term paper presentation on current developments	4
8	Guest lectures	
9		
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Latif M. Jiji, Heat Conduction, 3rd edn., Springer, 2009.
2. Latif M. Jiji, Heat Convection, Springer.
3. Zhuomin M. Zhang, Nano / Microscale Heat Transfer, Mcgraw Hill, 2007.
4. George Karniadakis, Ali Beskök, N. R. Aluru, Microflows and Nanoflows: Fundamentals and Simulation, Springer, 2005.
5. G. Chen, Nanoscale Energy Transfer and Conversion: A Parallel Treatment of Electrons, Molecules, Phonons, and Photons , Oxford University Press, January 2005
6. C. B. Sobhan, G.P. Peterson, Microscale and Nanoscale Heat Transfer : Fundamentals and Engineering Applications, CRC Press Taylor and Francis Group, 2008.
7. Tabeling Patrick, "Microfluidics", Oxford University press, 2005.
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8. D.Y. Tzou., Macro to Microscale Heat Transfer : The Lagging behaviour, Taylor & Francis, 1997.
5. S. Kakac, L.L. Vasiliev, Y. Bayazitoglu, Y. Yener., Microscale Heat Transfer, Fundamental and Applications, Springer, 2005.
6. W.J. Minkowyez and E.M. Sparrow., Advances in Numerical Heat Transfer, Taylor & Francis, 1997.
7. W.J. Minkowyez, E.M. Sparrow and J.Y. Murthy. Handbook of Numerical Heat Transfer, John Wiley & Sons, 2006.
8. L. Zhang, K. E. Goodson, Thomas William Kenny, Silicon Microchannel Heat Sinks: Theories and Phenomena, Springer, 2004
9. Wang, L., Zhou, X., and Wei, Xiaohao, "Heat Conduction – Mathematical models and analytical solutions", Springer, 2008
10. Yarin, L.P., Mosyak, A., Hetsroni, G., "Fluid Flow, Heat Transfer and Boiling in Micro-Channels", Springer, 2008
11. Volz, Sebastian (Ed.), "Microscale and Nanoscale Heat Transfer", Springer- Berlin, 2007
12. Li, Dongqing(Ed.), "Encyclopedia of Microfluidics and Nanofluidics", Vol I-III, Springer, 2008

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Slides/ photos of applications
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	PC and projection system.
19.7	Site visits	Manufacturing facilities of microscale devices

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Numerical Simulation
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (< 45 characters)	RADIATIVE HEAT TRANSFER
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	MCL 821
6.	Status (category for program)	PE for MET. and OC for other programmes

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Prabal Talukdar, Sangeeta Kohli, Anjan Ray & others	
12.	Will the course require any visiting faculty?	

13.	Course objective <i>(about 50 words):</i> The course introduces students to fundamentals aspects of thermal radiation heat transfer including some application areas beyond what is taught in the core course Advanced Heat and Mass Transfer.
14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Introduction to Radiation- Recapitulation: Radiative properties of opaque surfaces, Intensity, emissive power, radiosity, Planck's law, Wien's displacement law, Black and Gray surfaces, View factors. Enclosure with Transparent Medium- Enclosure analysis for diffuse-gray surfaces and non-diffuse, non-gray surfaces, net radiation method. Radiative heat transfer in Participating Medium- Radiation in absorbing, emitting and scattering media. Absorption, scattering and extinction coefficients, Radiative transfer equation Analytical solution of radiative transfer equation Introduction to different radiation model- Discrete transfer method, discrete ordinates method Radiation from particulate media, Dependent versus independent scattering Non-gray radiation, Modelling of non-gray radiation Transient radiation and its solution Radiative transfer in porous media Combined Heat Transfer Modes- Radiation with conduction, combined boundary layer

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Radiation- Recapitulation: Radiative properties of opaque surfaces, Intensity, emissive power, radiosity, Planck's law, Wien's displacement law, Black and Gray surfaces, Emissivity, absorptivity, Spectral and directional variations	2
2	View factor and its determination by various methods, Area and contour integration, view factor algebra, Unit sphere method, crossed string method	4
3	Surface Radiation exchange among gray diffuse surfaces, Electrical network analogy, Radiation exchange between partially specular gray surfaces, radiation shield, semitransparent sheets Surface radiation exchange with convection, conduction and surface radiation in Fins	7
4	Radiative transfer in participating media - Derivation radiative transfer equation (RTE) for absorbing, emitting and scattering media, Integral formulation of RTE	4
5	Solution of radiative transfer equation for plane parallel media by analytical method, radiative equilibrium, divergence of radiative heat flux	3
6	Radiative properties of particulate media, Radiative properties of large spheres, Rayleigh scattering, radiative properties of semitransparent media	2
7	Radiation model: Approximate solution of RTE, optically thin and thick approximation, discrete transfer method, flux method, discrete ordinates methods, finite volume methods	6
8	Collimated radiation, transient effects	3
9	Treatment of non-gray extinction coefficients, Box model, WSGG model	4
10	Radiation combined with conduction and convection, solidification problem, combined boundary layer	4

11	Radiative transfer in porous media, packed bed, foam, determination of extinction coefficient	3
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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COURSE TOTAL (14 times 'P')		8

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Radiative heat transfer, MF Modest, McGraw-Hill.
2. Thermal Radiation Heat Transfer, J Howell, R Siegel, P Menguc, CRC press.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Slides/ photos of applications
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	PC and projection system.
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	Numerical Simulation
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (<i>< 45 characters</i>)	STEAM AND GAS TURBINES
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	MCL 822
6.	Status (<i>category for program</i>)	DE for PG programmes in Mechanical Engg. and OC for other programmes

7.	Pre-requisites (<i>course no./title</i>)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	YES - MEL811

9.	Not allowed for (<i>indicate program names</i>)	NAs
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Drs Subbarao, Premachandran and other interested faculty.
12.	Will the course require any visiting faculty?
13.	Course objective <i>(about 50 words):</i> The main objective of this course is to train the students in the area of comprehensive thermo-fluid designing of turbines used in various applications. The course moves from the analysis of existing practices to exploring of limitations and finally towards advanced practices.
14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Introduction, Recapitulation of heat cycles of steam power plants and gas turbine engines, Thermodynamics and fluid dynamics of compressible flow through turbines, meanline analysis and design of axial flow turbines, Three dimensional flows in axial flow turbines, Partial admission turbines, Turbines for nuclear power plants, Steam turbines for co-generation, turbine for super critical thermal power plant, operation of turbine plants- start up and shut-down of a turbine, steady state operation

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction, Recapitulation of heat cycles of steam power plants and gas turbine engines	3
2	Thermodynamics and fluid dynamics of compressible flow through turbines	4
3	Energy conversion in a turbine stage- velocity diagram, reaction of turbine stage	6
4	Geometrical and gas dynamic characteristics of of turbine cascade	6
5	Axial flow turbines- meanline analysis and design	4
6	Three dimensional flows in axial flow turbines- theory of radial equilibrium, off-design performance of a stage	5
7	Radial turbines-design method of radial flowturbines	5
8	Turbine performance map,effect of cooing of turbine efficiency	3
9	Partial admission turbines, Turbines for nuclear power plants, Steam turbines for co-generation, turbine for super-critical thermal power plant	4
10	Governing of steam and gas turbines.	1
11	operation of turbines- start up and shut-down of a turbine, steady state operation	1
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Design of Power Plant Cycles using steam turbines	4
2	Design of Gas Turbine Cycles	2
3	Design of Blade of turbine blade geometry	2
4	Testing of turbine cascades with 2D blades.	2
5	Testing of turbine cascades with 3D blades.	2
6	Testing of advanced blades with lean	2
7	Testing of advanced blades with bow	2
8	Analysis of primary losses in turbines	4
9	Analysis of Secondary losses in turbines	4
10	Estimation of entropy generation in steam and gas turbines	4
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Ronald H. Aungier, Turbine Aerodynamics: Axial-Flow and Radial-Flow Turbine Design and Analysis, American Society of Mechanical Engineers, 2006
2. A.S. Leizerovich, Steam Turbines for Modern Fossil-fuel Power Plants, CRC Press, 2007
3. H.I.H. Saravanamuttoo, G.F.C. Rogers, H. Cohen, Gas turbine Theory, Pearson Education, 2001.
4. Claire Soares, Gas Turbines - A Handbook of Air, Land and Sea Applications, Butterworth-Heinemann, 2008
5. P. Walsh, P. Fletcher, Gas Turbine Performance, ASME Press
6. D.G. Wilson, T. Korakianitis, The design of high efficiency turbomachinery and gas turbines, Prentice Hall, 1998

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Slides/ photos of applications
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	PC and projection system.
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (< 45 characters)	THERMAL DESIGN
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	MCL 823
6.	Status (category for program)	PE for MET and OC for other programmes

7.	Pre-requisites (course no./title)	Nil
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8.	Status vis-à-vis other courses (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	Nil
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Prabal Talukdar, Sangeeta Kohli, Premachandran, Sanjeev Jain& others	
12.	Will the course require any visiting faculty?	

13.	Course objective <i>(about 50 words):</i> The course will enable the students to design various thermal components as well as systems. Design and optimization of a few important thermal components would be taught in the 1st module. In the 2nd module, students will be able to mathematically model a thermal system and subsequently simulate it by solving the mathematical equation(s) describing the physical system. The course will also enable students to optimize thermal systems.
14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Introduction to design, modelling and simulation, components and systems Component design Design of heat sink - single fin optimization, multiple fin array Design of compact heat exchangers - Fundamentals, shell and tube heat exchangers, plate heat exchangers, finned tube heat exchangers Design of Heat pipe - Fundamentals, design procedure Design of thermoelectric devices - Fundamentals, thermoelectric generator, thermoelectric cooler, module design System design: Design of thermal systems: System identification and description with mathematical modelling: Examples with Power plant, refrigeration plant, HVAC systems, pump pipe network, electric space heaters, wind tunnel Development of a numerical model, mathematical techniques, solution of non-linear equations, numerical model for a system, system simulation, methods of numerical simulation Optimization -basic concepts, optimization of thermal systems, Lagrange multiplier, optimization of unconstrained problems, search based methods, Genetic algorithm, Differential Evolution method Thermal design based on inverse methods - Definition, estimation of boundary condition, conjugate gradient method

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction: Definition of design, difference between design and analysis, classification of design, steps in design, thermal components, sub-systems, systems, processes	2
2	Design of heat sink:Recapitulation, Longitudinal fin of rectangular profile, heat transfer from fin, effectiveness, efficiency, corrected profile length, optimizations for single fin and multiple fin array, fin design with thermal radiation, optimization of thermal insulations	5
3	Design of compact heat exchangers: Fundamentals, shell and tube heat exchangers, plate-fin heat exchangers, finned tube heat exchangers, pressure drop in compact heat exchangers	6
4	Design of heat pipe - fundamentals, classifications, different limits, design calculation	4
5	Design of thermoelectric cooler, Fundamentals - thermoelectric effect, thermoelectric generator, thermoelectric cooler, design calculations	3
6	System identification and description and component design: Power plant, refrigeration plant, HVAC systems, pump pipe network, condensers, electric space heaters, wind tunnel	6
7	Modelling and Simulation: Development of a numerical model, Mathematical techniques, solution of non-linear equations, curve fitting, numerical model for a system, system simulation, methods of numerical simulation, steady lumped systems, dynamic simulation of lumped systems	6
8	Optimization: Problem formulation, basic concepts, optimization of thermal systems, Lagrange multiplier, optimization of unconstrained problems, computational approach,Search based methods, geometric programming	6
9	Design of thermal systems with inverse methods - concept of inverse	4

	problem, conjugate gradient method, Introduction to evolutionary algorithms - Genetic algorithm, differential evolution, Ant colony optimization and its application to inverse design problems	
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11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Design of heat sink, tool - programming with Matlab or any other tools	4
2	Design of heat exchangers - programming with Matlab or other tools	4
3	Design of heat pipe - programming with Matlab or any other tools	2
4	Design of thermoelectric cooler - programming with Matlab or any other tool	2
5	Thermal system simulation - pump pipe network, HVAC systems, power plant systems etc.	4
6	Optimization of thermal systems - model development and numerical simulations	6
7	Design with inverse methods	6
8		
9		

10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Lee, K., Thermal Design
2. Stoecker, W.F., Design of Thermal Systems, 3rd ed., McGraw-Hill, New York.
3. Jaluria, Y., Design and optimization of thermal systems, CRC press
4. Thermal design & optimization - Bejan, A., Tsatsaronis, Moran, John Wiley.

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Slides/ photos of applications
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	PC and projection system.
19.7	Site visits	

20. Design content of the course (Percent of student time with examples, if possible)

20.1	Design-type problems	With the aid of numerical Simulations
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	

20.5	Others (please specify)	
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Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (<i>< 45 characters</i>)	TURBOCOMPRESSORS
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	MCL 824
6.	Status (<i>category for program</i>)	DE for PG programmes in Mechanical Engg. and OC for other programmes

7.	Pre-requisites (<i>course no./title</i>)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No

8.3	Supercedes any existing course	YES - MEL8XX
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9.	Not allowed for (indicate program names)	-
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Drs P.M.V.Subbarao, B.Premachandran and other interested faculty.	
12.	Will the course require any visiting faculty?	

13.	Course objective <i>(about 50 words):</i> The fluid dynamics of turbo-compressors is very complex due to existence of global adverse pressure gradient. This make design and analysis of these machines very special and exclusive. This course is aimed at understanding and resolving these issues.
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14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> Introduction, Fluid mechanics and thermodynamics of axial and radial flow compressors, operation and performance of compressors, compressor cascades, blade to blade flow for axial compressors with subsonic inlet flow, blade-to-blade flow for axial flow compressors with supersonic inlet flow, loss correlations, performance analysis of axial flow compressors, Centrifugal compressor- the centrifugal impeller, diffuser of centrifugal compressor, stall and surge, supersonic compressors, compressor instrumentation and testing
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15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction	1
2	Thermodynamics and fluid dynamics of flow through compressors	4
3	Stage parameters, factors affecting stage pressure ratio, degree of reaction, meanline analysis	6
4	Dimensional analysis, specific speed	2
5	compressor cascades, blade to blade flow for axial compressors with subsonic inlet flow, blade-to-blade flow for axial flow compressors with supersonic inlet flow, loss correlations, performance analysis of axial flow compressors	5
6	Centrifugal compressor- centrifugal impeller: calculation methods and predictions of flow in impellers, slip and estimation of slip factor, loss in impeller	7
7	Diffuser for centrifugal compressor: Vanless diffuser, vaned diffuser, volute and scroll	4
8	stall and surge, blade vibration	4
9	Compressor behaviour during start up, starting problems of multistage axial flow compressor, means of suppressing starting problem	2
10	Off-design performance of compressors, effect of inlet flow conditions on compressor performance	2
11	Supersonic compressors	3
12	Compressor instrumentation and testing	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. N.A. Cumpsty, Compressor aerodynamics, Longman Scientific & Technical, 1989
2. J.K. Horlack, Axial Flow Compressors: Fluid Mechanics and Thermodynamics, Krieger Pub Co., 1982
3. R.H. Aungier, Axial-flow Compressors: A Strategy for Aerodynamic Design and Analysis, ASME Press, 2003.
5. R.H. Aungier, Centrifugal Compressors: A Strategy for Aerodynamic Design and Analysis, ASME Press, 2000
6. K.H. Ludtke, Process Centrifugal Compressors, Springer, 2004.
7. M.P. Boyce, Centrifugal Compressors - A Basic Guide, PennWell Publisher, 2003
8. H.I.H. Saravanamuttoo, G.F.C. Rogers, H. Cohen, P.V. Straznicky, Gas Turbine Theory, Pearson Education, 2008.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Slides/ photos of applications
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	PC and projection system.
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	Mechanical Engineering
2.	Course Title (<i>< 45 characters</i>)	DESIGN OF WIND POWER FARMS
3.	L-T-P structure	3-0-2
4.	Credits	4
5.	Course number	MCL 825
6.	Status (<i>category for program</i>)	DE for PG programmes in Mechanical Engg. and OC for other programmes

7.	Pre-requisites (<i>course no./title</i>)	Nil
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8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (<i>indicate program names</i>)	NA
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10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
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11.	Faculty who will teach the course Drs P M V Subbarao, Premachandran and other interested faculty	
12.	Will the course require any visiting faculty?	No

13.	Course objective <i>(about 50 words):</i> The goal of this course is to discuss advanced principles of thermodynamics, fluid mechanics and mechanical systems used in wind turbine analysis and design. The course will start from design of individual wind turbine and slowly move towards design of a wind farm by considering local conditions.
14.	Course contents <i>(about 100 words) (Include laboratory/design activities):</i> General Introduction to Wind Turbines, Analysis of wind source, 2-D Aerodynamics, 3-D Aerodynamics, Momentum Theory for an Ideal Wind Turbine, wind turbine performance, Design of HAWT, Design of VAWT, Component sizing, Analysis and design of wind farms, Optimal selection of layouts.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	General Introduction to Wind Turbines, classification & status	2
2	Thermodynamics analysis and Betz theory	3
3	Fluid dynamic analysis of wind source and classification of sources	3
4	2-D aerodynamics of wind turbine & blade	6
5	3-D aerodynamics of blade	4
6	Aerodynamics of rotor wakes and selection of number of blades & speed	5
7	Analysis of rotor design and selection of capacity	5
8	Design of horizontal axis wind turbines	5
9	Design of vertical axis wind turbines	3
10	Controls for wind turbines	2
11	Auxiliary systems	2
12	Special designs for micro wind turbines	2
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

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17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours

1	Statistical analysis of wind data and estimation of potential	4
2	Design of simple & Ideal wind turbine	2
3	Design & selecton of Blade geometry	2
4	Tesing of blades	2
5	Design of HAWT	4
6	Design of VAWT	4
7	Design of Micro Wind turbines	4
8	Estimation of forces acting on wind turbines	2
9	Case studies & wind farm desing	4
10		
COURSE TOTAL (14 times 'P')		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Martin O. L. Hansen, Aerodynamics of Wind Turbines Turbine Aerodynamics: Second edition, Earthscan, UK, 2008.
2. Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi Wind Energy Handbook, John Wiley and Sons, 2010.
3. Abbot, H. and von Doenhoff, A. E., Theory of Wing Sections, Dover Publications, New York.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	Wind tunnel, Turbo-machinery laboratory
19.3	Teaching aides (videos, etc.)	Slides/ photos of applications

19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	PC and projection system.
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	60
20.2	Open-ended problems	30
20.3	Project-type activity	10
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)